Understanding Affordances in Health Apps for Cardiovascular Care through Topic Modeling of User Reviews

Research Paper

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Abstract. This study applies topic modeling to explore and understand affordances in health apps for cardivasculare care. We analyzed 37,693 app user reviews (google play store) from 22 monitoring and vital sign tracking apps for individuals with heart failure and related cardiovascular diseases. The goal was to identify patterns in user experiences, revealing six key pattern: (1) Data Management and Documentation, (2) Measurement and Monitoring, (3) Vital Data Analysis and Evaluation, (4) Sensor-Based Functions & Usability, (5) Interaction and System Optimization, and (6) Business Model and Monetization. Our findings offer valuable insights for both research and practice, contributing to a deeper understanding of affordances in health apps for cardiovascular care.

Keywords: topic modeling, heart failure, affordance theory, health apps

1 Introduction

According to the Global Burden of Disease database, cardiovascular disease affects an estimated 60 million people in Europe, with an additional 13 million new cases each year. Cardiovascular disease is the leading cause of mortality in EU at 36%, followed by cancer at 26% (European Heart Network, n.d.). Patients with heart failure (HF) are especially encouraged to collect data on their health, such as heart rate, step count, single-lead ECG, oxygen saturation and blood pressure, to document the progression of their disease (Bayoumy et al., 2021). HF is a clinical syndrome that often presents with symptoms such as breathlessness, fatigue, and ankle swelling. It is a functional abnormality of the heart that results in inadequate cardiac output. HF can be divided into NYHA (*New York Heart Association*) classes I to IV, which form a functional classification of symptoms and activities (McDonagh et al., 2021). Primary care physicians, cardiologists and clinicians can then use the additional data during the patient's regular check-ups and take appropriate action if needed. In this way, health apps can provide risk assessment, HF management and telemonitoring (Bayoumy et al., 2021). However, the use of technology like medical health devices is not enough, it must meet patient needs (Kimani et al., 2018; MacDonald et al., 2023; Nguyen et al., 2017). With a shortage of healthcare personnel in Organisation for Economic Co-operation and Development countries, it is crucial to determine if digital solutions, particularly mobile apps, can potentially be a resource to support the care of patients with heart failure (Lorkowski & Jugowicz, 2020; OECD/European Union, 2022; Sivakumar et al., 2023).

The design and usability of monitoring applications for HF patients and healthcare professionals to monitor and support patients in the home environment have been evaluated (Alnosayan et al., 2017; Melero-Muñoz et al., 2022). However, the evaluation showed that there is still room for improvement in terms of user acceptance and that patients still see room for optimisation when it comes to customising the app, visualising information, configuring alarms and offering help guides (Alnosayan et al., 2017; Bylappa et al., 2022). Some clinical trials have already successfully shown that the use of self-management interventions, such as monitoring apps in HF patients in the home environment, can reduce all-cause mortality and HF-related hospital readmissions (Liu et al., 2022). In Germany, for example, it is currently possible to obtain a prescription for an app that can be used by HF patients, but the app must be listed in the DiGA directory (Federal Institute for Drugs and Medical Devices (BfArM), 2025). There, the health apps go through an approval process to prove the medical benefit and are ultimately reimbursed by the health insurance companies (Federal Institute for Drugs and Medical Devices (BfArM, 2023). Alternatively, there are so-called lifestyle and health apps that are freely available, e.g. in the Google Play store, and can be used by HF patients at home. Analyzing user perspectives can contribute to the development of more effective digital health solutions (Sivakumar et al., 2023).

Each patient who interacts with a health application perceives different affordances, such as perceived connective, utilitarian, hedonic or instrumental affordances (Guo et al., 2023; Liu et al., 2021). Gibson (1977) first introduced the theory of affordances in the field of psychology. An affordance is a potential action that an object offers a subject to achieve its goals. In this process, they consider the possibilities the object presents to them based on how they perceive it. Gibson proposed that affordances are objective possibilities for interacting with objects or the environment that exist independent of an individual's perception (Gibson, 1977). In the field of information systems (IS), affordances have a relational character between the user and the object (Thapa & Sein, 2018; Volkhoff & Strong, 2017). The affordances built into an IT system by designers can be perceived by users or remain hidden (Osch & Mendelson, 2011; Thapa & Sein, 2018). Thus, there are affordances that are present at the start and those that are only discovered during utilization (Osch & Mendelson, 2011). Computational methods such as topic modeling using LDA provide pattern recognition of socio-technical interactions in large amounts of data such as user reviews or in images (Miranda et al., 2022).

Topic modeling is a computational approach used in text analysis and natural language processing (DiMaggio et al., 2013). Liu et al. (2021) identified the perceived connective, utilitarian and hedonic affordances when analysing chronic disease management applications, and the authors Guo et al. (2023) examined fertility and pregnancy applications and identified the instrumental affordance. In this paper, we do not aim to use topic modeling to identify affordances directly, but to extract usage patterns and perceptions from which affordances for future monitoring and vital signs tracking applications and HF patients can be conceptually derived.

We conducted a topic modeling analysis of publicly available user reviews of monitoring and vital signs tracking apps for HF patients to identify patterns. We aim to contribute to the understanding of perceived affordances using affordances theory and show how topic modeling analysis can help conceptualise perceived affordances. We investigate the following research question (RQ): RQ 1: *What user experience patterns can be identified in user reviews of heart failure and vital signs tracking apps, and how do these patterns relate to potential affordances?* RQ2**:** *What are the implications for research and practice that can be derived from the results of RQ1?* In order to answer these research questions, this publication follows a clear structure: Section two provides the theoretical background, followed by a clarification of the concept of affordances as originally defined and used in IS and related work. The third section presents the research approach, from data collection to the application of topic modeling algorithms. Section four presents the results of the topic modeling analysis, the patterns identified and the affordances that result. The discussion outlines the implications for research and practice. The paper concludes with a conclusion and a future outlook.

2 Theoretical background and related work

Gibson (1977) first introduced the theory of affordances in the field of psychology. Later, Norman (1988) contributed to the definition of affordances, referring specifically to the perceived affordances from a design perspective. He suggests that affordances are perceived as actual properties of an object or as cognitive and social aspects. Norman's definition of affordances embraces not only objective properties of the environment or design of an object, but also subjective ones, which are dependent on the abilities and knowledge of the individual (Norman, 1988). This was the initial step in introducing affordance theory into IS. Affordances can also emerge from socio-technical interactions and have been examined in the domain of IS (Hutchby, 2001; Leonardi, 2011; Markus & Silver, 2008). Hutchby (2001) differentiates between functional affordances and relational affordances. The first enable an individual to interact with an object or perform an activity such as swimming, taking photographs, etc. The relational affordances are present when the affordances of an object differ between individuals (e.g. within human or animal species) (Hutchby, 2001). Valbø's (2021) review highlights Markus and Silver's (2008) and Leonardi's (2011) pioneering work in applying affordance theory to IS. Markus and Silver (2008) defined functional affordances as “a type of relationship between a technical object and a specified user (or user group) that identifies what the user may be able to do with the object, given the user’s capabilities and goals”. In this context, the functional affordances in the relationship between the Information Technology (IT) artefact and the potential user show what potential uses the artefact offers for goal-oriented activities (Markus & Silver, 2008). The perception of affordances may vary according to individual abilities, experiences, and technical possibilities. A study by Osch and Mendelson (2011) recognized designed, improvised, and emergent affordances. These depend on the user group perceiving them. Designers perceived the designed affordances, users recognized the improvised affordances, and emergent affordances were neither pre-designed nor unconsciously noted by either group (Osch & Mendelson, 2011). There has been a shift in IS from individual affordances to organizational affordances. This shift is reflected in a subject that encompasses a user group or organization, along with their actions, objectives and social context (Volkoff & Strong, 2013; Zammuto et al., 2007).

Affordances have also been analyzed in the context of healthcare. Song et al. (2021) used affordance theory to investigate the factors that influence users' intention to continue using short video apps for health information (Song et al., 2021). In a study conducted by Liu et al. (2021), the researchers analyzed the perceived connective, utilitarian, and hedonic affordances in users of chronic disease management applications. The results showed that these affordances positively impacted social interactivity, informativeness, technology, function, and enjoyment. Consequently, these factors have an influence on health literacy. Guo et al. (2023) conducted a topic modeling analysis of fertility and pregnancy applications by analyzing user reviews from the Apple App Store. They discovered that certain topics, including tracking, guiding, and reminding, can be classified as instrumental affordances. Additionally, they categorized the topics of interactivity, usability and gamification as experiential affordances and the topics of self-nurturing and peer support as empowerment affordances. Alshawmar et al. (2021) identified four shared affordances of wellness mHealth apps, including promoting goals, comparing oneself to others, coaching, and nurturing. These affordances led to immediate concrete outcomes such as habit formation, self-awareness, and goal attainment. Other related work has used the Apple App Store to examine affordances using topic modeling in user reviews of wellness mHealth apps and fertility and pregnancy apps (Alshawmar et al., 2021; Guo et al., 2023).

Our paper differs from related work by focusing on the application context of cardiovascular disease and heart failure. It contributes to how patterns can be identified from user reviews to conceptually derive affordances. To the best of our knowledge, it is the first work that has focused on the study of monitoring and vital signs tracking apps for patients with HF and other cardiac conditions.

3 Methods

When conducting the topic modeling analysis, we follow the methodological approach of Guo et al. (2023) and Miranda et al. (2022). The following section explains our 5-step quantitative method procedure for the preparation of the topic modeling analysis.

Step 1: Topic modeling is a technique used in text mining and natural language processing. It uses an algorithm to identify hidden semantic structures in a large corpus of text and creates an overview in the form of several word lists, called topics (Blei et al., 2010; Blei et al., 2003; DiMaggio et al., 2013; Jelodar et al., 2019). These topics represent groups of words that frequently occur together and are related in content. One of the most well-known topic modeling algorithms is Latent Dirichlet Allocation (LDA) (Blei et al., 2010; Blei et al., 2003; Jelodar et al., 2019). For our analysis, we used the open source software LDA MALLET, which provides a more efficient and scalable implementation of LDA. It is based on Gibbs sampling and allows faster processing of large textual datasets compared to the standard LDA implementation

(McCallum, 2023). User reviews from the Google Play Store serve as the textual basis for the topic modeling analysis, with LDA MALLET ensuring scalability for varying review volumes across apps.

Step 2: Application selection. The Google Play Store was selected for analysis to identify relevant apps for heart failure patients. The search strategy, which was implemented in the Google Play Store, was based on keywords such as "heart failure", "heart", "heart telemonitoring", "heart tracking" and "heart monitor". To reduce potential confirmation bias in the selection of apps from the Google Play Store, we applied predefined inclusion criteria. In a first step, 66 apps were identified, of which 5 were eliminated due to duplicates. The remaining 61 apps were subjected to a detailed relevance check, and 26 apps did not meet the pre-defined inclusion criteria. Applications were selected based on the description in the Google Play Store and the screenshots shown. The study's inclusion criteria require the selection of apps that are appropriate for individuals with heart failure disease. These criteria include telemonitoring capability, the ability to track and measure vital signs, a specific focus on heart-related information, and the provision of relevant information tailored to patients with heart failure. The aim is to select applications that meet the specific needs and requirements of people living with heart failure based on previous work (Dias & Cunha, 2018; Kimani et al., 2018; MacDonald et al., 2023). Of the remaining 35 apps, 13 were excluded due to a lack of user reviews. Finally, 22 apps remained and were included in the subsequent topic modeling analysis.

Step 3: Data cleaning and preparation. The review selection process begins with scraping user reviews from the Google Play Store using PyCharm and Python for 22 app IDs (JetBrains, 2023). Reviews were limited to English and the USA but had no restrictions on time, length, or number. Only the title and main text were analyzed, yielding 37,693 reviews. The text was then cleaned by removing links, emojis, punctuation, and stopwords using libraries like spaCy. Finally, LDA MALLET and Gensim were used for topic modeling, incorporating a bigram model to improve word grouping, considering only bigrams appearing at least five times with a PMI score over 100 (Chuang et al., 2012). Trigrams were excluded to avoid false positives.

Step 4: Analysis with LDA model. To determine the most suitable number of topics, we calculated the coherence score. This score indicates how effectively the words in each topic correspond to a distinct idea. Our analysis revealed that the coherence score was highest when using 10 topics, reaching a value of 0.5713. The coherence score is 0.5713, indicating moderate coherence. A score of 1 would imply perfect coherence and that the words in a topic are better connected or thematically coherent. Therefore, we chose to analyze and interpret these 10 topics further (refer to Figure 1). By using pyLDAvis, the results are visualized in an inter-topic distance map and the 30 most salient terms for each of the 10 topics are displayed (Sievert & Shirley, 2014). The most frequent words in topics are those that occur more often together. These top 30 salient high probability words are used to interpret and semantically characterize the topics (Syed & Spruit, 2017). A higher saliency value indicates that the term is particularly important or conspicuous in relation to the topic in the model (Chuang et al., 2012). The relevance of a term allows it to be ranked within a topic. In pyLDAvis, the Sievert (2014) definition of relevance is used. The top 30 most salient terms differ by topic and the estimated term frequency (red bar in the legend) is shown compared to the total term frequency (blue bar in the legend) (McCallum, 2023; Sievert & Shirley, 2014).

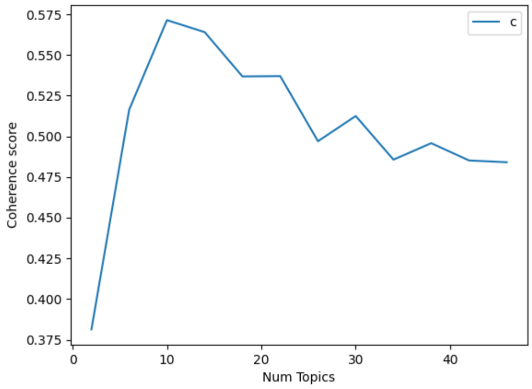

Figure 1. Coherence score for number of topics (range from 0 to 50).

Step 5: Derivation of user patterns. As shown in Figure 2, some of the ten topics demonstrate a high degree of content overlap. These topics were examined in more detail and summarised as user patterns to enable greater clarity for further evaluation. These six patterns formed the basis for a workshop discussion based on the work of Volkhoff and Strong (2017).

4 Results

A total of 37,693 app reviews were extracted from the Google Play Store and employed for topic modeling analysis. The intertopic distance map (refer to Figure 2) displays 10 topics with the total term frequency for all 10 topics. This map enhances our understanding of topic similarities, allowing us to see which topics overlap in terms. For instance, topics 1,2,3,4,6,7 and 10 demonstrate a significant degree of similarity. Table 1 illustrates the topics identified, along with the selection of the most important terms from each topic and their distribution as a percentage. The term distribution within the topic fluctuates between 9.4% and 10.9%. These topics formed the basis for discussion in a workshop with research colleagues, where systematic and theoretical consideration was given to how the 10 themes identified could be meaningfully summarised into patterns. In order to create a common understanding of the patterns, potential actions were defined that could be performed during the interaction between the user and the application. Six patterns (P) were summarised (see Figure 3).
Data Management and Documentation (P1) refers to the ability to store, manage and share medical data with clinicians. It is formed by the topics “Reporting” and “Medical Records”. **Topic “Reporting“** relates to the process of connecting and reporting information and data within an application. This topic covers words such as "information," "transmit," and "record". User reviews highlight the need for better report accessibility: *"Truly wish they made it easier to find prior reports."*

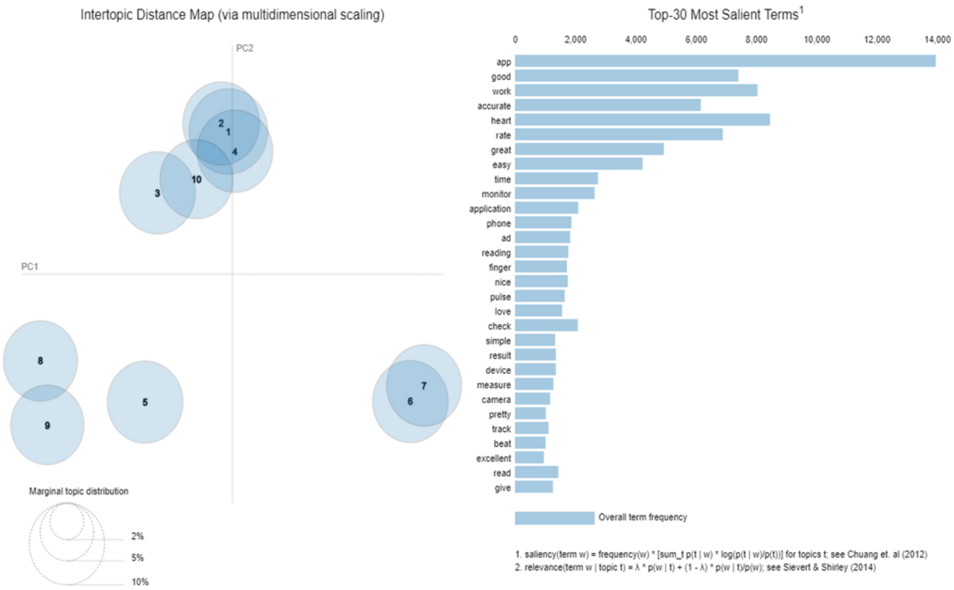

Figure 2. Visualization of Topic Modeling Results.

"Found it very useful for daily check-ups.". **Topic "Medical Records"** pertains to retrieving and comparing medical data over time, and includes words such as "time", "reading", "doctor", "record" and "history". A user highlights the app's functionality as a quick and easy heart rate monitor with a comprehensive history and notes feature, stating, "*Quick easy heart rate monitor, with history and notes*". Additionally, the PDF export feature is appreciated for sharing records with doctors: "*The ability to save to PDF is great so I can send it to my doctor and attach it to my medical records*."

Measurement and Monitoring (P2) addresses at the potential for real-time monitoring of health data and automated alerts, and summarizes the topics of health tracking and monitoring. **Topic "Health Tracking"** includes words like "track", "check", "measure", "heart" and "health". In one user review, the app is described as "*I recently had a heart attack and needed a simple app to track my bpm/rhythm/history.*". Furthermore, a user shares that the app "*helps me to keep track and show my doctor what is happening.*". Another mentions, "*Use it to track heart rate after taking my meds*". **Topic "Monitoring"** encounter words such as "monitoring", "application", "feature", and "graphic". One user finds that "*The graphic representation is pretty helpful*". Nevertheless, another user notes a limitation: "*Graphics shows only last 30 measures. You can't compare all your measures in a day*". It addresses a user's concern about the limited time frame of the graph, which makes it difficult to effectively compare all of the day's readings.

Vital Data Analysis and Evaluation (P3) refers to the ability to self-monitor and evaluate health parameters and is composed of the topic "Vital Sign Assessment".

Table 1. Results from Topic Modeling.

No.	Topic tokens (Sample)	Topics	Token (%)
1	“day”, “log”, “information”, “report”	Reporting	10.9
2	“ad”, “pay”, ”free”, “premium”	Subscription	10.4
3	“finger”, “camera”, “sensor”, “detect”	Phone Sensor	10.1
4	“time”, “doctor”, “record”, “history”	Medical Rec-ords	10.1
5	“check”, “measurement”, “pulse”,	Vital Sign Assessment	10.1
6	“track”, “check”, “measure”, “health”	Health Tracking	10
7	“monitor”, “feature”, “graphic”	Monitoring	9.9
8	“watch”, “interface”, “reminder”	Interactivity	9.6
9	“helpful”, “performance”, “optimize”	Performance Optimization	9.4
10	“accurate”, “easy”, “convenient”	Usability	9.4

Topic “Vital Sign Assessment” encompasses words such as "check", "measure", "pulse" and "show". Another user review commended the app as “*Excellent heart rate tracker, easy to use*". This emphasizes the app's excellence in heart rate tracking, underlined by its user-friendly interface and the ability to review historical readings. Furthermore, one user describes the app as "*Easy, quick, and accurate (comparing each measurement with my recent frequent medical appointments)."*. This indicates a high level of awareness, because the user is able to compare and shows medical knowledge.

Sensor-based functions and usability (P4) refers to the improvement of user-friendliness through optimised sensor integration. It is combined in the topics "Phone Sensor" and "Usability". **Topic “Phone Sensor”** is about "camera", "phone", "sensor" and "detect". A user expresses his first experience with the app "*I notice that my BPM results on this app are 3 BPMs below my medically obtained ones*". In a another user review, the user provides insights into the functionality of the app, mentioning "*I know while taking my pulse when I have my finger on the sensor the light on the sensor area gets really really hot*”. This indirectly highlights the user's awareness of the sensor's response, specifically noting the temperature increase during the pulse measurement. **Topic “Usability”** contains words such as “accurate”', “simple”, “reliable” and “convenient”. A user commended, "*Easy to activate and track history*". This highlights the user's experience with the application's ease of activation and ability to track historical data. Furthermore, the user appreciates the design of the application, stating: "*Nice graphics and easy understanding data*". This highlights the user's perception of the ease of understanding the data, highlighting the importance of visual elements in improving usability.

Interaction and System Optimisation (P5) covers application personalisation, user-centred design and performance optimisation and is formed by the topics 'Interactivity' and 'Performance Optimisation'. **Topic “Interactivity”** refers to "watch", "rating", "design", "interface", and "reminder. One user expresses the positive impact of the interactivity, stating, "*It has saved me many trips to the doctor and it can be very* *reassuring to know that I can send my ECGs to a medical team if necessary*". It highlights the practical benefits of the interactive features, particularly in terms of reducing the need for frequent visits to the doctor and providing reassurance through the ability to share health data with a medical team. **Topic "Performance Optimization"** is contains tokens like "helpful", "performance", "feature", and "optimize". A user expresses by saying, "*So helpful. I have an ICM, but this gives me real-time heart rate, which can be so important*.". It underscores the importance of the application in providing real-time heart rate information and emphasizes its usefulness in complementing existing medical devices. Moreover, a user notes, "*It's also proven useful in determining if new medication is helpful or not, being able to see changes over time in my heart rate*". This review supports the application's role in helping users assess the effectiveness of medication by allowing them to track changes in their heart rate over time.

Business Model and Monetisation (P6) refers to the ability to monetise through subscriptions and paid features and consists of the topic "Subscription". **Topic "Subscription"** focuses on different tokens, such as "ad", "free", and "premium". The user experience is articulated in a way that underlines the limitations of the subscription model, as one user notes: "*The device is fine, but nearly everything in the app is locked behind a subscription, including several 'types' of data reports*". Conversely, another user highlights the perceived value of a subscription: "*I like the additional information and support that a subscription offers, which is why I chose to pay for one*". This quote reflects the user's appreciation of the additional features provided by a subscription, juxtaposed with the observation that the device and app work well without it.

In a workshop with research colleagues, Volkhoff and Strong's (2017) proposals on Level of Awareness and the distinction between physical abilities and knowledge were discussed and applied to the identified patterns. The mapping of user-specific characteristics to the patterns shows that certain affordances are either perceived or hidden depending on the combination of knowledge and physical abilities as well as the respective level of awareness.The knowledge of a user can be different (e.g. user-specific characteristics) and determines how the app is used. Knowledge can consist of health literacy, technical skills, digital literacy, self-regulation skills and financial decision-making skills. Figure 3 shows that most patterns require a combination of health literacy, technical literacy and digital literacy. **P1** assumes a certain awareness of the possibility of storing and sharing medical data. While some users will actively search for these features, others will discover them during the usage process. The ability to use depends on the knowledge of exporting and comparing data and the physical ability to navigate within the application. **P2** requires a higher level of awareness for real-time monitoring and alerts. Users who are actively tracking their heart health often have a high level of awareness of the need for data collection. This requires an understanding of the importance of vital signs and the physical ability to take measurements and interpret the results. **P3** builds on this and requires the ability to evaluate health data independently. Users who compare their results with medical values demonstrate a high level of awareness and medical knowledge. **P4** varies in user experience: some discover the sensor function through use, while tech-savvy users question its accuracy. This shows different levels of awareness, while usability is influenced by physical interaction with the sensor technology. **P5** requires user awareness of interactive and personalised elements. Users with high system awareness optimise their use through targeted interactions, while others encounter technical barriers such as app crashes. **P6** shows dependence of the level of awareness on financial decision-making skills: users who are aware of the benefits of a subscription take advantage of additional features to monitor their health, while others are only aware of restrictions.

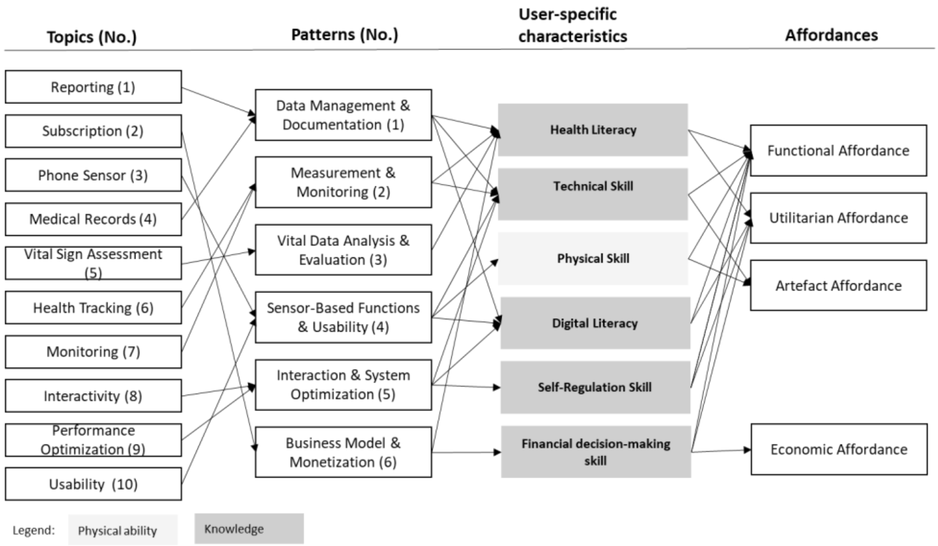

Figure 3: Consolidated results

5 Discussion

Our study contributes to the understanding of affordances in the context of monitoring and vital signs tracking apps for HF patients. Based on the results presented, the following implications for research and practice can be derived (see Table 2).

The use of topic modeling contributes to the further development of affordance theory. Affordances remain relational (Thapa & Sein, 2018; Volkhoff & Strong, 2017), but computational methods allow the systematic identification of recurring interaction patterns (Miranda et al., 2022). As Volkhoff & Strong (2017) suggested, this work attempts to answer the question of how capable users need to be to actualise certain affordances. It emerges that users must demonstrate different levels of knowledge and skill to perceive different types of affordance. Volkhoff & Strong (2017) recommend avoiding the term perceived affordances and instead speaking of the level of awareness of an affordance. The level of awareness may be artificially delayed because certain features of an application are hidden behind a paywall, such as a subscription model, so that the level of awareness of an affordance remains hidden to a user until they have unlocked all features.

In the works of Liu et al. (2021) and Guo et al. (2023), individual affordances were categorised as either empowerment or utilitarian. However, the aim of this study was to identify high-level types of affordances that can be derived from user reviews. When elaborating on affordances in heart failure monitoring apps in future, this paper recommends creating bundles of affordances and breaking them down into several levels of detail. For instance, 'monitoring' could be subdivided into 'collecting data', 'viewing data', 'detecting changes' and 'receiving notifications' (Volkhoff & Strong, 2017). Some of the identified user patterns are consistent with findings from the literature, such as Measurement and Monitoring (P2) and Vital Data Analysis and Evaluation (P3), which align with core functionalities found in user-centered app developments like the modular structure of HerzFit (Reimer et al., 2024). In the HerzFit project, personas were developed to guide the app’s design. In the future, the identified user patterns and characteristics may be used to enrich such personas and support more nuanced user modeling in early development phases. Chauhan et al. (2025) identify critical gaps in the current app landscape, particularly the lack of DACH-specific, interoperable, sex-sensitive, and evidence-based solutions for cardiovascular health management. The results show that affordances do not occur in isolation, but can be interdependent. This highlights the need to consider affordances not only relationally, but also in their temporal and functional sequence. During an interaction between user and application, several affordances can be perceived simultaneously (Volkhoff & Strong, 2017). For example, in order to perceive the usefulness of analysing and evaluating vital data, the functionality in the app must first be used. This shows that affordances can also be sequential and bundled (Mesgari et al., 2023; Thapa & Sein, 2018).

Developers should consider that affordances must be perceived to be used; essential features should therefore not be hidden behind paywalls if they are critical to medical benefit. User reviews can help identify overlooked or emerging affordances (Osch & Mendelson, 2011). Applications should offer mechanisms to gradually increase awareness of affordances, such as interactive tutorials or usage-based unlocks. While affordances may enable certain activities, they do not guarantee that these will occur (Markus & Silver, 2008). Usage patterns suggest that affordances often build on each other, making it important to guide users intuitively from one to the next. Varying levels of knowledge and physical ability require different interaction options—aligning with patients' desire for individualization and adaptation (Alnosayan et al., 2017; Bylappa et al., 2022).

As every research study has its limitations, so does this study. While topic modeling is not ideal for analyzing relational affordances, computational methods still provide valuable insights. Its effectiveness depends on data quality, with our coherence score of 0.5713 indicating moderate coherence. Interpretation and evaluation of themes also rely on the researcher. Additionally, user feedback fluctuates over time due to updates, bug fixes, and app advancements. Some of the research and practical implications were derived through interpretation of the data in combination with related literature. As such, they reflect plausible but not directly observable constructs (e.g., health or digital literacy) and should be considered exploratory in nature. Conducting semi-structured interviews with HF patients using these apps could have provided deeper insights into affordance awareness, revealing which affordances are actualized and which remain unperceived as intended by designers. This study only analyzed Google Play Store data, omitting potential differences from the Apple Store. Variability in review length and quality, as well as the lack of age, gender and socio-economic status, are further limitations.

Table 2: Main Findings and Implications for research and practice

Main findings:
Based on the analysed user reviews, a total of six patterns identified: Data Management and Documentation (P1), Measurement and Monitoring (P2), Vital Data Analysis and Evaluation (P3), Sensor-Based Functions and Usability (P4), Interaction and System Optimization (P5) and Business Model and Monetization (P6)
Implications for research
Future research should incorporate hidden affordances into analyses to better understand the factors influencing their perception and awareness.
Research should explore the interdependencies of affordances in terms of their hierarchical, sequential, and bundled nature.
Research should create detailed bundles of affordances in heart failure apps, breaking them down into granular levels.
Implications for practise and app development
Developers should design affordances to be easily perceivable and usable.
Developers should keep in mind that affordances often build on each other.
Depending on the level of knowledge and physical ability of users, developers should offer different interaction options to enable optimal use of affordances .

6 Conclusion

This study contributes to understanding patterns and affordances in cardiovascular disease through user reviews of monitoring and vital signs tracking apps. To answer RQ1, app reviews from the Google Play Store were analyzed using topic modeling, resulting in 10 topics from which 6 patterns were derived. Based on RQ2, 8 implications for research and practice were identified. The use of topic modeling demonstrates how affordance theory can be extended. Future studies could validate these findings through replication and qualitative research, such as interviews with heart failure patients, and integrate sentiment or cluster analysis to further explore how users perceive and engage with affordances.

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