

A review of sensemaking design elements: towards an affordances typology

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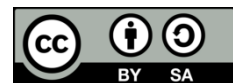
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ABSTRACT

This study explores the intersection of interaction design and sensemaking within digital systems, aiming to identify and categorize key affordances that enhance user sensemaking. Starting with a focused literature review, key design elements such as tagging and annotation are identified, important for effective sensemaking in interaction design. Drawing on Maier's construct of affordances, the behaviours of these design elements are analyzed to derive specific affordances integral to enhancing user experience. The primary objective is to develop a generalized affordance typology that supports sensemaking across various digital systems. This typology organizes the derived affordances into broad themes such as effortless discovery, expressive freedom, collaborative engagement, cognitive support, insight enhancement, and user empowerment. This typology serves as a tool for interaction designers, facilitating the application of these themes in various design scenarios to create more intuitive and effective digital environment for sensemaking.

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1. INTRODUCTION

Sensemaking is a vital activity in the interaction of users with digital systems, allowing individuals to understand and interpret information. Sensemaking can be defined as “the process through which individuals give meaning to their collective experiences” [1]. There are five distinct schools of sensemaking with five major research streams, including user studies, organizational communication, knowledge management, cognitive system engineering, and human-computer interaction (HCI) [2]. In digital systems, sensemaking is mainly mapped to the field of HCI, related to the interpretation of external data [3].

In the context of interaction design, this process is often supported by affordances, which can be defined as the actionable possibilities perceived by users based on the properties of digital elements and their own capabilities [4]. In HCI, the concept of design affordances, rooted in ecological psychology, explains how digital interface elements enable sensemaking. Although sensemaking research in HCI is extensive, few studies have specifically examined the affordances that best support this process. Existing works have, however, identified design elements that make sensemaking more intuitive in digital systems. This paper reviews such studies to extract key design elements, determine their associated affordances, and propose a generalized typology of sensemaking affordances applicable across digital platforms. Recognizing these affordances bridges user capabilities and system functions, guiding designers in creating intuitive and accessible environments that enhance users’ interpretation and understanding of information.

2. LITERATURE REVIEW

2.1. Design affordances

The term 'affordance' was first coined in ecological psychology to describe the actionable possibilities available to an agent in their environment [5]. In HCI, it was later redefined as the relationship between an object's properties and the user's capabilities, determining how the object can be used [4]. This perspective highlights how users interpret and interact with interface elements based on perceived possibilities, whether or not those actions were intended by the designer [6]. Subsequent studies expanded the concept, classifying affordances as cognitive, physical, sensory, functional, or emotional, each addressing different aspects of user interaction [7]. This framework has been instrumental in guiding designers on how to tailor user interfaces to better meet user needs and improve the overall user experience.

Beyond terminology and categorization, scholars have advanced affordance as a relational theory of design. Affordance-based design (ABD), introduced as part of engineering design methodology, contrasts with purely functional approaches by emphasizing the relationship between artifacts and users [8]. While aligned with Norman's artifact-user-affordance model, ABD broadens its scope from the "design of everyday things" to the "design of everything" [9]. Within this construct, one system may afford behaviour to another, as illustrated by the examples in Table 1 [9].

Table 1. Examples of affordances, systems, and behaviours

Affordance	System 1	System 2	Behaviour
Typability	Person	Keyboard	Typing
Turnability	Gear 1	Gear 2	Power transmission
Legibility	Person	Letters	Reading
Comfort(ability)	Person	Air conditioner	Cooling air
Sitability	Person	Recliner	Reclining
Clampability	Clamp	Loose objects	Clamping

2.2. Sensemaking in digital systems

Sensemaking is generally defined as the process through which individuals give meanings to situations [1]. In digital systems, especially concerning the field of HCI, the contribution was made by [10], where the focus of this sensemaking is on searching for representation and encoding data in digital tasks. According to this work, sensemaking is the process of choosing, using, and shifting between various cognitive and external resources that are available to a sense-maker in order to lower the costs associated with information processing [2].

In the early 1990s, sensemaking goal in HCI is to create and work with meaningful representations to support insights, and execution of intelligent actions [10]. With this in mind, this brand of sensemaking presented a recurring pattern in the form of 'Learning Loop Complex', focusing on system representation, information retrieval, and user interface design [11]. As shown in Figure 1, Russell's learning loop complex illustrates how users interact with representations and refine understanding over time.

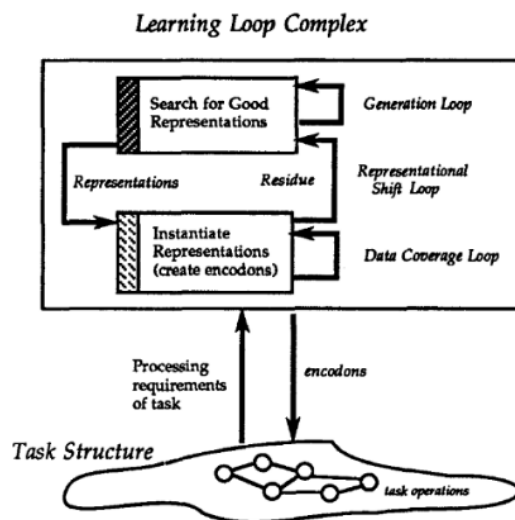


Figure 1. Russell's learning loop complex

An extension of the learning loop sensemaking model in HCI was proposed later in this work [10] where the process of shaping representation is discussed in two different loops: the foraging, and the sensemaking loop. In the foraging loop, user seeks and filters information, then reads and extracts information which might also include organizing them into schemas to aids analysis. Meanwhile in the sensemaking loop, user iteratively develop a mental model from the schemas that provide understanding of the data [12]. Figure 2 shows the sensemaking model with the foraging and sensemaking loop [12].

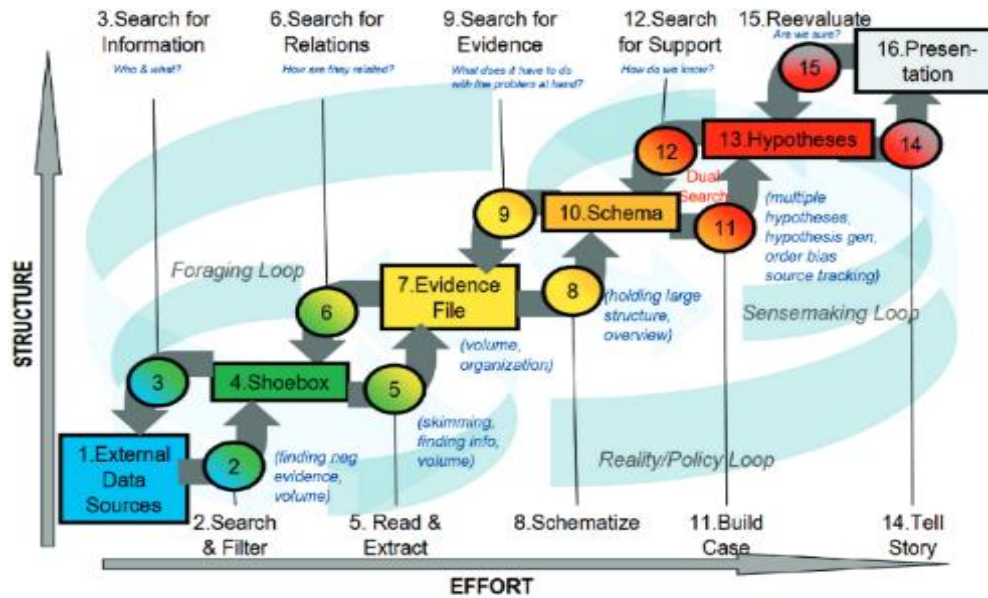


Figure 2. Pirolli and card’s sensemaking

2.3. Design affordances for sensemaking

Research in design affordances that support sensemaking is still developing and largely underexplored. Because the concept of affordance originates in ecological psychology, many derivations on this concept exist in many research areas not necessarily interaction design. In some works, ‘sensemaking’ is listed as an affordance, further muddling the effort of identifying affordances for sensemaking design. Table 2 summarizes affordances extracted from prior research focused on sensemaking in design contexts [13]-[15].

The limitation of identifying design affordances as presented in Table 2 does not reflect the amount of research that have been undertaken in designing for sensemaking. There are many research efforts initiated that uncovered design elements supporting sensemaking, many of which resulted in the development of sensemaking prototypes. Therefore, in this research a review of these research is undertaken, and the design affordances of the identified elements are subsequently derived.

Table 2. Summary of affordances identified in prior sensemaking-focused design studies

Affordance	Sensemaking focus	Source
Disruptive ambiguity and surprise		
Noticing and bracketing	Environmental sustainability	[13]
Open and inclusive communication		
Presumption and action planning		
Hypertextuality		
Retrievability		
Importance	Users of online news websites	[14]
Immediacy		
Convenience		
Genre		
Interactivity		
Noticing	Dashboard in learning analytics	[15]
Interpreting		

3. METHOD

The methodology of this research is designed to answer the following research questions: 1) What are the design elements identified in interaction design research as supporting sensemaking? 2) What are the affordances associated with the identified design elements? and 3) What sensemaking affordances typology can be synthesized from the associated affordances?

Figure 3 shows the methodology framework of this research. A search strategy was employed using Google Scholar academic database. The reason this platform is used is because it provides the largest coverage of published academic research [16]. The search terms used included 'sensemaking', 'interaction design', 'digital systems', 'design elements' and combinations thereof. Variations of spellings were also used i.e. both 'sensemaking' and 'sense-making'. The inclusion criteria for studies were those that specifically addressed the implementation of design elements in digital systems aiming to support sensemaking.

Upon identification of these design elements, another database search was conducted to derive the affordances associated with them, combining the identified elements with 'affordances' as the search terms. Finally concept synthesis of the derived affordances is conducted for the uncovering of the affordances typology, a generalized list for embedding sensemaking in digital systems.

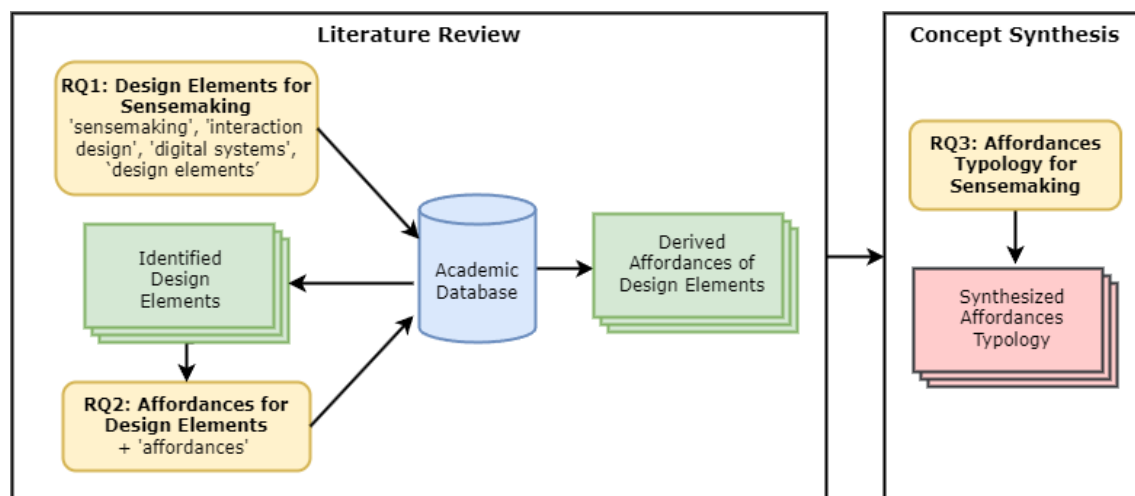


Figure 3. Research methodology framework

4. FINDINGS

4.1. Design elements for sensemaking

4.1.1. Tagging

Tagging refers to the process of users adding descriptive keywords or tags to digital content such as images, videos, or articles, to facilitate content organization and retrieval [17]. Users can click any tag and be brought to all contents tagged the same. While social tagging originally has been used for personal collection of items, it has been integrated into systems mainly personalized recommendations, such as retrieving music based on moods [18]. Tagging is said to be well-accepted due to several factors such as allowing personal bookmarking, supporting knowledge discovery and retrieval, low barrier to participation, and reflecting conceptual structure of community [19]. Social tagging brings about the arising of folksonomy, and has been hypothesized to support sensemaking since it first gained prominence in the days of Web 2.0 [20]. This is because social tagging gives rise to collective intelligence, in the form of user-generated tags that facilitates the categorization and description of online content, thereby aiding individuals in making sense of the vast amount of information available on social media and other online platforms [21].

As the process of social tagging allows users to label and categorize content based on their own interpretations and understanding, it aligns with the mechanism of bracketing and labelling, and so the way in which content is labelled influences how individuals comprehend and utilize the information in their interactions and activities [22]. Sensemaking as supported by social tagging has been described as semantic stabilization of tags used, demonstrated by emerging consensus on particular terms over time [23]. Collaborative tagging of group chat has also been discovered to help support sensemaking of large conversations [24].

4.1.2. Annotation

Sensemaking can also be supported by system designs that support annotations, a concept closely related with tagging. Early studies on facilitating sensemaking in user interfaces have demonstrated that measurable learning gains can be achieved through access to social annotations made by others [25]. Comments, ratings (votes and numbers), and tags are examples of annotations. Catseye is a lightweight annotation tool used within an integrated development environment (IDE), which allow developers to annotate their code to enhance sensemaking when completing debugging tasks [26]. In another research, annotation practices, combined with multimodal data including telemetry, video, and conversation were helpful in ideation and developing context for research in the wild [27]. Annotations such as ratings and reviews is also considered as part of human-human data for recommending contents such as movies [28].

4.1.3. Collecting and organizing

Designs elements that support users in collecting and organizing are said to enhance sensemaking. SenseMap, a browser-based online sensemaking tool that was designed based on Pirolli and Card's sensemaking theory help users to collect and curate information from the web, which can then be curated that essentially signifies the sensemaking process [29]. Meanwhile, ForSense is a sensemaking tool that starts the process by supporting users in the foraging process of collecting information, and enhance the sensemaking phase by integrating machine learning [30]. Digital curation is an interest field of many researchers. There are many web services that provide tools for collecting online content for digital curation, and one of the most noted is Pinterest, with 322 million monthly active users [31]. Content curation is closely associated with sensemaking, where it is deemed as the central process, and adds value to the content [32].

4.1.4. Collaboration and sharing

Collaboration and sharing are important in enhancing sensemaking, particularly in information-rich environments. The integration of collaborative tools and platforms facilitates the combination of diverse perspectives, enabling a collective approach to information understanding and decision-making. Collaborative tools such as shared digital workspaces play a substantial role as non-human actors in the sensemaking process and influence the co-constructed meaning of participants [33]. For example, crowd synthesis was a tool developed to allow crowds to extract categories and clusters from data collaboratively by scaffolding expertise for novice crowd workers and creating consistent categories [34], and CrowdTrace introduced a crowd auditing step to a crowdsourced distributed analysis [35]. Affordances that support collaboration and sharing may include shared whiteboards, video conferencing [36], and virtual sticky notes [37] among others. These affordances not only democratize the sensemaking process but also ensure that diverse viewpoints are considered, leading to more inclusive outcomes.

4.2. Affordances of design elements for sensemaking

The five design elements purported to support sensemaking as identified from the review above include tagging, annotation, visualization, collecting and organizing, and collaboration and sharing. This list is not claimed to be exhaustive, but it serves as a starting point as they have been consistently highlighted in the literature as key components that facilitate the process of sensemaking, providing users with the tools to manage and interpret complex information effectively. In order to derive the affordances associated with the design elements above, behaviours of these elements as described in the related literature are listed, influenced by affordances construct of Maier as shown previously in Table 2. Table 3 shows the design elements, their behaviours, and affordances mapped to them derived from literatures. By understanding the behaviours of these elements, the mapping of affordances with the selected designs is more intuitive. Inspired by Maier's construct, this approach attempts to be scholarly rather than deviating from established principles.

Table 3. Derived affordances mapped from identified design elements and behaviours

Design element	Behaviour	Affordance
Tagging	Adding descriptive words to content [17]	Freely describing content [38] Knowledge representation [39]
	Tag click-through [40]	Resource discovery [41]
Annotation	Arising folksonomy [20]	Community knowledge [42]
	Content recommendation [28]	Decentralize control from BigTechs [43]
Visualization	Note annotations [26]	Externalizing thoughts [44]
	Show visual representations [45]	Supporting new insights [46] Providing situation awareness [47]
Collecting and organizing	Curate web content: bookmark, clipping, drag and drop [48]	Externalizing users' memory [48]
Collaboration and sharing	Shared spaces: whiteboard [36], sticky notes [37]	Co-create meaning [33]

4.3. Affordances typology for sensemaking

From the five identified design elements, eight design behaviours and ten associated affordances have been derived. While these affordances are well-aligned with the specific design elements and behaviours shown in Table 3, the goal of developing a robust sensemaking affordance typology requires a further generalization and distillation of these affordances. To achieve this, a concept synthesis process is undertaken, merging some of the individual affordances into broader, more generalized themes. Table 4 shows the results of this effort.

This table presents a generalized affordance typology that categorizes ten specific affordances into six broader themes. The consolidation of these affordances into these typologies enhances their applicability and relevance across various design contexts. This typology offers flexibility to be mapped onto new design elements or interactions. For example, while the 'effortless discovery' typology is originally derived from the affordance of resource discovery typically associated with tagging, it can readily be applied to design elements such as text auto-complete, enhancing the user's ability to quickly access information and supporting their sensemaking.

While this typology is derived strictly from literature focused on design affordances within interaction design, recent studies on algorithmic systems and misinformation [49]-[51] raise important questions about how users make sense of information in increasingly complex digital environments. These studies, though outside the scope of the typology's derivation, highlight potential application areas for future research, particularly in evaluating how affordance structures may support user agency, critical interpretation, and resilience against algorithmic bias and misinformation.

Table 4. Affordances typology for sensemaking

Affordances typology	Derived affordances of design elements	Explanation
Effortless discovery	Resource discovery	Facilitates easy and rapid access to necessary information, streamlining the discovery process for users.
Expressive freedom	Freely describing content	Allows users to freely express and categorize content, emphasizing user autonomy and reducing barriers to entry.
Collaborative engagement	Community knowledge, co-create meaning	Encourages active participation, knowledge sharing, and collaborative content creation within a community, fostering a collaborative environment and promoting shared understanding.
Cognitive support	Externalizing memory, externalizing thoughts,	Aids in offloading and retrieving information and structuring thoughts, effectively supporting memory recall and enhancing clarity in complex problem-solving, thus reducing cognitive load.
Insight enhancement	Supporting new insights, providing situation awareness, knowledge representation	Promotes the generation of new perspectives and deeper understanding through advanced visualization and data analysis tools.
User empowerment	Decentralizing control	Increases user control over digital interactions, promoting independence and personalized experiences in navigating and managing content.

5. CONCLUSION

This study reviews design elements that support sensemaking in digital environments to identify key components and their affordances. Elements such as tagging, annotation, visualization, organization, and collaboration were analyzed through Maier's affordance construct, resulting in ten affordances that were generalized into a typology comprising effortless discovery, expressive freedom, collaborative engagement, cognitive support, insight enhancement, and user empowerment. The typology highlights how design elements facilitate sensemaking and offers a practical guide for developing intuitive, user-centered digital systems. While the review was not exhaustive and the typology remains to be empirically validated, it provides a foundational framework for exploring how design can enhance sensemaking. Future research should assess its applicability through user studies and real-world implementation especially through digital contexts.

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C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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