Designing Responsive GUIs

AN INTELLIGENT INTERFACE THAT TAILORS INFORMATION PRESENTATION BY RESPONDING TO A USER'S COGNITIVE STATE

RACHAEL L. PAINE

Submitted in partial fulfillment for the degree of **Master of Graphic Design** / May 18th, 2018
Department of Graphic and Industrial Design / College of Design / North Carolina State University

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Deborah Littlejohn, PhD • Assistant Professor • *Committee Chair*

Matthew Peterson, PhD • Assistant Professor • *Committee Member*

Scott Townsend • Associate Professor • *Committee Member*

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/ to Denise
You told me to jump—
starting this adventure. I'm grateful.

/ to Phillip + Isaiah
You watch—which makes me
do great stuff.

/ to Kelley, Dajana, Bree + Laura
You bridge the fiery fence so I can
escape the foggy haze. Thanks for that.

/ to Edward
It's definitely a story.

/ to Deb
I couldn't have done it without you.

It takes a village.
Or, in my case, nine kick-ass individuals.

CONTENTS

ABSTRACT

A person faced with caring for a loved one with a serious health diagnosis has an immediate thirst for knowledge, even while their cognitive ability to find—let alone comprehend—useful information may be hindered due to their traumatized, high-stress mental state. The design of most online health information search platforms do not consider the cognitive state of this type of user, even though new technologies, such as machine learning and artificial intelligence, have the potential to offer personalized support for this particular information-seeking circumstance. The design of standard search tools and features encountered on ordinary health information websites typically take a one-size-fits-all approach.

The objective of this study is to determine how intelligent human-computer interfaces can present information in meaningful and clearly comprehensive ways by responding to the health information-seeker's cognitive state—in particular, for someone who is under duress from a recent medical diagnosis. In this study, cognitive state refers to the psychological and emotional state of the user. Methods included semi-structured qualitative interviews with 20 patient advocates from the NC Rare Disease Council and subsequent prototype testing. Data suggests that people under duress prefer that complex health information be presented in a minimal (i.e., simple content structure) fashion using assistive delivery strategies such as withholding, gathering, and prioritizing. This project suggests a useful framework for professionals involved in the design of medical information search tools, user-centric design methods, and intelligent interface design.

SECTION ONE

THE CONTEXT

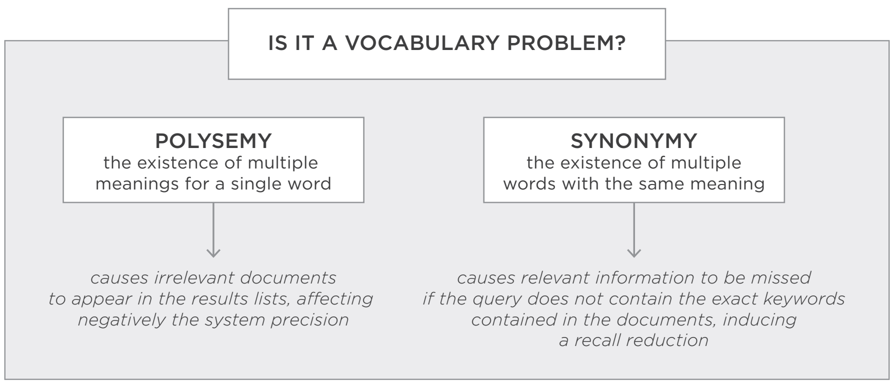


FIGURE 1.1 *The above chart represents the vocabulary problem in human-system communication as presented by Furnas, Landauer, Gomez and Dumais (as cited in Micarelli et al., 2007).*

AREA OF INVESTIGATION

This project centers around an activity ubiquitous in our everyday life—searching the Web. Today's Web user relies heavily on search engines for their information needs. According to Wilson *(2012)*, "search user interfaces (SUIs) represent the gateway between people who have a task to complete and repositories of information and data stored around the world." As the information available on the Web continues to expand, traditional search engines struggle to meet user's demands for effective and efficient searching *(Micarelli et al., 2007)*.

Users search the Web through a few seemingly simple steps. They formulate a query (keyword search), wait for the results, and sift through them. Sometimes the results meet user expectations, but often they do not. The more specific a query, the more relevant the results. Language nuances can make it challenging to choose precise wording when developing a query (**Figure 1.1**). The trial and error process of entering queries, waiting for results, and sifting through them can be time-consuming and frustrating when the results fail to meet user expectations.

According to numbers from the Pew Research Center's Internet and American Life Project, 72% of internet users say they have looked online for health information within the past year. Such a figure indicates peoples reliance on the Web for health information. Researchers at Microsoft Research Lab Redmond have studied challenges of health-related Web searching. Their research shows that the content of Web search result pages contributed to heightened anxiety in the user *(as cited in McGee, 2008)*.

For this project, I am interested in a very particular health information-seeking circumstance. I am considering a parent faced with the devastating news of having a child diagnosed with a serious, life-threatening rare disease. A parent in this circumstance has an immediate thirst for knowledge concerning the medical condition and how to manage care moving forward. Having access to large quantities of information is an essential part of overseeing care. Receiving and interpreting this information, and subsequently taking timely action, will provide their child with opportunities that could potentially extend life and health.

The number of factors that come into play in the care and support of the recently diagnosed child creates a tremendous need for understanding complex medical information. As the parent begins to seek this information, their cognitive ability to find—let alone comprehend—it may be hindered due to their traumatized, high-stress mental state.

Stressed mental states affect a person's cognitive function. Per Dr. Vincent Covello from the Center for Risk Communication, stress and mental noise can reduce the ability to process information by up to 80%. Cognitive stress responses also include a reduced ability to concentrate, think clearly, and remember information *(Health psychology, n.d.)*. These statistics point to a need to address the traumatized user with functional interfaces and site features that will maximize their ability to search for, navigate, comprehend, remember and apply needed information.

The design of most online health information search platforms do not consider the cognitive state of this type of user. The design of standard search tools and features encountered on ordinary health information websites typically take a one-size-fits-all approach.

New technologies, such as machine learning, augmented intelligence, and data fusion have the potential to offer personalized support for this particular information-seeking circumstance. As designers, this is exciting news! Computers are no longer dumb boxes that limit the types of interactions we can facilitate through designed interfaces. Computers can learn about us. We can begin to see past the technological limitations requiring one interface for all users and instead create one interface which will adapt to each individual.

SEARCH USER INTERFACE (SUI)
the means through which a human interacts with online search systems to find information

QUERY
the technical name for the search keywords input by a user into an SUI

JUSTIFICATION

The proposed project builds on three areas of growing strategic importance to the field of design and visual communication. Human-centered design practices informed by principles from non-design disciplines is one area that has already become a regularized strategy related to graphic design, such as user experience design (UXD) and human-computer interaction (HCI). Being 'human-centered' in design practice implies much more than merely putting users at the center of design effort; it requires that designers deeply understand the users of design as people—including not only wants, needs, behaviors, emotions, and contexts of use, but the physical, socio-cultural, and psychological processes that drive them. This sort of deep knowledge demands that graphic designers inform their work using research from non-design disciplines such as cognitive psychology, anthropology, computer science, and economics, among others. This project and its subsequent documentation could be an informative example for designers looking to incorporate multi-disciplinary research informing their work.

Concurrently, the graphic design field has recently acknowledged the importance of understanding data-driven business processes for maintaining its professional relevance. Contemporary businesses collect and use various types of data as an essential strategic decision-making resource. Specifically, the design of online products and services that graphic designers help produce are informed by such informatics, in that intelligent features and tools are embedded for customers, who, in turn, customize them to fit their own specific needs. Designers need to understand how this data-driven customization process works, requiring not only human-centered approaches, but basic knowledge about data itself.

As the world becomes increasingly oversaturated with data, users need tools for finding patterns in big data through customized information searches. This project will aim to meet the user's desire for data-aware tools that read and learn from their behavior while allowing for adaptive and personalized ways of consuming and delivering information.

HUMAN-CENTERED DESIGN
a design and management framework that develops solutions to problems by involving the human perspective in all steps of the problem-solving process

USER EXPERIENCE DESIGN (UXD)
the process of creating products that provide meaningful and relevant experiences to users

HUMAN-COMPUTER INTERACTION (HCI)
researches the design and use of computer technology, focused on the interfaces between people (users) and computers

BIG DATA
a term that describes the large volume of data – both structured and unstructured

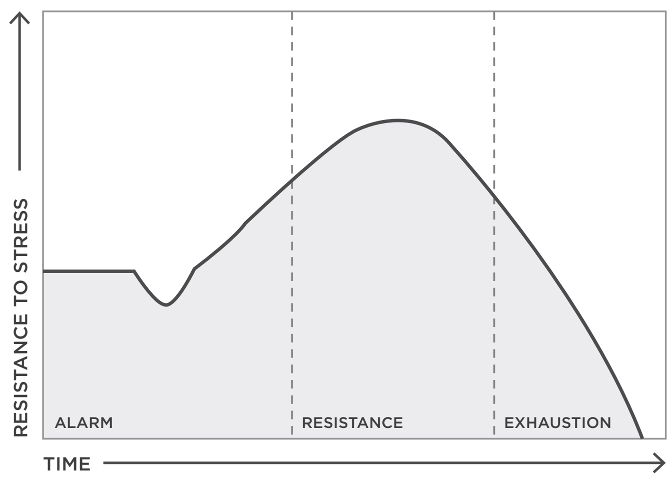


FIGURE 1.2: *Psychologists define stress as how the body reacts to a stressor. Acute stressors affect an organism in the short term and chronic stressors over more extended periods of time. The general adaptation syndrome (GAS) is a profile of how organisms respond to stress. Three phases characterize GAS: (1) ALARM: a nonspecific mobilization phase, which promotes sympathetic nervous system activity, (2) RESISTANCE: a resistance phase, during which the organism makes e orts to cope with the threat, (3) EXHAUSTION/RECOVERY: and an exhaustion phase, which occurs if the organism fails to overcome the threat and depletes its physiological resources.*

FIGURE 1.3: *Stress and mental noise can reduce the ability to process information by up to 80%.*

CONTEXT + CONDITIONS

STRESS + COGNITION

In this study, I am questioning how intelligent human-computer interfaces can present information in meaningful ways, responding to the health information-seeker's cognitive state. A caretaker's stress level will fluctuate from the moment of diagnosis through the period in which they continue to manage care. Subsequently, the responses they require from an adaptive system will shift as well.

To begin this investigation, I looked at how stress affects the user's cognitive state. In this study, cognitive state refers to the psychological and emotional state of the user. The following theories and researched principles will help guide the development of information delivery tools.

Stress is a state of mental or emotional strain resulting from adverse or demanding circumstances. Along with emotional and behavioral responses, psychologists recognize that people experience cognitive changes when faced with taxing situations. These responses include a reduced ability to concentrate, think clearly, and remember accurately. Stress also hinders decision-making skills *(Health psychology, n.d.)*.

Changes at the physiological level have been shown to be closely related to cognitive performance. To better understand the physical reaction to stress, I referred to **Hans Selye's General Adaptation Syndrome (GAS) Theory of Stress** *(as cited in Rosch, n.d.)*. Three stages characterize the general adaptation syndrome—alarm, resistance, and exhaustion (Figure 1.2).

Physical and psychological changes tend to occur together, and one response can trigger the other *(Health psychology, n.d.)*. Chamberlain, Muller, Blackwell, Robbins, and Sahakian *(as cited in Palacios-Garcia et al., 2017)* have shown that extreme stress may impair working memory—the part of a person's cognitive system responsible for temporarily holding information available for processing. Dr. Vincent Covello from the Center for Risk Communication concurs. Covello's **Mental Noise Theory** states that stress and mental noise can reduce the ability to process information by up to 80% (Figure 1.3). Working memory is also essential for reasoning, decision-making, and linguistic processing *(Malenka et al., 2009)*.

In addition to negatively affecting the processing of information, Eysenck and Calvo have documented how stress affects task performance by preempting the storage capacity of the working memory system. **Processing Efficiency Theory** (Figure 4) describes how stress impairs efficiency rather than effectiveness when completing a cognitive task *(Eysenck et al., 2007)*. For example, a caregiver may be able to find and understand essential information regarding a rare disease, but it will require additional effort.

Eysenck and Calvo joined with Derakshan and Santos *(2007)* to develop **Attentional Control Theory** which examines how anxiety and stress may affect attentional control and cognitive performance. This theory states that when stress levels are high, goal-oriented attention—the capacity a person has to choose what they pay attention to—is impaired. It then takes above average willpower to complete tasks.

In review, the above research indicates that stress affects cognition in the following ways:

/ Reduced the ability to concentrate, think clearly, and remember accurately
/ Hindered decision-making skills
/ Impaired working memory
/ Reduced the ability to process information
/ Impaired reasoning and linguistic processing
/ Increased the efforts required to complete cognitive tasks
/ Reduced the ability to pay attention

STRESS
a state of mental or emotional strain or tension resulting from adverse or very demanding circumstances

COGNITIVE STATE
a person's thought processes and state of mind, their psychological and emotional state

WORKING MEMORY
the part of short-term memory that is concerned with immediate conscious perceptual and linguistic processing

/

When attempting to gather information to aid an important decision...this chaotic atmosphere can prove paralyzing.

Liese Zahabi (2010)

/

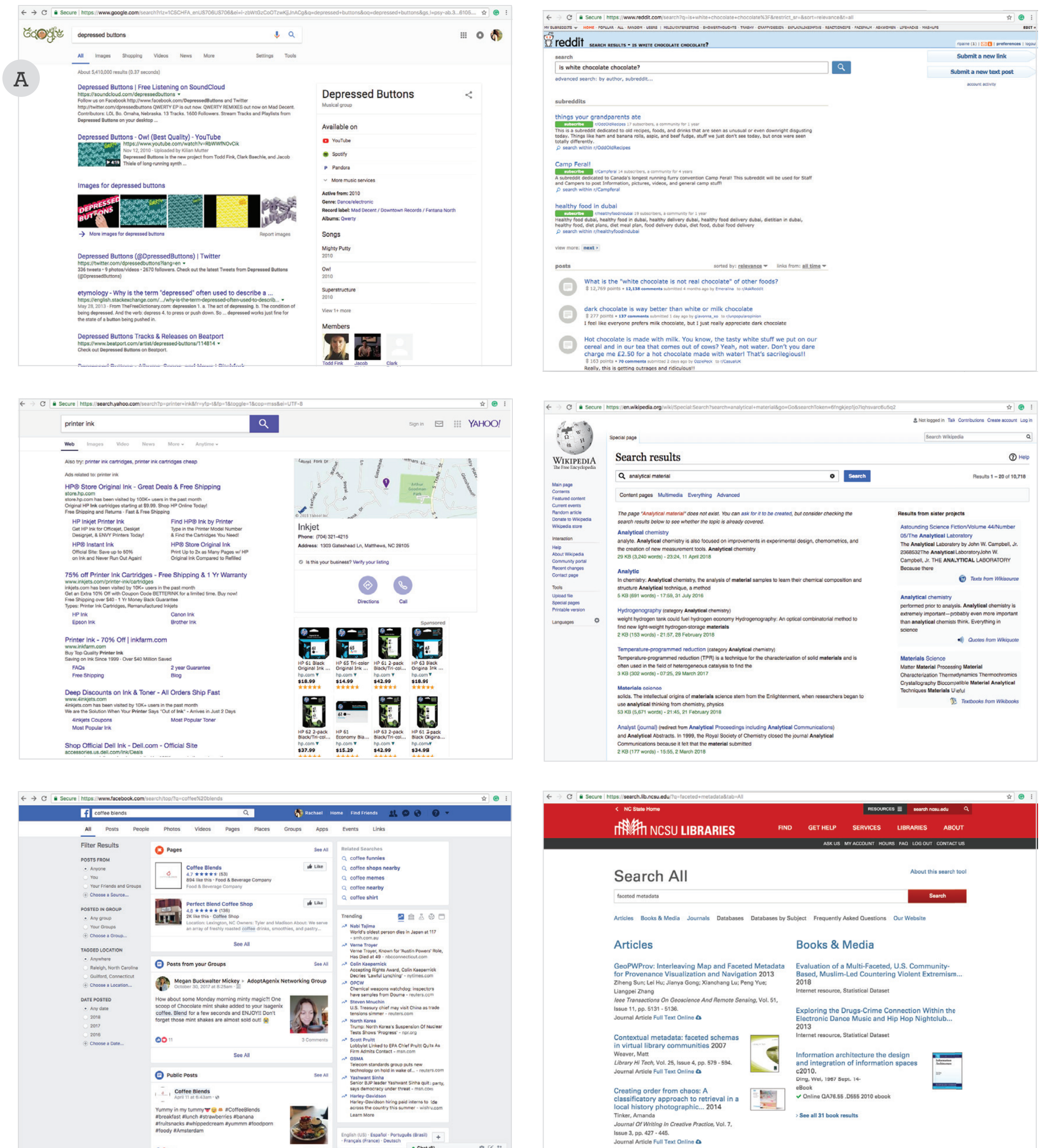


FIGURE 1.4: *Above are screenshots various search results for the following queries (from top left to bottom right): Google "depressed buttons", Reddit "is white chocolate chocolate", Yahoo "printer ink", Facebook "coffee blends", Wikipedia "analytical material", NCSU Libraries "faceted metadata." Retrieved on April 21, 2018.*

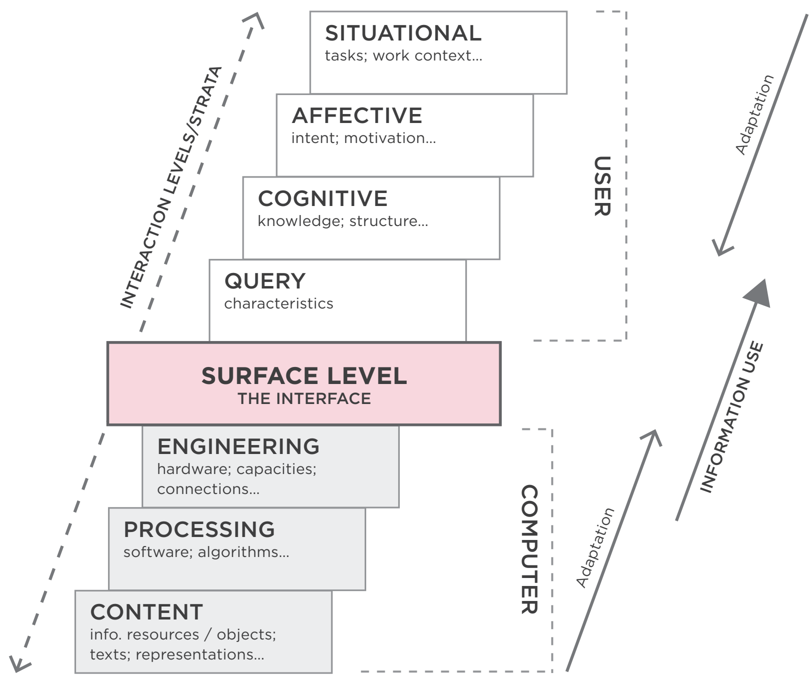


FIGURE 1.5 *(adapted from Saracevic's "Stratified Model of Information Retrieval Interaction"): Saracevic's (as cited in Wilson, 2012) layered model of interactive interface retrieval, where the user interface is influenced by factors of the users and of the technology. The user and the system are both participating in the process of information retrieval, meeting at the interface level.*

CURRENT TECHNOLOGIES

As the act of searching the Web for information is so ubiquitous in our everyday lives, it is difficult to find a person who hasn't experienced the frustration of poor search user interface (SUI) performance. Examples of frustrating experiences range from queries resulting in irrelevant results to overwhelming and exhaustive search engine result pages. See screen A in Figure 1.4 as an example of irrelevant query results. I entered the keywords "depressed buttons" hoping to find images and/or instructions for designing an interface navigation button. Instead, I received information regarding a band named Depressed Buttons. See all examples in Figure 1.4 of overwhelming search engine result pages. Users have grown apathetic to this try-and-try-again inefficient system as it is necessary to meet our information needs.

An SUI is where searchers and technology meet *(Wilson, 2012)*. Current experiences of search systems operate along asymmetrical, one-way, communication channels. While the computer is continually sending messages regarding its status to the user, it is unable to detect the user's status or condition *(Gettinger et al., 2003)*. As Picard *(as cited in Hettinger et al., 2003)* stated so clearly, "People express their frustration to the computer, but it cannot see it or do anything about it." This asymmetry limits the computer's ability to deliver meaningful experiences to the user.

According to Rieh and Xie *(2005)*, "A significant problem of Web searching is that most interactions take place on the surface level only (Figure 1.5). In the current design of Web search engines, the system has no effective way to understand the user's cognitive, affective, and situational levels...the user and the system meet only on the surface or interface level interacting through queries and results displayed."

SEARCH ENGINE RESULTS PAGE (SERP)
the page displayed by a Web search engine in response to a query by a searcher

The display of results does little to help the situation. Search engine result pages are crowded, employ limited hierarchy of information, and provide little navigational cues for the reader. The current user experience of online searching for information is less than ideal. Frustrating for any user, this experience can be particularly detrimental to a user in a sensitive cognitive state. Until we begin to reimagine these technologies, designers will fail to meet the needs of individual users.

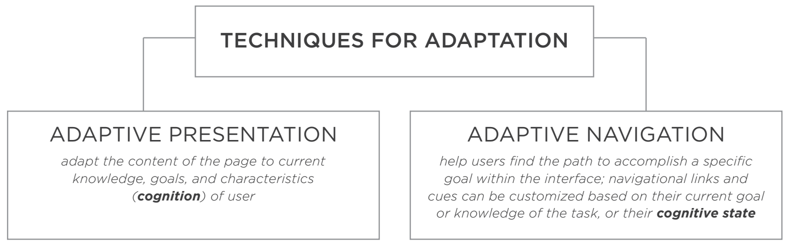


FIGURE 1.6: *Two Major Techniques Used for Adaptation according to Krish Ramachandran (2009).*

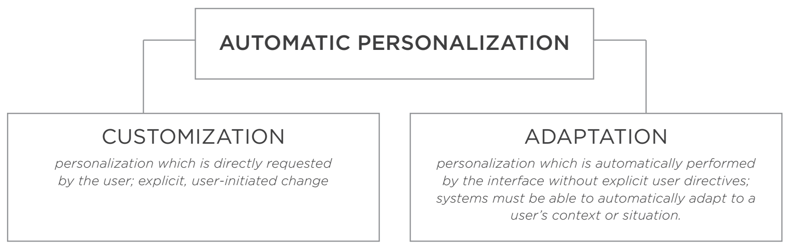


FIGURE 1.7: *Two Methods for Automatic Personalization according to Daniel S. Weld, Corin Anderson, Pedro Domingos, Oren Etzioni, Krysztof Gajos, Tessa Lau, and Steve Wolfman (2003).*

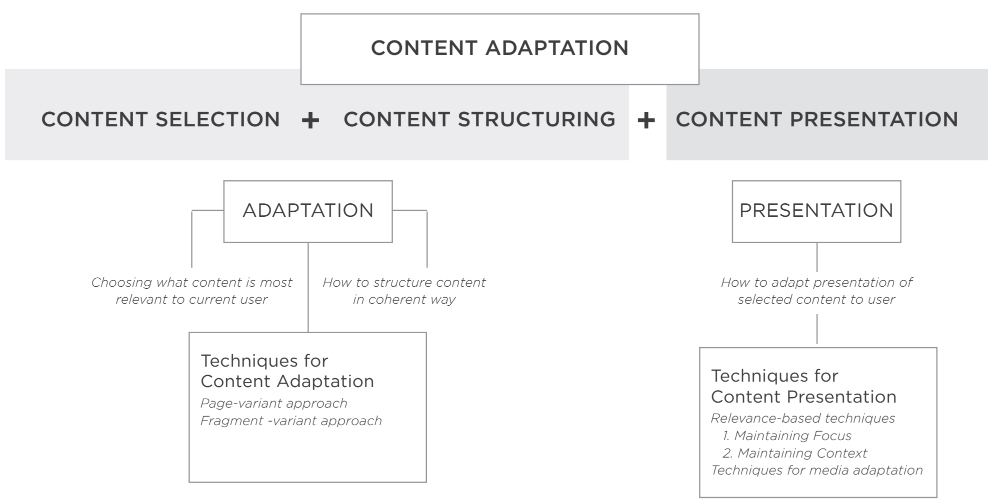


FIGURE 1.8: *Bunt, Carenini, and Conati (2007) describe adaptive presentation of content and how to present web-based content to best suit the individual users' needs.*

NEW TECHNOLOGIES

The previous section described the limited affordances of current technical systems to meet the demand of today's information-seeker. As the information available on the Web rapidly expands, and technologies continue to increase in functional complexity, users will continue to experience problems meeting their goals and intentions. "Errors occur, frustration mounts, workload soars unnecessarily" *(Hettinger et al., 2003)*.

One potential means of addressing this problem is to employ the emerging technologic landscape available to today's designer. Smart technologies—such as machine learning, augmented intelligence, and data fusion—offer designers the potential to develop seamless, responsive user experiences moving forward.

Designers can create interfaces that read and respond, in real time, to the user's situational, affective, and cognitive states. By designing responsive GUIs, we have the opportunity to bring to life search systems that read and learn from user behavior, continually customizing and improving the experience as a user interacts. New technologies expand designers capacity for creating human-centered digital communication environments, offering diversified methods for users to interact with information. Technology systems begin to serve as supportive communicators rather than ill-equipped machines.

For this project, I am using a definition for adaptive interfaces written by Hettinger, Branco, Encarnacao, and Bonato *(2003)*. An adaptive interface is one which can modify its response to meaningful variations in the user's cognitive and/or emotional state. "The purpose of these modifications is to promote safer and more effective human-machine system performance."

Several concepts, definitions, and techniques regarding adaptive technologies informed my project. See Figures 1.6, 1.7, and 1.8 for visual diagrams of a few of those concepts.

MACHINE LEARNING
using statistical techniques to give computer systems the ability to "learn" with data in place of being programmed

AUGMENTED INTELLIGENCE
the use of information technology in augmenting human capabilities

DATA FUSION
integrating multiple data sources to produce more accurate and useful information

ADAPTIVE INTERFACES
a user interface which changes to meet the needs of each individual user based on some meaningful determinant

We were given no information at all when [our daughter] was diagnosed. I asked the doctor...he said I should Google it when I got home. It was terrifying.

Parent of a Child with Idiopathic Intracranial Hypertension (RDUK, 2016)

USER IN CONTEXT

A well-designed user interface facilitates effective communication between the user and the technology system. Establishing a clear understanding of the user is essential. Goals, knowledge level, and behaviors are distinguishing characteristics of an individual user. The purpose of an adaptive interface is to address diverse users at various cognitive states, with different knowledge levels, having different past experiences with an interface *(Ramanchandran, 2009)*.

To better understand the primary caregiver of a child recently diagnosed with a serious rare condition, we must first understand the context of rare diseases. The National Institutes of Health (NIH) defines a rare disease as one that affects fewer than 200,000 people. The word "rare" infers these conditions are uncommon. However, there are over 7000 classified rare diseases and more than 300 million people worldwide currently diagnosed. Rare diseases are chronic and often life-threatening. A diagnosis of this magnitude is sure to shake the world of a parent.

Information plays a crucial role for this parent, and often this information is difficult to acquire. According to a survey conducted by Rare Disease UK (RDUK), 70% of people reported feeling they had not received sufficient information on the condition following diagnosis. One parent stated, "if it wasn't for the internet, I would know nothing about [the condition]."

With parents being left to research their child's medical condition without assistance, 35% of respondents indicated that they struggled to understand information about the rare disease. Another parent reported, "Having to search for all the information myself has led me to various levels of misinformation which has only added to my stress."

Being able to access and understand information regarding their child's condition is essential for a parent to make informed decisions about care and treatment.

RARE DISEASE
In the United States, a rare disease is defined as a condition that affects fewer than 200,000 people

Even a single user will require different features of an interface depending on the context and time of use *(Weld et al., 2003)*. It is important to note the dramatic fluctuations could potentially occur in this particular user. First, there will be a variance in mental states from moments of extreme trauma and stress to moments of increased calm acceptance. These will likely ebb and flow. Many of my design prototypes are considering the parent who is recently traumatized by the diagnosis and therefore I am inferring a high-stress state. Second, there will be a natural fluctuation of user proficiency with an interface. This scale will run from novice to expert and the user will most likely only travel this path once, with small setbacks when they are away from the system for extended periods of time.

LIMITATIONS + ASSUMPTIONS

LIMITATIONS

/ Caregivers face a wide array of issues when making decisions about the care of a child diagnosed with a rare disease. This project is concerned mainly with information-seeking behaviors related to gaining medical, social, and financial information. The goal was to discover methods and features to optimize the customization of such tools.

/ This project was focused only on caregivers who need community support and information; however, readers can imagine how the design of intelligent information-seeking features and tools could be applied to other end-user types, such as physicians, medical researchers, and clinicians. Relatedly, this project is not concerned with the highly specialized technical knowledge required to study rare diseases or develop cures and treatments. Nor does it consider the highly technical expertise required to program and code intelligent features and tools. Prototypes are visualized in terms of detailed 'snapshots' that indicate contexts of use.

ASSUMPTIONS

/ With new technologies, such as machine learning, augmented intelligence, and data fusion, the prototypes in the investigation are technologically feasible. These emerging technologies will affordably allow large-scale system adaptations in the near future.

/ The caregiver has average technology, internet use, and research/information-seeking skills. They have an interest in being very involved in the health decision-making processes for their child and feel a responsibility to conduct searching to inform those decisions.

/ The child's diagnosis of the rare disease will cause significant stress on the caregiver.

/ Health information-seekers in a high-stress cognitive state would prefer a search interface that assists with the searching and adapts the delivery and consumption of information.

/ As users are familiar with the current search engines' interface, it is best to perform the adaptive features within that familiar space to limit difficulty of user or stress for exposure to new technology. For this reason, I designed the investigations as GUIs rather than another option, such as a gestural interface, touch user interface, or voice user interface.

SECTION TWO

THE INVESTIGATION

RESEARCH QUESTION

How can the design of a ***responsive graphical user interface*** *(GUI) for an online* ***data repository*** *adapt to different* ***cognitive states*** *of primary caregivers who are engaged in* ***information-seeking*** *and* ***knowledge-acquisition*** *search processes to learn about a dependent's medical condition?*

How can the design of search tools that interpret and learn from user search behavior allow for adaptive and personalized ways of delivering and consuming information according to the user's cognitive state?

How can a suite of information navigation aids respond to a caregiver's shifting cognitive state as s/he acquires and archives information culled from multiple sources about a dependent's medical condition?

How can the design of interface search features track knowledge acquisition progress to serve as an ongoing personal reference tool as a user gradually learns and adapts to their changing medical, professional, and social situations?

How can the design of a responsive interface assist non-experts in developing expert research behaviors that aid in effective and autonomous decision making?

How can a data-aware notification system alert users to changes in information and knowledge in both just-in-time and over-time delivery approaches?

RESPONSIVE INTERFACE
a user interface which responds to the needs of each individual user

GRAPHICAL USER INTERFACE (GUI)
a visual way of interacting with a computer using items such as windows, icons, and menus, used by most modern operating systems

DATA REPOSITORY
a database holding consolidated data from various sources

COGNITIVE STATE
a person's thought processes and state of mind, their psychological and emotional state

INFORMATION-SEEKING
the activity of attempting to obtain information in both human and technological contexts

KNOWLEDGE-ACQUISITION
the process of extracting, structuring and organizing knowledge

FIGURE 2.1: *Mental Noise Theory states that Stress and mental noise can reduce the ability to process information by up to 80%.*

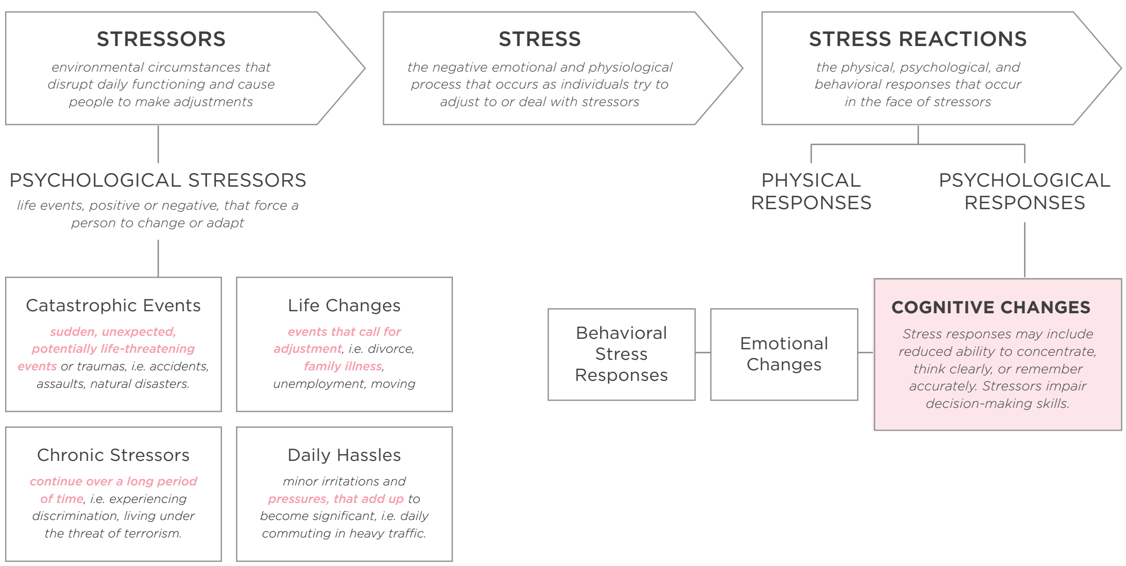


FIGURE 2.2: *A concept map defining stressors, stress, and stress reaction. Pink highlights are indicated as areas most applicable to the rare disease context.*

LITERATURE REVIEW

This literature review briefly touches on the most relevant texts categorized under the broad research categories of stress and cognition, search engines, navigation, and adaptive interfaces. Where appropriate, readers will find additional highlights from the literature near the prototypes which it informed.

SUBJECT ONE

STRESS + COGNITION

KEYWORDS:
Risk Communication, Mental Noise Theory, Negative Dominance Theory, Trust Determination Theory

General Adaptation Syndrome (Gas), Health Psychology, Post traumatic Stress Disorder (Ptsd), Social Support, Stress, Stress Reactions, Stressors

Risk Communication: Principles, Tools, and Techniques

Dr. Vincent T. Covello

Covello is an expert in the field of risk communication, a science-based discipline studying and developing best practices for communicating about risk. In this writing, Covello defines risk as "a threat of loss, real or perceived, to that which we value." As high concern situations alter the typical rules of communication, the goals of risk communication are to enhance the knowledge and understanding of the person(s) receiving the potentially alarming news. Considering cognitive state is vital in understanding how to deliver such information. Covello's research has shown that when people are concerned or stressed, they struggle to hear, understand, and remember information. Covello has coined this phenomenon **Mental Noise Theory** (Figure 2.1). He also notes that in a stressed state, people increase focus on negative over positive aspects, which he refers to as **Negative Dominance Theory**. A trusted source should be the one to share the risk communication (**Trust Determination Theory**). For my investigation, I was interested in how an interface could use these theories as guiding principles for delivering messages to a stressed or traumatized user.

Health Psychology

Compton College Psychology Department

This chapter outline lays the groundwork for understanding the implications of stress on cognitive function. Stress is the negative emotion and physiological process that occurs as individuals try to adjust to a stressor (Figure 2.2). Psychologists recognize that people experience three types of psychological responses to stress: emotional changes, cognitive changes, and behavioral changes. For this project's focus, it is imperative to understand the cognitive changes associated with stress. Stress responses in this category include reduced ability to concentrate, think clearly, and remember accurately. Stress also hinders decision-making skills.

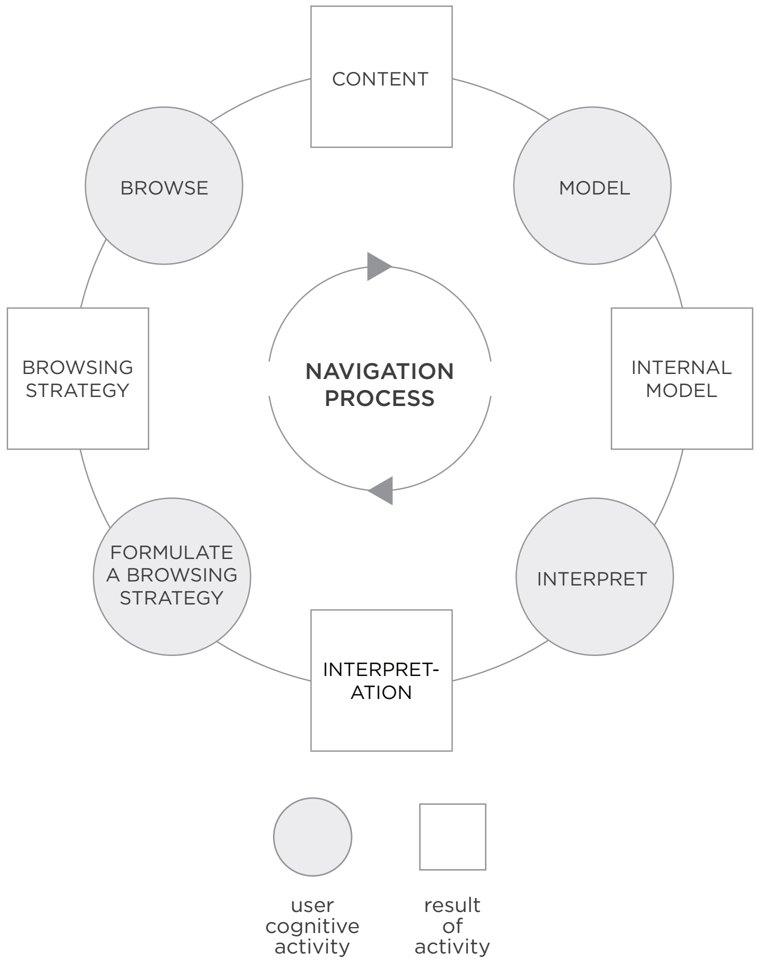


FIGURE 2.3 (adapted from Figure 1, Spence, 1999)**:** *Spence's framework consists of four cognitive activities, each with its own returned result.*

SUBJECT TWO

NAVIGATION

A Framework for Navigation

Robert Spence

The issue of interaction design to support navigation is challenging, notes Spence. To assist this challenge, he presents a simplified framework for navigation that can be applied in physical, abstract, and social environments (Figure 2.3). He defines navigation, a definition which remains prevalent in the field of human-computer interaction, as "the creation and interpretation of an internal (mental) model, and its component activities are browsing, modeling, interpretation and the formulation of browsing strategy." By dividing navigation into four activities (browsing, modeling, interpreting, formulating a browsing strategy), this framework allows for developing organized methods of supporting navigation for the user. Navigation is primarily concerned with learning about a space rather than using it.

CompactMap: A Mental Map Preserving Visual Interface for Streaming Text Data

Xiaotong Liu, Yifan Hu, Stephen North, Han-Wei Shen

The authors discuss the increasingly difficult task of visualizing large quantities of streaming text data to aid in preserving the user's mental map, tracking ongoing topic changes, and using display space efficiently. The authors present an online visual interface called CompactMap which employs dynamic spatiotemporal layouts of information packed into efficient clusters. Subsequent user testing showed that methods employed assisted in preserving the user's mental map.

The Conceptual Structure of Information Space

Paul P. Maglio, Teenie Matlock

Maglio and Matlock argue that designers of navigation tools and information spaces should consider peoples' natural ways of thinking about the Web as a physical space during the design process. Users discuss the World Wide Web in metaphorical language comparing it to physical space. People see themselves as metaphorically moving toward information, rather than information moving toward them. The way a user thinks about the Web has implications for how they navigate it and should guide how designers create navigation tools for moving through information spaces.

KEYWORDS:
Interaction, Schematic, Mental Model

Dynamic Visualization, Mental Map Preservation, Streaming Text Data, Visual Search Engine

Conceptual Structure, Target Domain, Image Schema, User Agent, Information Space

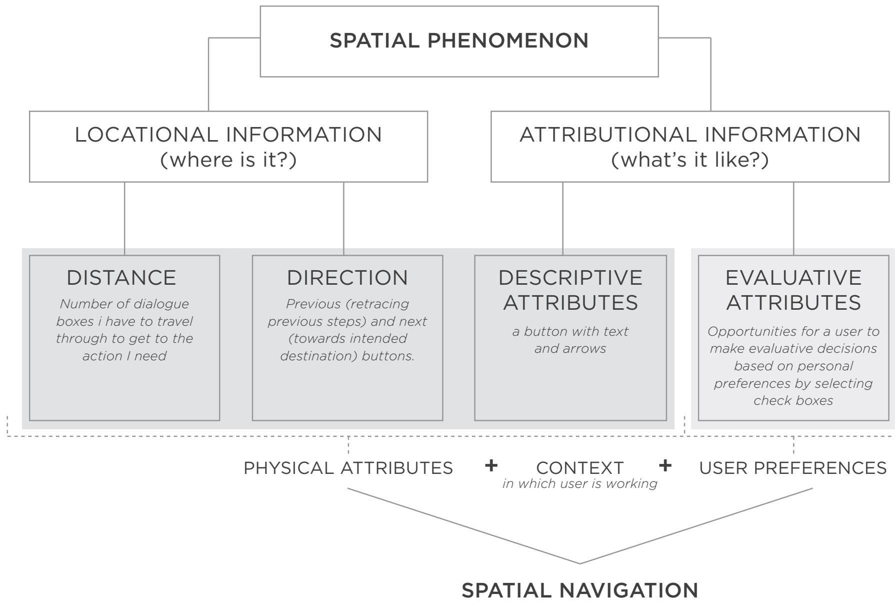


FIGURE 2.4: *The contents of a cognitive map contains two types of spatial information—locational and attributional. Both physical and evaluative attributes of a space along with the context which the user is working must all be considered when designing spatial navigation in GUIs.*

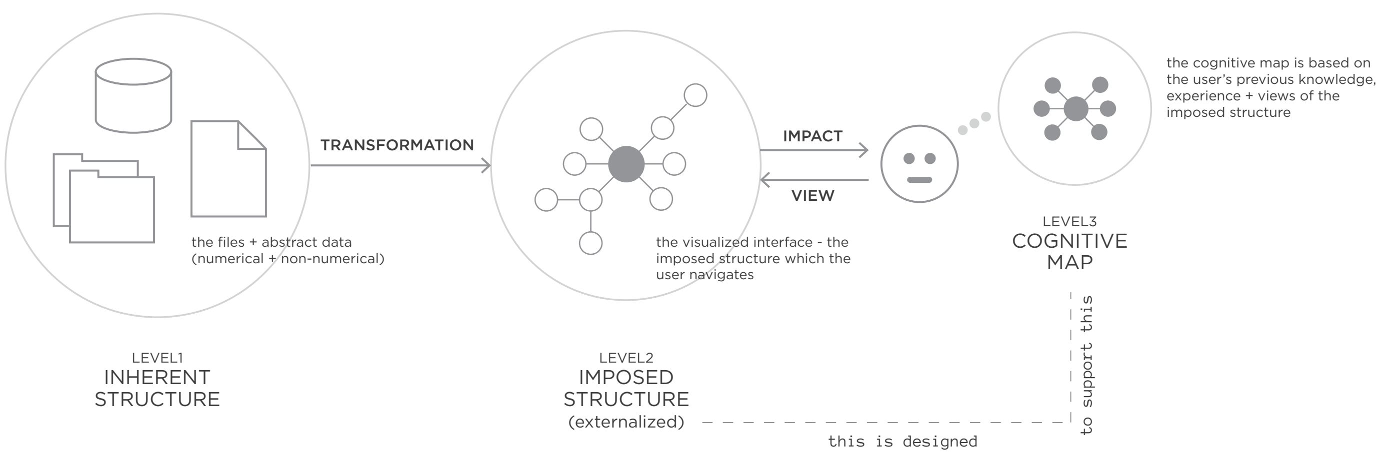


FIGURE 2.5 (adapted from Figure 4, Jul & Furnas, 1997)**:** *During a 1997 workshop on navigation in electron information environments, Apperly and others identified three levels of structure involved in navigation design.*

Navigation in Graphical User Interfaces
Rod McCall

Working with Dieberger and Tromp's metaphor of graphical user interfaces (GUIs) as information cities, McCall analyzes the assumptions that navigation in electronic worlds is adequately similar to physical geographic locations to inform design decisions. Thinking of GUIs as information cities, McCall considers the implications of seeing the user as a traveler with a desire to complete tasks as he/she moves towards a destination. He proposes designing task-based interfaces as a means of supporting user navigation (Figure 2.4). These task-based interfaces must enable contextual, spatially-based mental models. McCall's paper concludes with suggestions for developing navigational systems which support physical navigation, survey knowledge, contextual awareness, and user behavior.

Navigation in Electronic Worlds
Susan Jul, George Furnas

This report summarizes a workshop focused on issues surrounding navigation in electronic information environments including the psychology of navigation, navigation as a task, and what aspects affect how and why a user can find their way around. Jul and Furnas consider navigation to be a user activity and electronic information spaces to be the context for that activity. Five of the participants of this workshop, Apperley, Car, Jul, Leventhal, and Spence, discussed different types of structure to consider in navigational design. Figure 2.5 summarizes this discussion.

KEYWORDS:
Mental Map Preservation, Navigation, Electronic Worlds, Information Cities, Contextual Awareness

Navigation, Information Structure, Residue, Scent

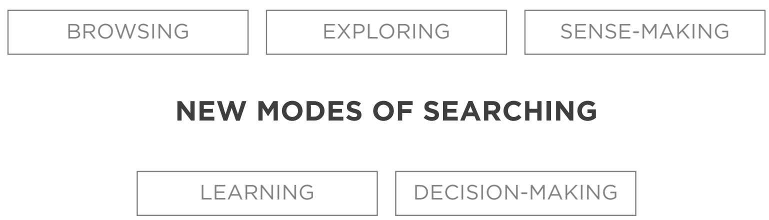


FIGURE 2.6: *Wilson notes that SUIs are no longer about analytical search strategies of submitting a search term and getting back results. Users want interfaces that can respond to scenarios of browsing, exploring, sense-making, learning and decision-making. "These different modes of searching presume longer periods of more diverse interaction. Consequently, SUIs are evolving to become increasingly interactive, in order to support a broader range of flexible and dynamic search experiences." (Wilson, 2012)*

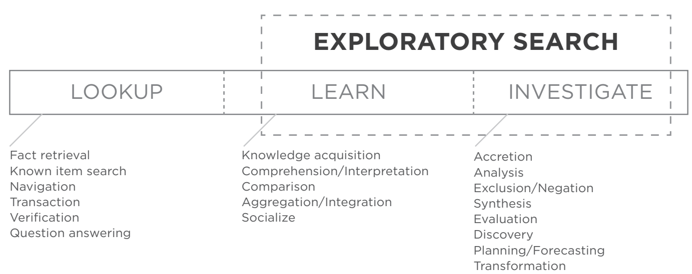


FIGURE 2.7: *Marchionini defines three kinds of information-seeking activities: lookup, learn, and investigate.*

SUBJECT THREE

SEARCH ENGINES

Search User Interface Design

Max L. Wilson

Wilson provides a thorough overview of search user interfaces (SUIs). Wilson talks about SUIs as the "gateway between people who have a task to complete, and the repositories of information and data stored around the world" on the Web. As technology advances, users require interfaces to support a more flexible and dynamic experience (Figure 2.6). He takes a multidisciplinary perspective when presenting the information as he acknowledges that many fields have a vested interested in the design of SUIs, including data science, computer science, human-computer interaction, user experience, and visual interface design. This book provides a detailed framework for best practices and guiding principles for evaluating SUIs. Topics include searcher-computer interaction, early search user interfaces, modern search user interfaces, experimental search user interfaces, and evaluative search user interfaces.

Exploratory Search: From Finding to Understanding

Gary Marchionini

After stating that search is a fundamental activity of life, Marchionini compares an organism's drive to fulfill Maslow's hierarchy of needs to how a modern information-seeker has a hierarchy of information needs. For each layer of information, a user needs, Marchionini defines three kinds of information-seeking activities: lookup, learn, and investigate. Users often engage in multiple types of information-seeking activities in unison, seeing these activities as tasks.

Analytical in nature, lookup is the most basic search activity. Lookup occurs when a user knows what information they want, inputs a specific query and retrieves a precise output from the interface. Searching to learn requires increased cognitive processing and interpretation as the user develops new knowledge. Investigative searches take place over multiple encounters with the intent of thoroughly accessing or analyzing information.

Learning and investigative search activities require increased cognitive participation on the user's part and serve as an exploratory process, which Marchionini terms 'exploratory search' (Figure 2.7). "Research tools critical for exploratory search success involve the creation of new interfaces that move the process beyond predictable fact retrieval."

KEYWORDS:
Search, Information Seeking, User Interface, User Experience, Interaction

Information Systems, Information Retrieval, Information-Seeking

SUBJECT FOUR

ADAPTIVE INTERFACES

Adaptive User Interfaces for Health Care Applications

Krish Ramachandran

Ramachandran discusses the potential for adaptive user interfaces in health care applications, responding according to a user's level of computer knowledge (from novice to expert). Ramachandran discusses two critical techniques for adaptation: adaptive presentation and adaptive navigation. Adaptive presentation involves personalizing content presented to the user whereas adaptive navigation consists of customizing how a user completes tasks.

Automatically Personalizing User Interfaces

Daniel S. Weld, Corin Anderson, Pedro Domingos, Oren Etzioni, Krysztof Gajos, Tessa Lau, Steve Wolfman

This paper discusses the limited nature of the one-size-fits-all interface in meeting the needs of users who increasingly require personalized solutions. Pointing out the increased focus on user-centered design, Weld et al. argue that generic interfaces fail to address user needs for a variety of tasks, context, and devices. Unfortunately, there are not enough designers to respond to the increased demand for personalized interfaces. Weld et al. present the solution as developing automatic personalization through customization (explicit, user-initiated change) and adaptation (interface-initiated change in response to routine user behavior). Adaptivity and customization are the only scalable approaches to personalization.

Personalized Search on the World Wide Web

Alessandro Micarelli, Fabio Gasparetti, Filippo Sciarrone, Susan Gauch

This writing outlines personalized search on the Web as a growing research field with the potential to solve the expanding information overload problem associated with online searching. Today's users require access and understanding of significant information to meet both personal and professional goals. Traditional search engines lack efficiency and effectiveness. Users formulate a query, wait for results, and sift through those results. Micarelli et al. propose that developing interfaces which facilitate personalized ways of searching the Web will simplify the searching process, increasing search accuracy and reducing user time to sift through results. Approaches and techniques for adaptation include data mining, machine learning, click-through data analysis, and past query tracking.

KEYWORDS:
Adaptive Presentation, Adaptive Navigation, User Interface, XML Code

Customization, Adaptation, Personalized Interfaces, User Behavior, Automatic Personalization

Search Engine, User Model, Relevance Feedback, Query Expansion, Result List

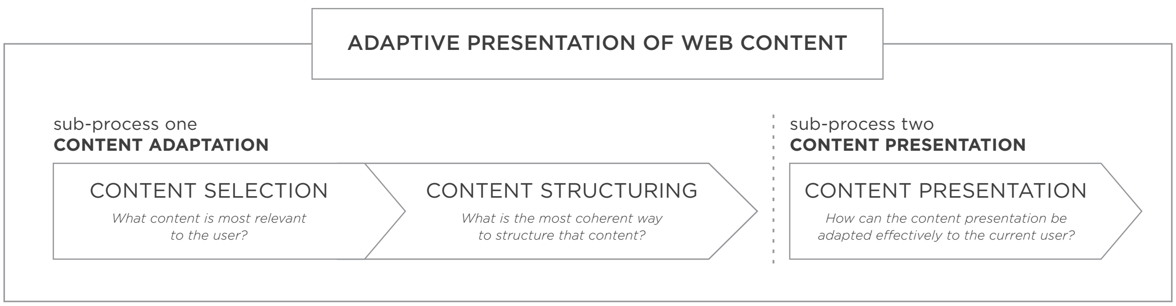


FIGURE 2.8: *The process of adaptive the presentation of content for Web application.*

Machine Learning for Adaptive User Interfaces
Pat Langley

This paper examines the growing need for customizable user interfaces and the affordances of machine learning in meeting that need. Early interactive systems have a limited ability to account for the differences in user knowledge and preferences. Machine learning can be used to create adaptive interfaces by employing inductive methods (learning through "noticing") to personalize behavior based on observation of user activity. Adaptive user interfaces collect data during each user interaction—continually improving the user experience and the ability of the system to adapt. They are, thus, considered 'learning' systems rather than 'learned' systems. This paper identifies two broad classes of adaptive user interfaces; informative interfaces and generative interfaces.

Adaptive Content Presentation for the Web
Andrea Bunt, Giuseppe Carenini, Cristina Conati

In this chapter, Bunt, Carenini, and Conati discuss techniques for adaptive presentation of Web-based content (i.e., how to present material to best suit an individual users' needs). The process of adapting content to an individual user's needs consists of two sub-processes: content adaptation and content presentation (Figure 2.8). Content adaptation involves deciding what content is most relevant to the user and how to structure that content before presenting. Content presentation involves how the selected content will most effectively adapt the presentation to the user. The authors provide several techniques for adapting presentation based on content relevance.

KEYWORDS:
Machine Learning, Global Position System, Informative System, Interactive Software, Generative Interface

Content Adaptation, Interaction Context, Natural Language Generation, Intelligent User Interface, Content Selection

SUBJECT FIVE

MISCELLANEOUS

Supporting Human Memory in Personal Information Management
David Elsweiler

Elsweiler's doctoral abstract summarizes the role of memory in personal information management (PIM), a research field which aims to develop tools and systems to help people manage and re-find personal information. Grounding his research in the psychology of memory, Elsweiler reports on his studies which track the different process people use for "finding" verses "re-finding" information. He discusses memory cues, people's increased memory of surrounding context, and suggests methods for developing interfaces which assist users with re-finding information.

AIGA Designer 2025: Why Design Education Should Pay Attention to Trends
AIGA Design Educators Community

This paper examines social, technological, and economic trends shaping professional design practice. These trends include a movement towards adaptive and personalized ways of consuming and delivering information a user desire data-aware tools that learn from their behavior. This writing was profoundly useful in understanding the current conditions for which designers should strive to situate work and research.

KEYWORDS:
Human-Centered Computing, Human Computer Interaction, Empirical Studies in HCI

Design Competencies, Trends, Educator-Oriented Programming

/

The only important
thing about design is
how it relates to people.

Victor Papanek

/

METHODS

I had the opportunity to employ qualitative research methods by collecting data from 20 patient advocates from the **NC Rare Disease Advisory Council**. I conducted semi-structured interview and prototype testing. Having direct interaction with this user group was essential for my investigation. I was designing with a very specific user and a very sensitive context in mind. Without direct access to the user group, poor assumptions may have lead to ill-informed design decisions. The following are descriptions for all methods employed during this project.

NC RARE DISEASE ADVISORY COUNCIL
House Bill 823, An Act Establishing the Advisory Council on Rare Diseases was signed by the governor on August 5th, 2015. The council's purpose is to advise the Governor, the Secretary, and the General Assembly on research, diagnosis, treatment, and education relating to rare diseases.

INTERVIEWS

"Interviews are a fundamental research method for direct contact with participants, to collect firsthand personal accounts of experience, opinions, attitudes, and perceptions." *(Martin & Hanington, 2012)*

USER TESTING

"Usability testing focuses on people and their tasks, and seeks empirical evidence about how to improve the usability of an interface." *(Martin & Hanington, 2012)*

USE CASE STUDY

"The case study is a research strategy involving in-depth investigation of single events or instances in context, using multiple sources of research evidence." *(Martin & Hanington, 2012)*

PERSONA

"Personas consolidate archetypal descriptions of user behavior patterns into representative profiles, to humanize design focus, test scenarios, and aid design communication." *(Martin & Hanington, 2012)*

RESEARCH THROUGH DESIGN

"Research through design recognizes the design process as a legitimate research activity, examining the tools and processes of design thinking and making within the project, bridging theory and building knowledge to enhance design practice." *(Martin & Hanington, 2012)*

PROTOTYPING

"Prototyping is the tangible creation of artifacts at various levels of resolution, for development and testing of ideas within design teams and with clients and users." *(Martin & Hanington, 2012)*

SCENARIOS

"A scenario is a narrative that explores the future use of a product from a user's point of view, helping design teams reason about its place in a person's day-to-day life." *(Martin & Hanington, 2012)*

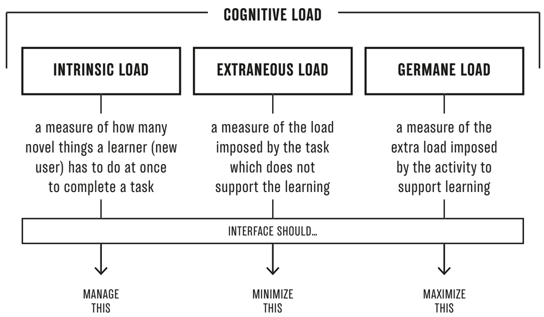


FIGURE 2.9: COGNITIVE LOAD THEORY

In cognitive psychology, cognitive load refers to the effort being used in the working memory.

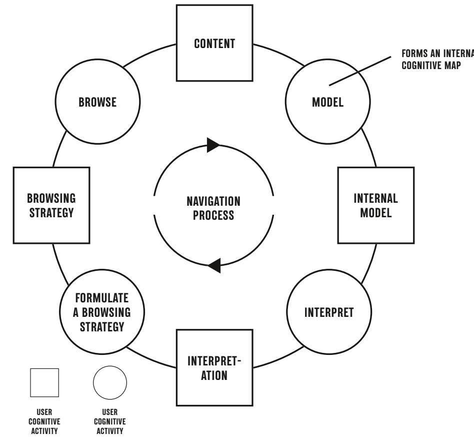


FIGURE 2.10: NAVIGATION FRAMEWORK

The four user activities that create the navigation process are browse, model, interpret, and formulate a browsing strategy.

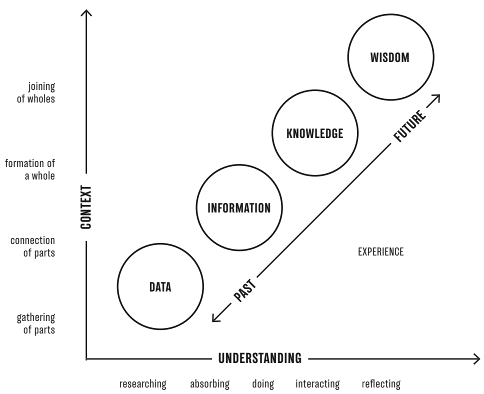


FIGURE 2.11: DIKW HIERARCHY

DIKW Hierarchy is a representation of the relationships between data, information, knowledge, and wisdom.

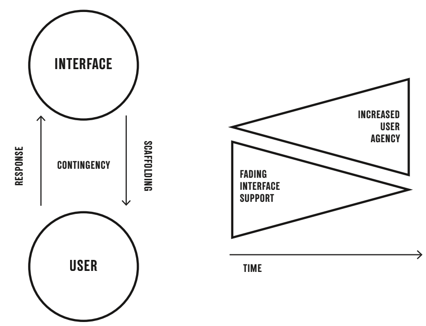


FIGURE 2.12: SCAFFOLDING THEORY

Scaffolding refers to a process in which teachers demonstrate how to solve a problem, and then step back, offering support as needed

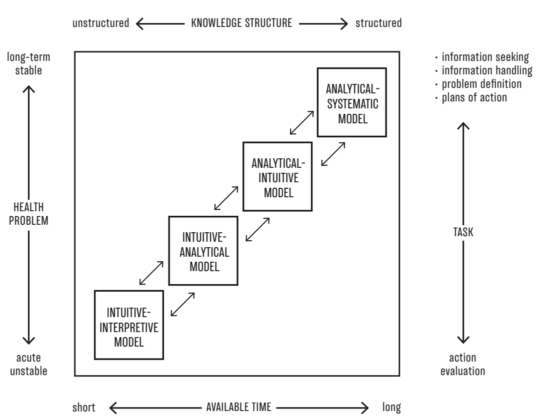


FIGURE 2.13: COGNITIVE CONTINUUM THEORY

Intuition and rational analysis are defined as two modes of cognition that can be placed at the ends of a continuum

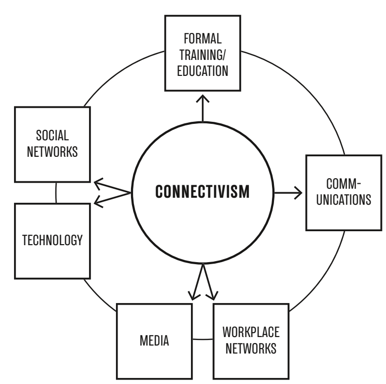


FIGURE 2.14: CONNECTIVISM LEARNING THEORY

Connectivism seeks to explain complex learning in a rapidly changing social digital world

CONCEPTUAL FRAMEWORK

I developed a conceptual framework (Figure 2.15) for my investigation to guide the design of mini-studies and final features. This conceptual framework was essential in structuring the research process and served to align four axes of information: researched theories, tools and features, stress level, and researchable subquestions.

RESEARCHED THEORIES

My research began by looking for existing theories to inform my study. I started searching psychology and learning theories. I chose six that seemed well-suited for the context of my study (Figures 2.9–2.14).

Sweller's Cognitive Load Theory suggests that learning tasks can create a cognitive load that impedes a person's ability to process information and create long-term memories. The theory serves as a guideline for assisting in presenting information which encourages learning activity, optimizing a person's ability to perform cognitive tasks *(Sweller, 1998)*.

Spence's Navigation Framework, previously discussed in the literature review, explains the four cognitive activities a user participates in while navigating physical, abstract, and social environments *(Spence, 1999)*.

Information Science's DIKW Hierarchy is a visual representation of the relationships between data, information, knowledge, and wisdom. According to Ackoff *(as cited in Bellinger et al., 2004)*, the content of a person's mind can be classified into five categories: data, information, knowledge, understanding, and wisdom. Knowledge is the processing and application of data and information, and wisdom is having the ability to make predictable inferences about the future.

According to **Bruner's Scaffolding Theory** *(as cited in Foley, 1994)*, supporting a user while they are adapting to a tool or technology, increases the likelihood that they'll that use the knowledge independently in the future. The theory suggests breaking learning into attainable, measurable steps to allow the learner to build upon prior experience.

The field of medicine uses **Hammond's Cognitive Continuum Theory** when considering medical practitioners ability to match cognitive processes to task requirements. The theory discusses the spectrum of intuition and rational analysis on decision making, breaking down complex judgments into smaller subcomponents *(Cader et al., 2005)*.

Siemens' Connectivism Learning Theory explains new opportunities for learning created by internet technologies. Technology can assist users with recognizing and synthesizing connections among information sets *(Siemens, 2005)*.

TOOLS + FEATURES

My research to this point—collecting theories and understanding cognitive state—began to suggest what tools and features an information space might need to aid the user in a high-stress state. These tools and features became the second axis in my framework. I choose five main tool categories:

/ Tools for Searching
seeking, filtering, customization

/ Tools for Navigating
wayfinding, dashboard, menu systems

/ Tools for Storing
search history, backtracking, note taking, memory triggers

/ Tools for Deciding
compare/contrast, decision aids

/ Tools for Notifying
alerts, notifications, sharing, calendar

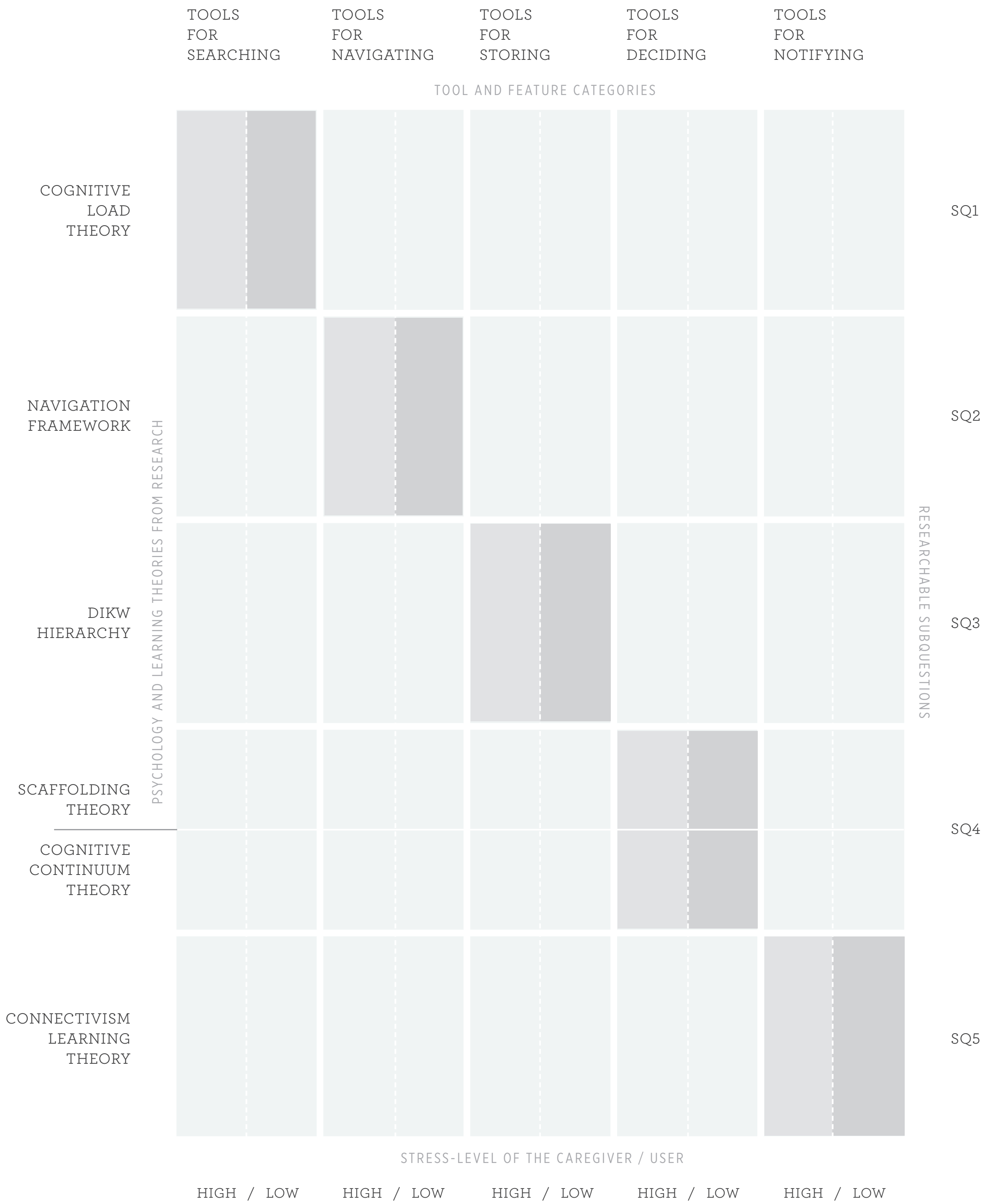


FIGURE 2.15: *By combining the following four axes of information, I developed my own conceptual framework to inform the design of my prototypes: Researched Theories, Tools and Features, Stress Level, and Subquestions.*

STRESS LEVEL

The next consideration for my framework was to look at various levels of cognitive strain. The user's cognitive state would be the determinant for the system's adaptation of content and information presentation. When first creating my matrix, I thought it best to consider high-stress and low-stress user states. Throughout my investigation, I also discussed looking at user's experience level with the system, i.e. as novice to expert. Another consideration was to categorize users based on time elapsed since diagnosis. Although all of these factors bear some relevance to my final adaptive features, my focus throughout became directed at the best practices for communicating to the high-stress, recently traumatized user. For this first framework, high-stress and low-stress will remain an axis, but note that in later work, this axis is dropped from the framework altogether.

SUBQUESTIONS

My goal for the conceptual framework was to create a structure for the research and making portions of my project. The investigation process is seeking to answer researchable questions. By pairing one theory with one tool category, I was able to formulate five focused subquestions (below).

SQ1: How can the design of search tools that interpret and learn from user search behavior allow for adaptive and personalized ways of delivering and consuming information according to the user's cognitive state?

SQ2: How can a suite of information navigation aids respond to a caregiver's shifting cognitive state as s/he acquires and archives information culled from multiple sources about a dependent's medical condition?

SQ3: How can the design of interface search features track knowledge acquisition progress to serve as an ongoing personal reference tool as a user gradually learns and adapts to their changing medical, professional, and social situations?

SQ4: How can the design of a responsive interface assist non-experts in developing expert research behaviors that aid in effective and autonomous decision making?

SQ5: How can a data-aware notification system alert users to changes in information and knowledge in both just-in-time and over-time delivery approaches?

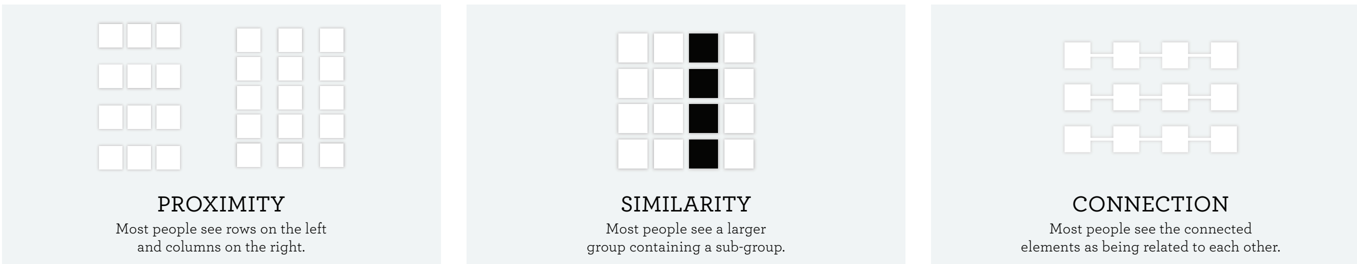


FIGURE 2.16: *Above are examples of Gestalt Principles. I've used the gestalt principles of similarity, proximity, and connection to develop the information presentation strategies (in the finding section) of organizing, filtering, and chunking.*

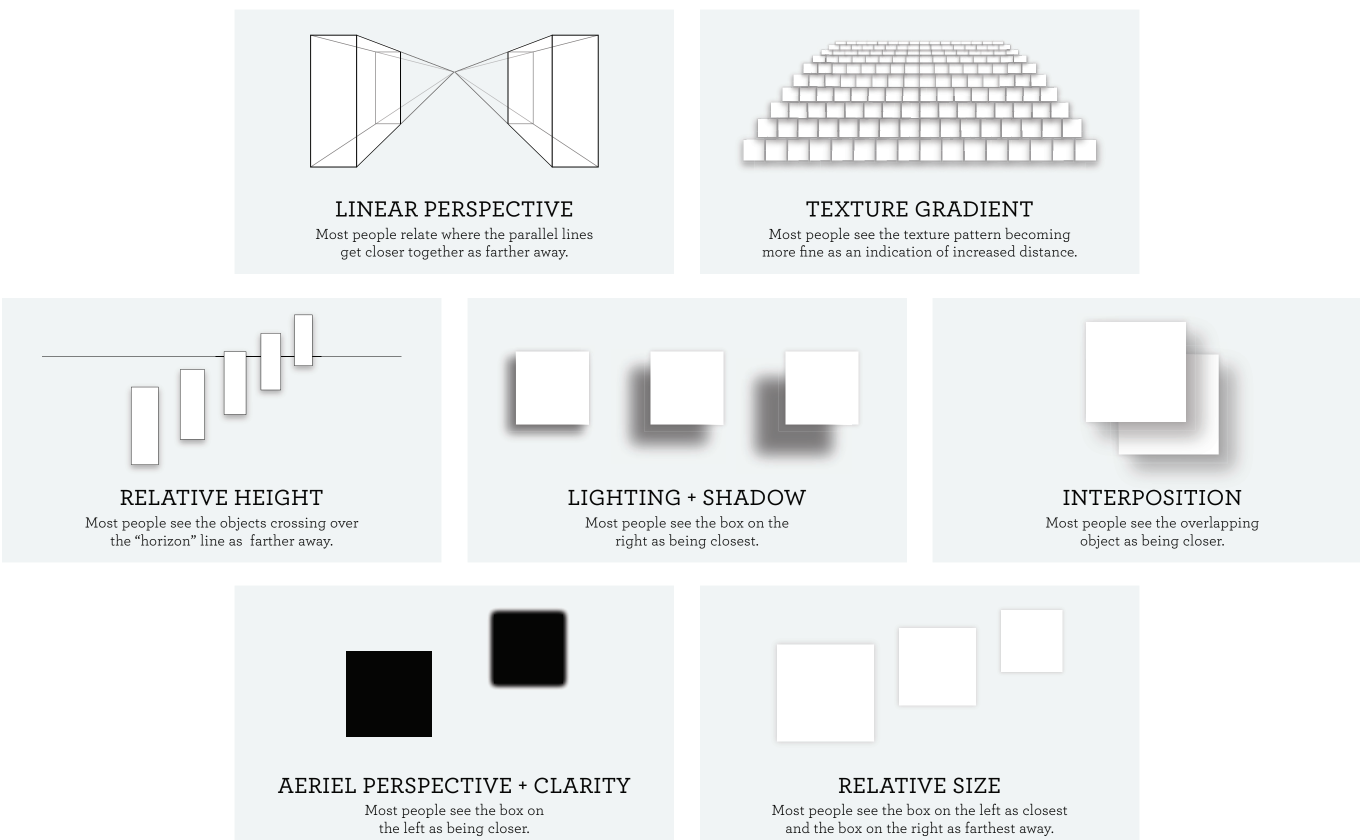


FIGURE 2.16: *Above are examples of Pictorial Depth Cues. I've used the pictorial depth cues of linear perspective, texture gradient, and relative height to represent time-based information whereas I've used shadow, interposition, clarity, and relative size to indicate urgency-based information.*

DESIGN PRINCIPLES

When I decided to design for a caregiver in a high-stress cognitive state, I wanted to find ways in which I could make design decisions which would be intuitively perceived by the user. I began looking into a variety of options for visual metaphors.

I ultimately landed on gestalt principles and pictorial depth cues. Throughout the visual studies, gestalt principles and pictorial depth cues are used to signify areas of time-based and urgency-based information. Also, these principles proved helpful in visually communicating the various information presentation strategies.

GESTALT PRINCIPLES

The focus of **Gestalt Theory** (**Figure 2.16**) is the idea that the grouping of characteristically similar stimuli cause people to structure or interpret a visual field or problem in a certain way *(Werthmeimer, 1923)*. I've used the gestalt principles of similarity, proximity, and connection to develop the information presentation strategies (in the finding section) of organizing, filtering, and chunking.

PICTORIAL DEPTH CUES

Pictorial depth cues are often used in flat compositions to create an impression of depth and space for the viewer. The presence of these cues serves to trigger visual memories of mental constructs of three-dimensional space in the viewer *(Rock et al., 1977)*. I've used the pictorial depth cues (**Figure 2.17**) of linear perspective, texture gradient, and relative height to represent time-based information whereas I've used shadow, interposition, clarity, and relative size to indicate urgency-based information.

SECTION THREE

THE FINDINGS

> If we knew what it was we were doing, it would not be called research, would it?
>
> *Albert Einstein*

FINDINGS

The above research culminated into three broad categories of findings. The first is a set of information presentation strategies. These are information delivery techniques shown to be preferred by people under duress. The second is user actions for which online searching can support. For this project, I am calling these user interactions, but it is important to note that these are responsibilities a caretaker must take outside of a search engine yet require access to information to perform. Third, are proposed design solutions, which appear in the Possibilities section of this document. Located with the proposed design solutions are final studies, design prototypes, and visual explorations created according to the project framework.

Gathering	Conversing	Filtering	Storing
Withholding	Prioritizing	Chunking	Notifying

INFORMATION PRESENTATION STRATEGIES

FIGURE 3.1: *Bolded information in the above chart located near visual studies indicates which presentation strategies are employed.*

INFORMATION PRESENTATION STRATEGIES

The data I collected suggests that people under duress prefer that complex health information be presented in a minimal (i.e., simple content structure) fashion using assistive delivery strategies. Below are brief descriptions of each approach. The studies in subsequent sections will explore how these strategies might exists within adaptable search tools and features. Chunking, filtering, storing, and notifying are principles familiar to the design community. Perhaps conversing is familiar to most designers as well. However, the information presentation techniques of withholding, gathering, and prioritizing and quite novel and unique to this project. Figure 3.1 represents a signifier to recognizing these information presentation strategies throughout my visual studies.

WITHHOLDING
In contrast with traditional online medical search engines which flood the user with all information up front, weighty health information will be presented in a scaffolded manner allowing the user to self-time the discovery of details.

GATHERING
The interface will continuously be working, searching all the relevant information databases to collect information for the user in one place.

PRIORITIZING
Information gathered will be organized and presented to the user in an urgency-based or time-based fashion, allowing the user to focus on addressing tasks for today while postponing tasks for the future.

CONVERSING:
The interface will serve as a digital facilitator, conversing with the user in a personal, humanized tone of voice.

FILTERING
While the interface is making decisions concerning priority and organization, it will communicate filtering options, and opportunities will be presented to the user to override default decisions.

CHUNKING
The interface will break text and multimedia content into smaller chunks to help users process, understand, and remember.

STORING
When a user comes across a new term or concept, they can request the interface "remember" that information for them, saving it in their dashboard.

NOTIFYING
When a user is away from the interface, they can rest assured that the searching will continue and the interface will alert them when new information becomes available.

LEARN ABOUT THE DISEASE	FIND SUPPORT SYSTEMS	FIND SPECIALISTS AND CLINICS	FIND AND MANAGE TREATMENTS	MANAGE INSURANCE AND FINANCIALS	FIND AND MANAGE MEDICATIONS	PARTICIPATE IN RESEARCH	BECOME AN ADVOCATE

FIGURE 3.2: *Above are eight broad categories of activities which a primary caregiver of a rare disease patient will participate in. A search engine can support these user activities by providing access to information.*

USER INTERACTIONS

As covered in the discussion of the user in context, the diagnosis of a child presents a parent with an immediate need to take action. One parent from the NC Rare Disease Council stated, "I was pulling all-nighters within the first 24 hours." The diagnosis, while traumatizing, is followed by the continuous stress of meeting the child's immediate and ongoing personal, financial, and medical needs.

To better understand what actions a parent of a recently diagnosed child needs to take, I conducted a thorough use case study. I culled information from several top rare disease information sites, collecting guidance for finding resources. I tracked information and resources as though I was a parent with a recently diagnosed child. I visited over 50 websites in the process! I discussed information-seeking habits with patient advocates from the NC Rare Disease Council. I also interviewed the director of NC State University's Design Library, Karen Dewitt. As an information scientist and a librarian, Dewitt was able to provide insight into effective analog and digital information search techniques.

I synthesized the data collected from the use case study into eight broad categories of activities which a primary caregiver of a rare disease patient will participate in (**Figure 3.2**). For this project, I am calling these user interactions. It is important to note that these are responsibilities a caretaker must take outside of a search engine yet require access to information to perform. The eight broad categories are as follows.

/ Learn about the disease
Parents seek information on the condition and associated symptoms.

/ Find support systems
Parents seek other people who understand how having the condition affects their lives.

/ Find specialists and clinics
Parents seek doctors knowledgeable about the disease and clinics offering focused treatments.

/ Find and coordinate treatments
Parents seek information about standard and investigational therapies. Finding therapies as soon as possible may add years of health and life to a child with a rare disease.

/ Find and manage medications
Parents seek drug options, including medicines classified as orphan drugs developed to diagnose, prevent or treat rare diseases and conditions.

/ Manage insurance and financials
The cost of care for rare medical conditions can place a significant financial burden on families. Parents seek financial assistance and advice on handling rejected insurance claims.

/ Participate in research
Parents seek information on participating in clinical trials to find new treatments and future cures.

/ Become an advocate
Parents seek to connect to the larger rare disease community, educating the public and medical professionals, and bringing issues before the governments.

ORPHAN DRUG
a pharmaceutical agent that has been developed specifically to treat a rare medical condition; the assignment of orphan status is a matter of public policy to ensure that medications are developed despite limited potential for profitability

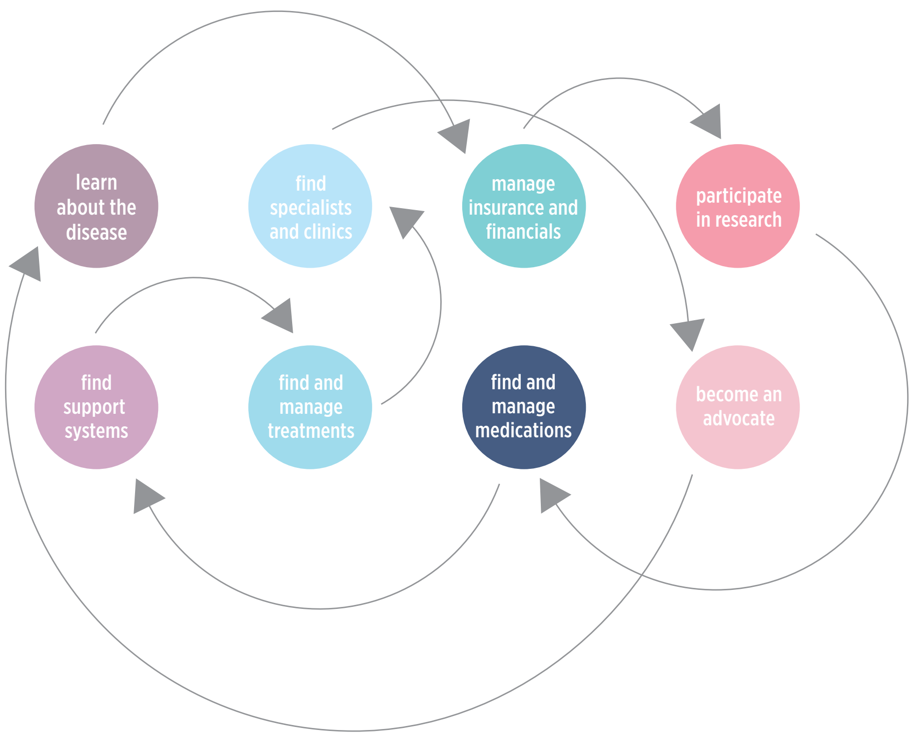
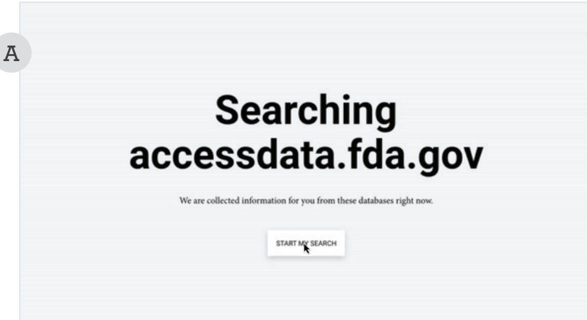


FIGURE 3.3: *A user will need to be able to quickly and easily explore information pertaining to various tasks.*

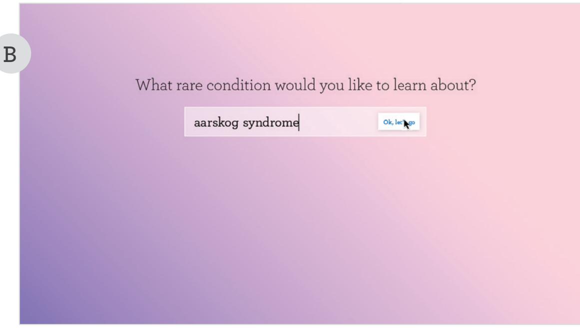
Online searching can support each of these actions. Visualizing the interactions in timeline form is simple. However, the process of learning under such circumstances will not occur linearly. To meet the ongoing needs of the child, a parent will cycle through these activities multiple times. Concurrently, when under stress, researching in a linear process is unlikely. I speculate that a traumatized user, desperate for information, will urgently jump around responding to the next thought. To support these conditions, the system will be designed as a looping navigation of experiences to promote discovery (**Figure 3.3**).

A



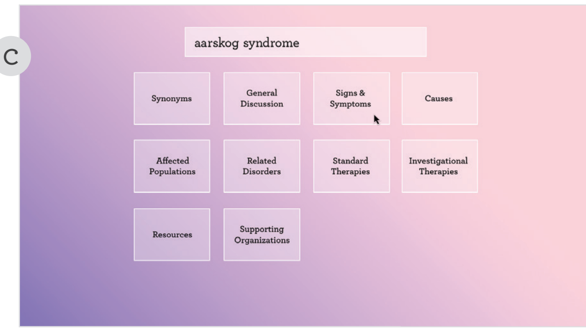
The interface continuously rotates the source of information, indicating that the system is gathering data for the user.

B



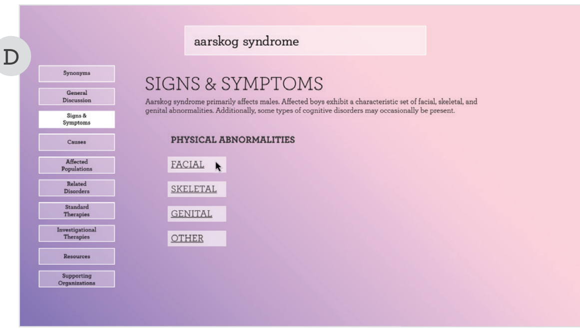
The interface uses a conversational tone-of-voice when prompting the user to search

C



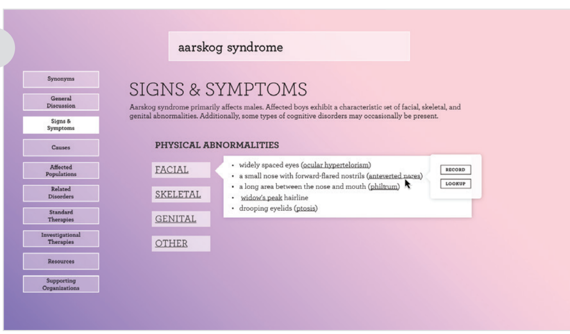
The interface delivers search results using chunking, categorizing, and filtering.

D



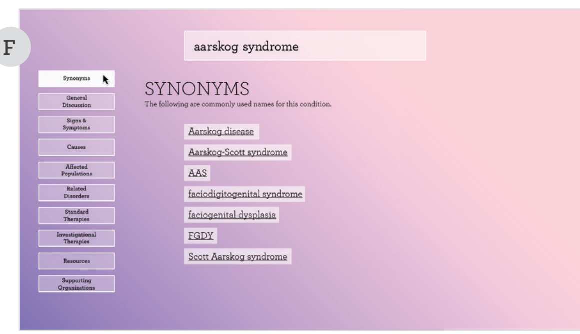
The user chooses to enter the "Signs & Symptoms" section. The interface is filtering, chunking, and withholding.

E



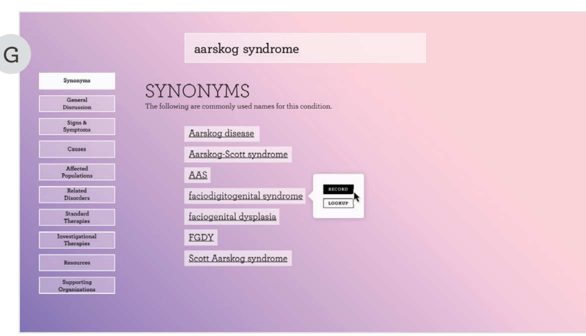
The user clicks for more information on facial abnormalities. The interface is filtering, chunking, withholding, and storing.

F



The user clicks on the "Synonyms" button in the left navigation. The interface is filtering, chunking, and withholding.

G



When clicking on faciodigitogenital syndrome, the user is given options to "Record" the keyword or "Lookup" its meaning.

H

In this screen, a user has clicked into deeper levels of information withheld up front. The user has access to all information upon click.

FIGURE 3.4: *Screens A through H use the information presentation strategies of gathering, withholding, conversing, filtering, chunking, and storing to redesign material about Aarskog Syndrome delivered initially on the NORD website..*

MINI STUDIES ROUND ONE

For the first set of mini-studies, I began by looking at redesigning one rare disease information page from the NORD (National Organization for Rare Disorders) website. In **Figure** 3.4, I took the information for the rare disease Aarskog Syndrome from the NORD website. The content in its original state is too large to show in this context. To give you a general idea of how it functions, the information for Aarskog Disease falls on one long page which a user will scroll nine or more times to cover the 2,259 words. The interface displays all material up front and does not offer options for expanding and collapsing content.

For my exploration, I kept all content within the same categories provided on the NORD site. I did not edit the content. What I was interested in was how I could deliver this information differently.

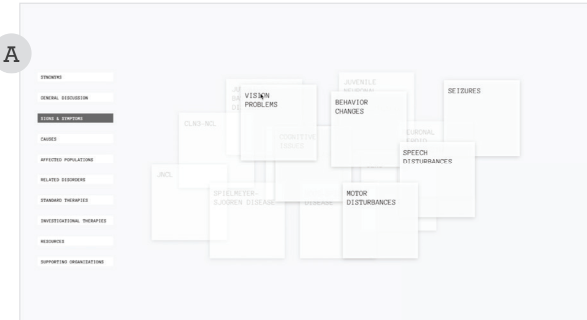
My main discovery from this round of mini-studies is that the information presentation strategies proposed on page 59 could substantially alter the experience of information. By employing the information presentation strategies of withholding, filtering, and chunking, information could be broken up into easy-to-digest pieces.

Gathering	**Conversing**	**Filtering**	**Storing**
Withholding	Prioritizing	**Chunking**	Notifying

INFORMATION PRESENTATION STRATEGIES

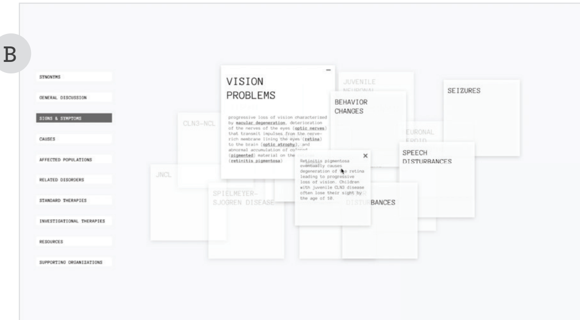
The content for this in its original form is available at rarediseases.org/rare-diseases/aarskog-syndrome/

A



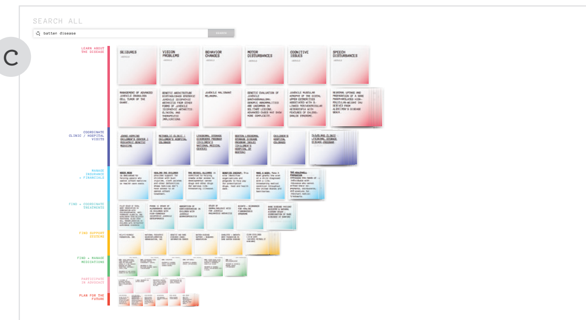
This study is exploring how filtered information can be presented to the user in a layered manner

B



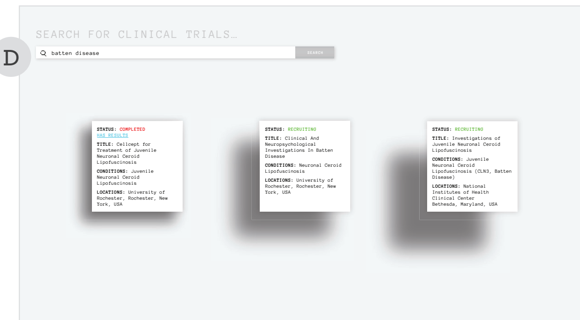
This study is exploring filtering, chunking, and withholding. The user can self-direct into deeper layers of information.

C



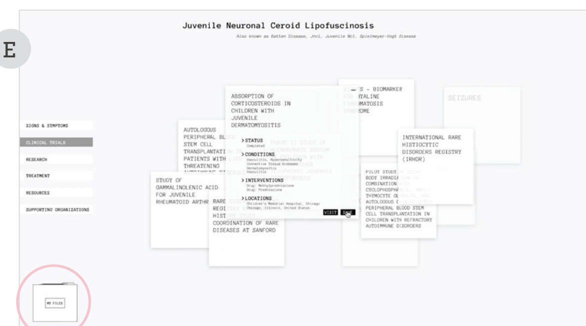
This study is exploring how gathered information can be filtered, chunked, and prioritized.

D



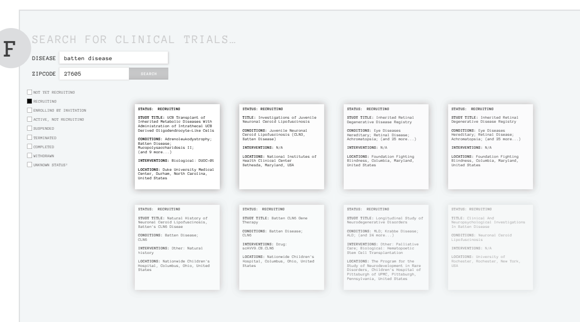
This study is exploring how depth perception can serve as a means of prioritizing search results.

E



This study is exploring chunking, withholding, filtering, and storing information. The file is visually saved in the "My Files" icon when the user clicks the store button.

F



This study is exploring how depth perception can serve as a means of prioritizing search results according to selected filters.

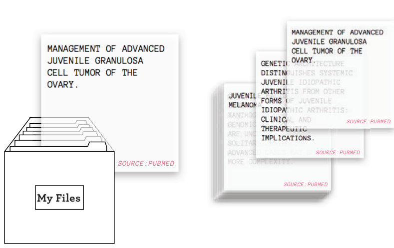


FIGURE Figure 3.5: *Screens A through F represent mini-studies exploring the use of pictorial depth cues and gestalt principles to indicate time-based and urgency-based information.*

MINI STUDIES ROUND TWO

When I moved on to round two of my mini-studies (Figure 3.5), I began to consider changing the information categories. The process of working through the needed user interactions began to unfold. I was looking for a principle that the studies could work through and tried to use depth cues and gestalt principles to indicate time-based and urgency-based information. I was hoping that these visual principles would create intuitive messages for the user. I discovered that by relying solely on the depth cues and gestalt principles to delivery information hierarchies, I designed compositions that seemingly created more anxiety in viewers. However, some of the mnemonic cues, for example, the files being shown going into the filing cabinet, demonstrated some potential for aiding the user in navigating an information space. Screens A, B, and E on the left represent three interactive, time-based sequences created during this round of mini-studies. Juvenile neuronal ceroid lipofuscinosis (also known as Batten Disease) information is for these mini-studies.

Gathering	Conversing	**Filtering**	**Storing**
Withholding	**Prioritizing**	**Chunking**	Notifying

INFORMATION PRESENTATION STRATEGIES

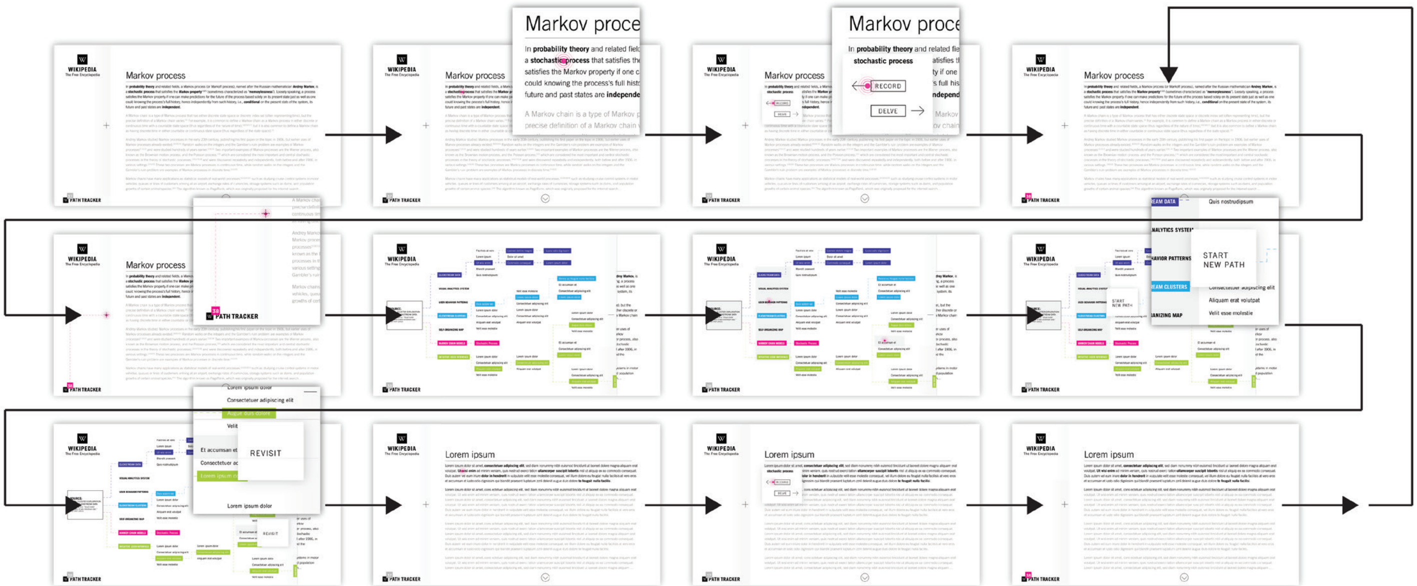


FIGURE 3.6: *In the above re-imagined Wikipedia navigation concept, a user is alerted by the interface of an unfamiliar word and prompts the user to delve deeper (researching the keyword) or to record (save the keyword for future research). Whether the user chooses to delve or record, these learning decisions and activities are collected on the interface's "Path Tracker Feature."*

FIGURE 3.7: *This screen shows a detailed view of the interfaces "Path Tracker Panel" where a user can see all learning pathways. A user can revisit a past search or start a new path from any point.*

MINI STUDIES ROUND TWO

For round three of my mini-studies, I revisited previous work I had completed during an eye-tracking workshop at NC State College of Design. Conducted by Brad Tober and Matthew Peterson, the gaze-based interface workshop facilitated a conceptual redesign of Wikipedia. I was interested in exploring solutions for what is commonly referred to as the "wiki rabbit hole" in which a user gets lost jumping from topic to topic and cannot retrace their steps. This mini-study is exploring a solution for getting lost during Web searches.

Figure 3.6 is a representation of a navigational interface for Wikipedia which allows a user to track pathways of information through the processes of delving deeper and recording keywords. Figure 3.7 shows the visualization of the learning pathways. A user can view the learning pathways in the Path Tracker Panel which opens from the left-hand navigation pane.

WIKI RABBIT HOLE
a long, winding, exploratory learning pathway which a reader travels by navigating from topic to topic while browsing Wikipedia; often getting sidetracked by many connections and offshoots

Gathering	Conversing	Filtering	**Storing**
Withholding	Prioritizing	Chunking	**Notifying**

INFORMATION PRESENTATION STRATEGIES

	SEARCHING	NAVIGATING	STORING	DECIDING	NOTIFYING
	USER / INTERFACE ACTION				
THEORY	*Cognitive Load Theory*	*Navigation Framework*	*DIKW Hierarchy*	*Scaffolding Theory and Cognitive Continuum Theory*	*Connectivism Learning Theory*
TOOL CATEGORY	*Search Tools*	*Information Navigation Aids*	*Knowledge Acquisition Trackers*	*Research Behavior Instruction Aids*	*Just-in-Time and Over-Time Notification Tools*
POINT OF ASSISTANCE	*Delivering and Consuming Information*	*Acquires and Archives Information*	*Ongoing Personal Reference Tool*	*Aid in Effective and Autonomous Decision Making*	*Notifying of Changes in Information*
FINAL FEATURE	*final feature one* *Withholding*	*final feature two* *Mental Map Navigation* *final feature three* *Continuous Annotated Side Navigation*	*final feature four* *Visualized Past Searches*	*final feature five* *Automatic Research Behavior Scaffolding*	*final feature six* *Visualized Gathering* *final feature seven* *Looping Connections*

FIGURE 3.8: *Use this framework as a map to section four of this book. The introduction of each final feature section that follows will refer to the cells in this framework, coded using the same color shown in the figure above.*

A SECOND FRAMEWORK

The conceptual framework shown in Figure 2.15 (page 50) guided the investigation and early mini-studies. While continuing to research, aiming to seek understanding in my problem space, a second framework began to take shape. This second framework is the original, but now combined with the context of my research. The simple grid identifies each user/interface action and breaks it down into four boxes, as seen in the Y-axis: a theory, a tool category, the point of assistance for the tool use, and the final feature I will design. Use this framework (Figure 3.8) as a map to section four of this book. The introduction of each final feature section that follows will refer to the cells in this framework.

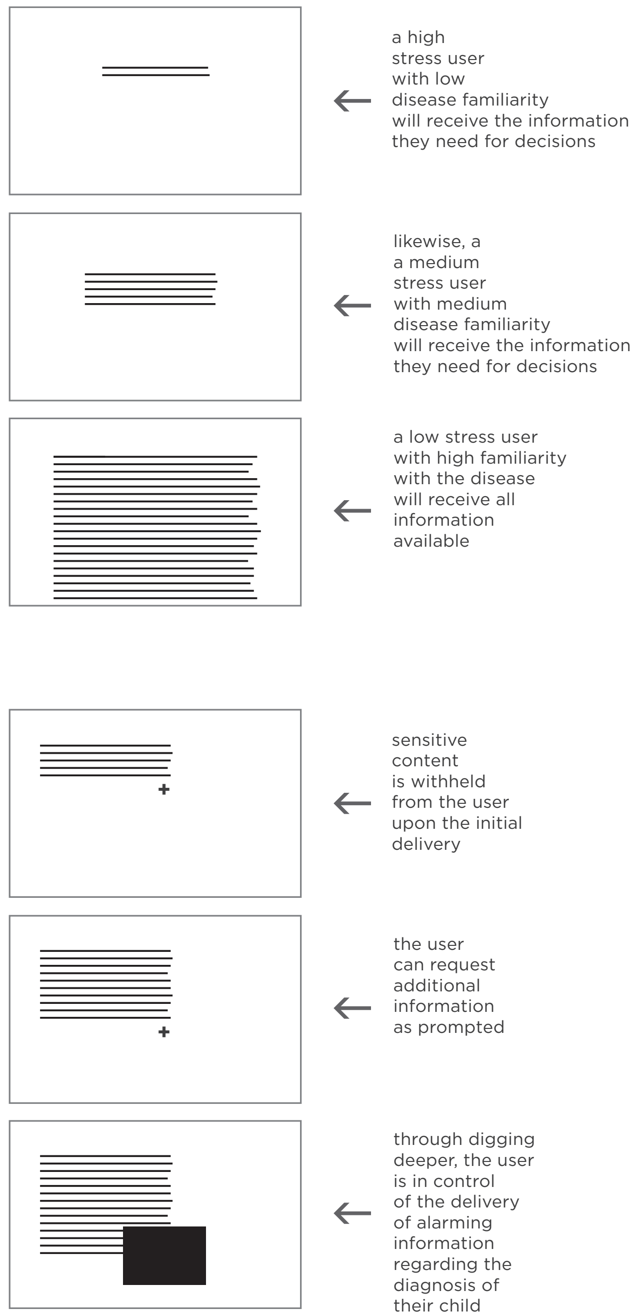
SECTION FOUR

THE POSSIBILITIES

SCENARIO

The parent has just left the doctor's office after receiving the diagnosis of Batten's Disease for her four-year-old daughter. The news is devastating. She immediately goes home and begins to search for information about the disease online. The first stop is Google. The internet floods with results. Within minutes, the parent finds out that her daughter is going to lose her eyesight by the age of six. And by the age of eight, she will be completely immobile, fully wheelchair bound. How horrifying! The worst news is that children with this diagnosis rarely live past the age of 12. This diagnosis was so unexpected, and on day one, the parent was unprepared for the shocking news of what the next few years would hold.

Instead of the typical "flood with all results" search engine result page (SERP), the proposed feature of Withholding Information presents information that is essential to a novice or stressed user, holding back sensitive content until they are cognitively ready to digest that information. Even in situations where the information may not be traumatizing, presenting advanced medical terminology in search results to a parent of a recently diagnosed child can increase confusion regarding health outcomes and treatment options. Tailoring information to a user's knowledge level can assist in effective decision making and reduce unnecessary cognitive strain and emotional upset.



TOOLS FOR SEARCHING

final feature one

As the interface I am designing is primarily a search user interface, it is essential to look at adaptive search tools. A caregiver in a recently traumatized state has limited time, patience, and mental faculties to deal with traditional search engines which flood the interface with results, causing information overload. For this study, I used Cognitive Load Theory to develop search tools that interpret and learn from user search behavior allowing for adaptive and personalized ways of delivering and consuming information according to the user's cognitive state. The final feature that appears in this search category is "Withholding Information." Study one was designed using Aarskog-Scott Syndrome information. Study two was designed using Progressive Multifocal Leukoencephalopathy information.

/

The explosive growth of the World Wide Web as a medium for information dissemination caused several new problems, which have to be solved. The problems are often linked to continuously increasing amount of information that we are faced with.

/ *Mária BIELIKOVÁ*

WITHHOLDING INFORMATION

The concept for this feature came from a conversation I had with the grandmother of a rare disease patient. This grandmother assisted her daughter (the parent of a child with a rare disease) in collecting valuable information from a closed Facebook support group. The grandmother served an essential function. Her daughter needed information to help her child who was suffering from a rare disease. However, she did not want to see posts from families talking about children “getting their angel wings” (common social media lingo indicating the death of a child). The grandmother actively withheld the information her daughter wasn’t ready to read while gathering the information she required. Can an interface serve as a virtual information sponsor, protecting the user from seeing things that cannot be unseen? In contrast with traditional online medical search engines which flood the user with all information up front, this feature proposes allowing the user to self-time the discovery of weighty health information.

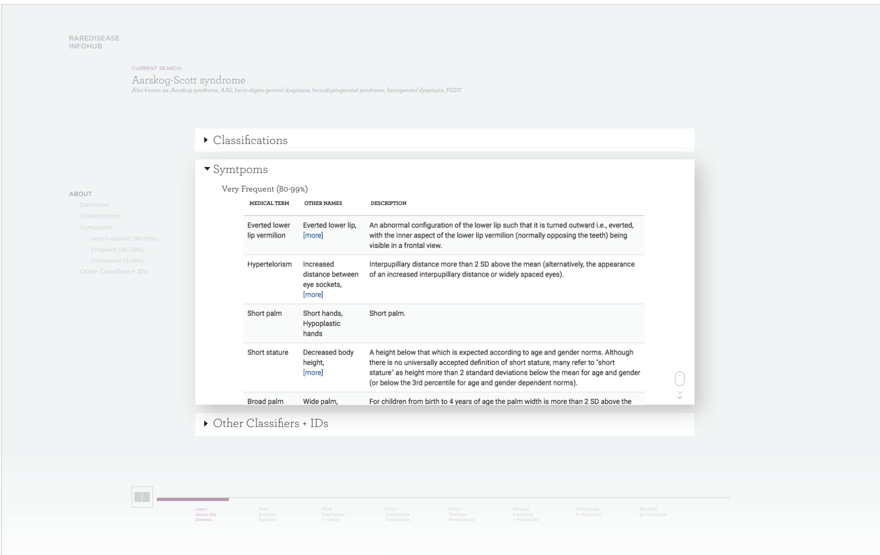


FIGURE 4.1 (above): *Context for the symptoms page, before the user begins to scroll.*

FIGURE 4.2 (right): *Scroll pattern for a user viewing the list of symptoms. A user would need to scroll ten times to see the full list of symptoms.*

WITHHOLDING INFORMATION: STUDY ONE

SENSITIVE INFORMATION, DIGGING DEEPER

In this first study of Withholding Information, I was interested in exploring the potential of on-demand content delivery. Traditional search engines provide the user with as much information is available upon the first request. In contrast, how would a search engine function if the interface holds back some information from the user upon the initial inquiry?

Figure 4.2 is an example of an interface presenting all the information upon initial inquiry. In this screen, a user has searched for symptoms of Aarskog-Scott Syndrome. To better help a user to understand the likelihood that a patient will experience a disease symptom, the system categorizes the results by "very frequent", "frequent", and "occasional." Figure 4.2 visually demonstrates the way a user would scroll through the results. From top to bottom, the user will scroll ten times to view the full set of symptoms.

According to Bunt, Carenini, and Conati *(2007)*, when a system displays large amounts of content, it increases the chance of generating information overload and reducing attention. In this scenario, as the system adapts to the stressed user, prompts are given to allow for self-paced digestion of the information (Figures 4.3-4.7). The system contains all of the same information as is displayed in Figure 4.2, but the Withholding Information feature gives more control to the user in determining the level of detail they would like to read.

I explored overlaying information boxes that span horizontally. Bunt, Carenini, and Conati *(2007)* discuss two different relevance-based content presentation techniques that were pertinent to this study: maintaining focus and maintaining context. By working in overlapping boxes of information, I was able to maintain reader focus by emphasizing what content is most relevant for the user. Each box is backed with a drop shadow, creating the illusion that other items on the screen are further back and less relevant. I also was able to maintain context as each item—even unselected categories such as "Cognitive Disorders" (Figure 4.4)—remain on the screen. Less-relevant items fade to 50% opacity yet stay visible to preserve the contextual information that they may provide.

As the system presents boxes of information, prompts are provided to click "MORE" for increased details. When getting into the technical terminology, a user has the option to lookup definitions or ask the system to remember information for later. By presenting the information in small chunks at the request of the user, the content is more digestible, easier to understand, and less overwhelming.

INFORMATION OVERLOAD
exposure to or provision of too much information or data

CHUNKING
breaking text and multimedia content into smaller chunks to help users process, understand, and remember it better

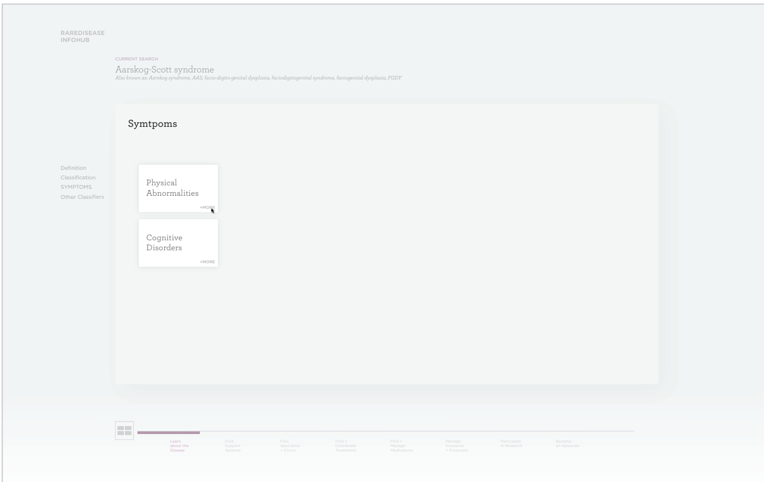
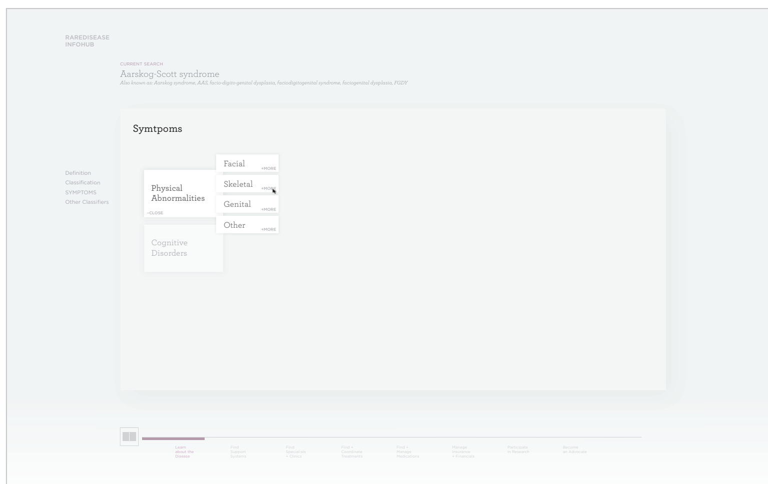


FIGURE 4.3: *Instead of delivering symptoms according to frequency rates (a meaningless statistical value for a novice, stressed user), symptoms appear under broad categories. For this example using a search for Aarskog-Scott Disease, symptoms appear in one of two classes: "Physical Abnormalities" or "Cognitive Disorders." The user has the opportunity to learn what symptoms fall into those categories by selecting "MORE."*

FIGURE 4.4: *The user has selected "MORE" on the "Physical Abnormalities" card. The interface presents four categories of physical abnormalities: facial, skeletal, genital, and other. The user clicks on the "Skeletal" button to learn more details about those symptoms.*



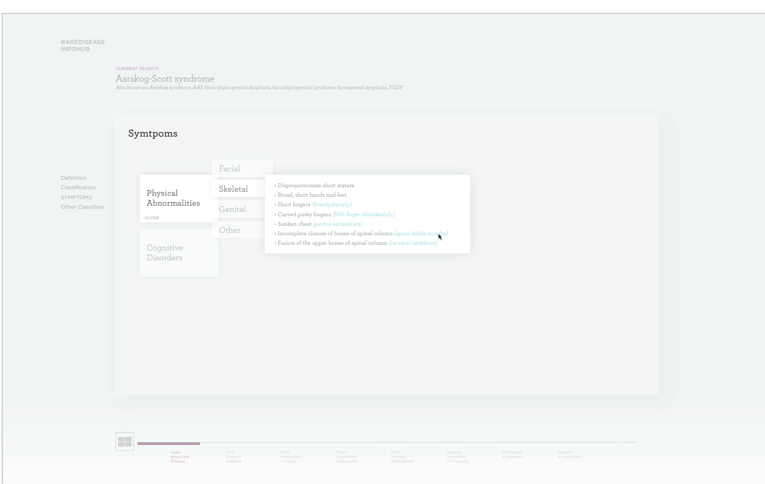


FIGURE 4.5: *After choosing to see more detail about the skeletal abnormalities, the user receives a list of seven common language symptom descriptions. For symptoms with technical definitions, the terms appear in blue text, indicating they are links for more information.*

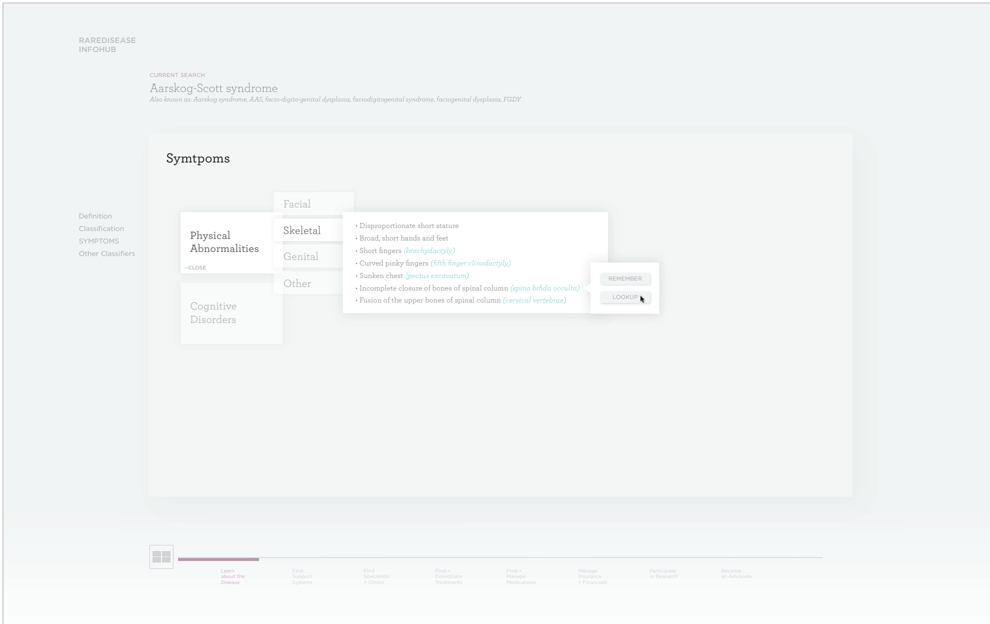


FIGURE 4.6: *The user clicks on the term "Spina bifida occulta." The interface offers the user options to either "Remember" or "Lookup." Remember is a function of the system where a user can save specific information for future reference. Lookup is another way of digging deeper into the data.*

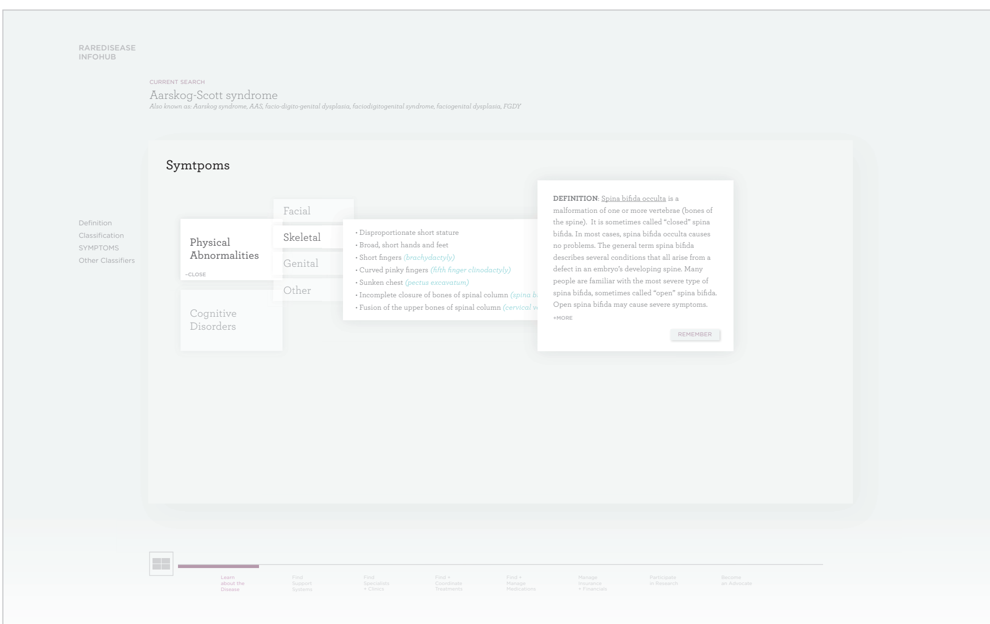


FIGURE 4.7: *After choosing the "Lookup" button, the technical definition for Spina bifida occulta appears. The user can see the path of their learning, which helps to maintain context, facilitating a lower-stress user experience.*

WITHHOLDING INFORMATION: STUDY TWO

ADAPTIVE PRESENTATION TO FACILITATE DECISION MAKING

For the second study of Withholding Information, I explored adaptive presentation strategies in the context of a user looking for a disease specialist. According to Ramachandran *(2009)*, customizing content to a user based on their current knowledge, goals or other relevant characteristics (such as cognitive state) is the goal of adaptive presentation. In this study, the system is using adaptation to present essential information to different user groups to facilitate decision making.

The user is searching for a disease specialist. It is often difficult to find a doctor who specializes in a rare disease. For the interface I am proposing, an algorithm would facilitate the selection process based on specific criteria. First, the system would look for doctors who have conducted a clinical trial on the rare disease. Second, it would search for published journal articles on the rare disease. Either of these cases would indicate a high likelihood that a doctor had a certain level of specialty with the disease in question. If the system is unable to find a doctor that met either criteria, it will proceed to locate doctors that specialize in the body system the rare disease affects.

Consider a user is searching for a Progressive Multifocal Leukoencephalopathy specialist and the interface is using published journal articles as the criteria for the results (Figure 4.8). For a novice user, the number of articles serves as the best indicator that a doctor may be a good fit as "1 article" means something to the novice user. It's fair to assume that a novice user understands a presence or increase in published articles may indicate the likelihood of the doctor in question being a disease specialist. Subsequently, an expert user will benefit from the additional information contained in the report abstract as the medical terminology means something to them and may help indicate if this doctor is indeed the type of specialist they need. Presenting the abstract to a novice user would be counterproductive. First, it would increase stress and cognitive load as the user is unfamiliar with the terminology introduced. Second, the content is meaningless and leaves the caretaker feeling inadequate for lacking the advanced knowledge. Figure 4.8 is a simple demonstration of adaptive presentation for three different user familiarity levels, two of which benefits from Withholding Information. See Figures 4.9-4.11 for a more contextualized view of this study.

ADAPTIVE PRESENTATION
personalizing the contents of a page presented based on a significant characteristic of the user, such as knowledge level or goals. Changing the language of the materials or modifying what contents are two ways this can be implemented

USER = High Stress / Low Familiarity

Content = **# of Articles**

1 Articles

USER = Medium Stress / Medium Familiarity

Content = **Articles Titles**

Autosomal dominant Kufs' disease: a cause of early onset dementia.

USER = Low Stress / High Familiarity

Content = **Article Abstracts**

Kufs' disease is the rare, adult-onset form of the neuronal ceroid-lipofuscinoses (NCL). Two clinical Kufs' phenotypes have been described, one featuring generalized tonic-clonic seizures and the other characterized by dementia. Autosomal dominant inheritance of Kufs' disease has been reported for only two families. The genetic and molecular defects underlying Kufs' disease are unknown. We report a third family with apparent autosomal dominant Kufs' disease in a family of English ancestry. Ten individuals (five men, five women) have been affected over five generations. Age of onset typically is in the fourth decade of life and is heralded by seizures. Clinical and neuropsychological assessments in several affected individuals, however, confirm the presence of dementia and follow-up evaluations suggest that dementia is the primary disabling feature of the illness. Motor abnormalities also are frequent. Neuropathological examination (three cases) documents the presence of neuronal lipopigment accumulation consistent with NCL. The combination of dementia and seizures in this and two other reported families with autosomal dominant Kufs' disease suggest that this entity represents a distinctive clinicopathological entity. Dementia is prominent but is almost always associated with generalized seizures and motoric disturbances early in the disease course. Kufs' disease should be considered in the differential diagnosis of early onset, atypical dementia.

FIGURE 4.8: *The above chart shows three levels of adaptive presentation for three different user types. First, the novice user receives the information about the number of available published reports. The mid-level user will also see the titles. Finally, the expert user will see article abstracts as well. As the user gains familiarity with disease information and medical terminology, the information presented will be comprehensible according to their current experience level.*

FIGURE 3.8: *Figure 4.9: For a novice user, the number of articles serves as the best indicator for choosing if this doctor may be a good fit as "1 article" means something to the novice user.*

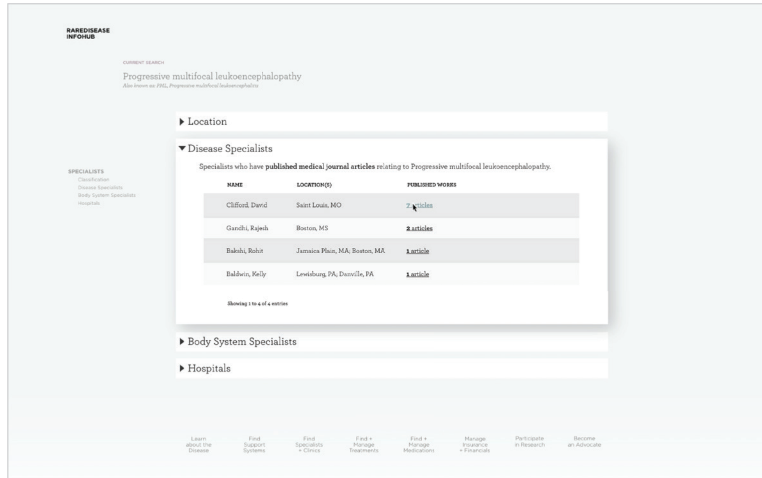


FIGURE 3.8: *Figure 4.10: When the user rolls over "7 articles", a pop up containing the article titles appears within the space. Context is more easily maintained if the user can still see some or all of the original content (Bunt, et al. 2007a). Keeping context reduces the cognitive load of difficult navigation tasks.*

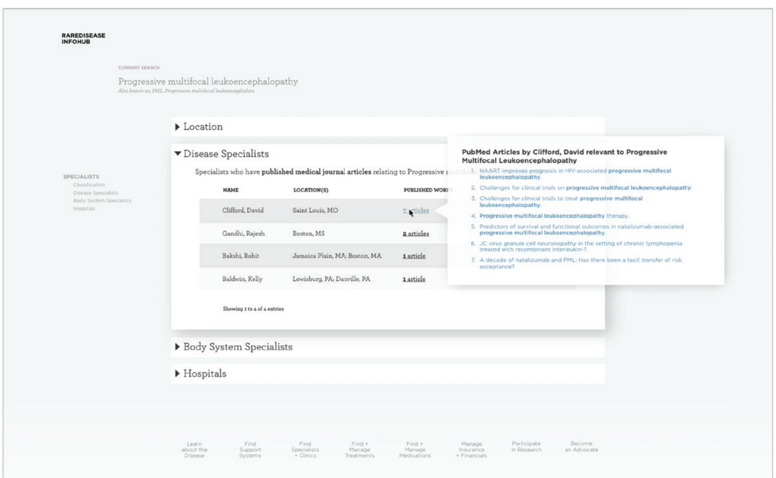
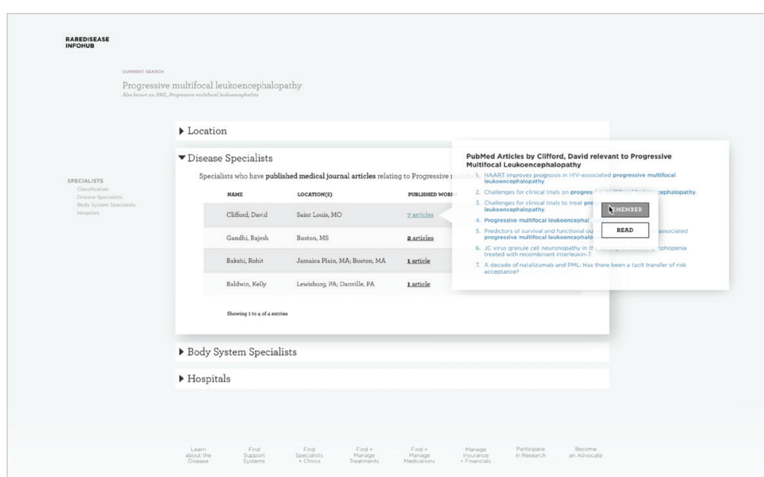


FIGURE 3.8: *Figure 4.11: This screen shows an example of the information presentation strategy of remembering. The user can indicate that this article is essential to read, but save it for a later date.*



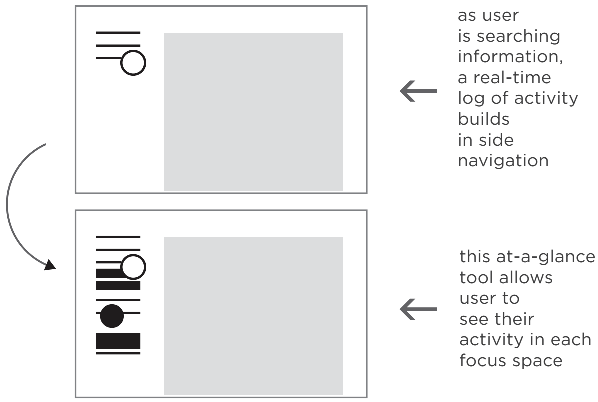
SCENARIO

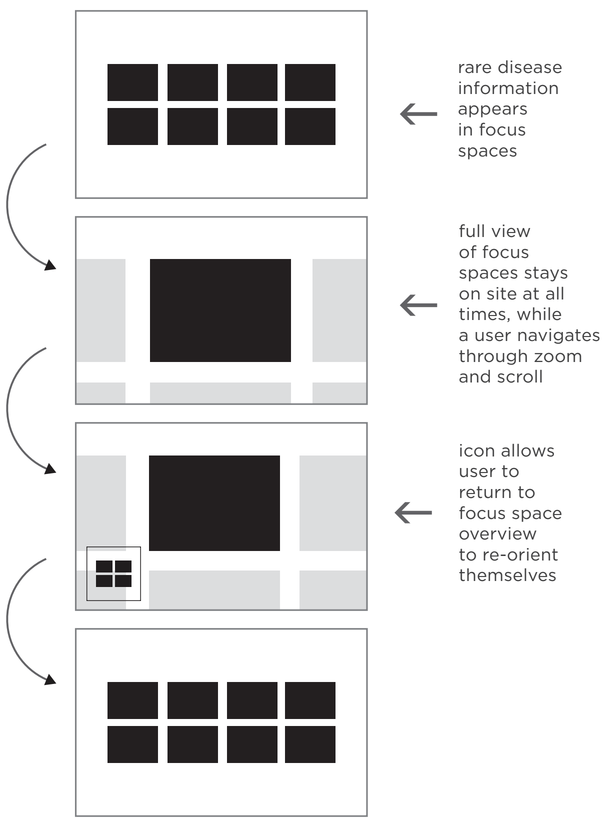
When frantically searching for medical, financial, and personal information while in a stressed state, the caregiver finds themselves jumping from page to page in traditional website navigation. Throughout the process, they struggle to orient themselves within the site.

How do they get back to the information they were viewing a few minutes ago? What information is under what heading? The mental energy that goes into learning and remembering how to navigate a website competes with the user's ability to find, comprehend, and retain the information they are seeking.

To alleviate the competing attention and energy required to navigate traditional websites while searching, I am proposing two features to assist the user in a high-stress cognitive state.

The interface will be designed to assist the user with navigation through aiding in the development of a mental map, facilitating the creation of an effective browsing strategy. Color is a secondary navigation cue.





TOOLS
FOR NAVIGATING

final features two + three

Another consideration in addressing the user in a high-stress cognitive state is navigation. Cognitive load increases when a user needs to contend with an interface along with the information the interface contains. Information overload can occur (McCall, 1998). For this study set, I used Spence's Navigation Framework to develop information navigation aids that respond to a caregiver's cognitive state as s/he acquires and archives health information. The final features that appear in this navigating category are "Mental Map Navigation" and "Continuous Annotated Side Navigation." Both of these studies were designed using Juvenile Neuronal Ceroid Lipofuscinosis information.

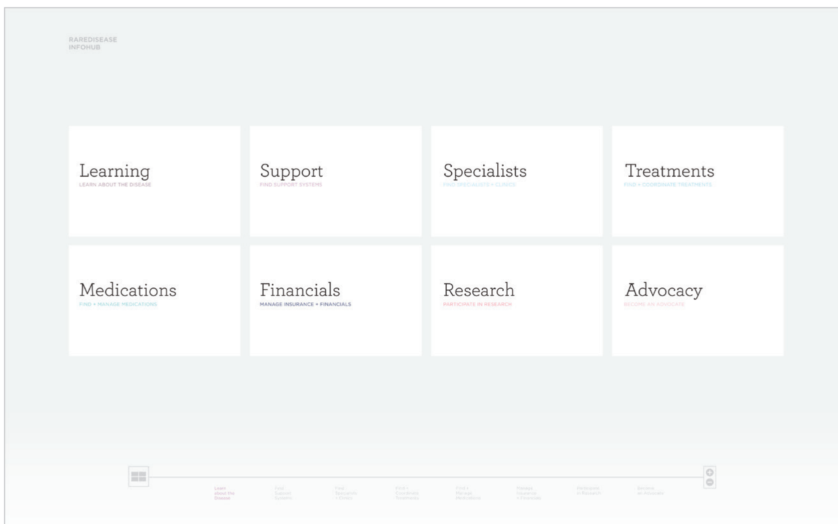


FIGURE 4.12: *The above interface is split into eight designed focus spaces that represent that various zones of information a user will search to aid in caretaking and health maintenance tasks.*

MENTAL MAP NAVIGATION

Similar to the way people move through the physical world, landmarks, districts, paths, and edges all serve as a means for users to visually locate the desired location. User's construct a mental map of a space to move within a digital information environment. Providing navigational cues to the user is key to aiding in spatial awareness. "Interfaces which use grouping of menus and buttons are in essence imposing a map upon the user. In doing so, these interfaces are attempting to encourage the user to think in terms of an overview (survey knowledge) of the interface" *(McCall, 1998)*.

I was interested in exploring how an interface can aid the user with externalizing a mental map of the site structure. In doing so, could this reduce the cognitive strain of navigation? The goal of this study is to facilitate a more efficient and useful experience for the caregiver in a high-stress cognitive state.

McCall discusses the concept of focus spaces in GUIs. A focus space is a grouping or chunking of related pieces of information which allows users to interpret and focus on the data of interest efficiently. "The idea of the focus space is to allow the user to focus attention on what is important thus reducing problems of information overload and divided attention." The information presentation strategy "Chunking" (see page 59) promotes the idea of spaces for particular tasks.

Neilson *(as cited in McCall, 1998)* notes that novice users struggle with information overload when navigating interfaces. The use of designed focus spaces can reduce this problem. For this study, I dividing the sitemap into the eight user interaction hubs (Figure 4.12). By serving as focus spaces for the eight user interactions (see page 61) the interface will support focused attention.

MENTAL MAP
a person's thought process about how something works in the real world; their mental representation of the surroundings

SPATIAL AWARENESS
a person's knowledge of objects in relationship to themselves in a given space

INFORMATION OVERLOAD
exposure to or provision of too much information or data

Navigation is the cognitive process of acquiring knowledge about a space, strategies for moving through space, and changing one's metaknowledge about a space.

Laura Leventhal

MENTAL MAP NAVIGATION: STUDY ONE

CARTESIAN COORDINATE SYSTEM

In my first Mental Map study, I designed for navigation based on a Cartesian coordinate system (Figure 4.13). By developing a navigation system similar to a cartographic map, the user has an appropriate schema for how to navigate this new "information map." According to Old *(2002)*, the "contents" of an information map are information objects, or landmarks, situated in the coordinate system.

When first approaching this portion of the interface, the user sees the eight focus spaces (Figure 4.14). They see the entire contents of the interface at first glance. Each focus space represents an opportunity where they can travel—or dig deeper—to consume information.

The user double-clicks a focus space to move into it. Instead of taking the user away from the page—the way traditional breadcrumb navigation would function—the site zooms in on the selected area. In the example shown on the next page, the user has chosen to view the Advocacy area (Figure 4.15, Screen B). An animated zoom occurs, enabling the user to continually orient themselves within the broader information map.

Once fully zoomed in, the user can scroll among the various focus spaces, a task aided by the memory of the map overview experienced up front. If the user chooses to go back to the overview of the eight information focus spaces to re-orient themselves, they simply select the icon in the lower left-hand corner of the screen (Figure 4.15, Screen G).

What I am proposing with this study is a navigation system in which the entire site is available, or visible, to the user at all times. They simply zoom and scroll at will while the interface provides cues for orientation. Enabling a user to zoom in and out while navigating interface objects and spaces preserves continuity and spatial narrative *(Willenskomer, 2017)*. This seamless transitioning between the site overview and the focus spaces supports usability by communicating additional areas of content outside of the current view while the self-guided zoom feature facilitates the creation of a spatial mental model for the user.

In his navigation framework, Spence (1999) notes that it is crucial for the content a user is browsing to match the type of internal mental map most relevant to the task involved. The user is accustomed to using search engines for collected information. For this reason, each focus space displays results in the familiar mental model of a scrollable, single page website (Figure 4.15, Screen F).

CARTESIAN COORDINATE SYSTEM
a system of numerical points on perpendicular lines intersecting at a central point called the origin; Cartesian coordinates serve to pinpoint location on a map or graph

CARTOGRAPHIC MAP
a diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc.

BREADCRUMB NAVIGATION
a secondary navigation scheme showing the user's location in a website; horizontally arranged text links separated by the "greater than" symbol

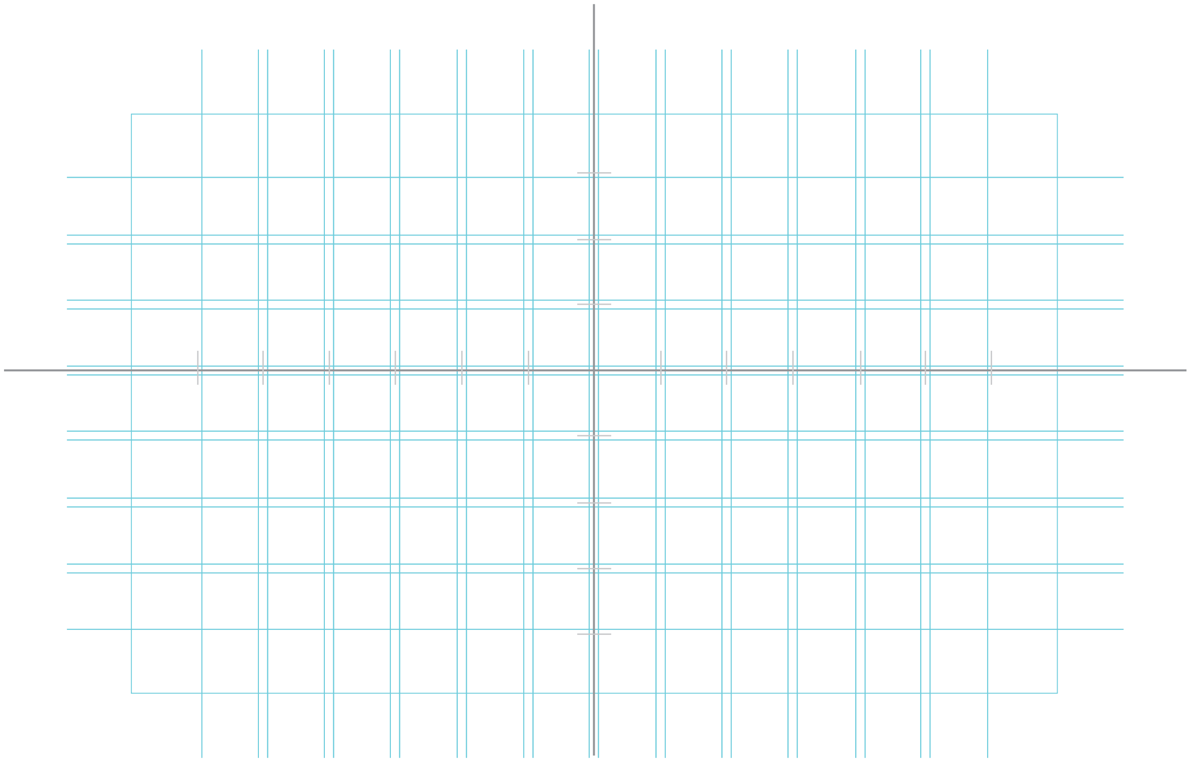


FIGURE 4.13: *Site grid structure inspired by a 2D Cartesian coordinate system.*

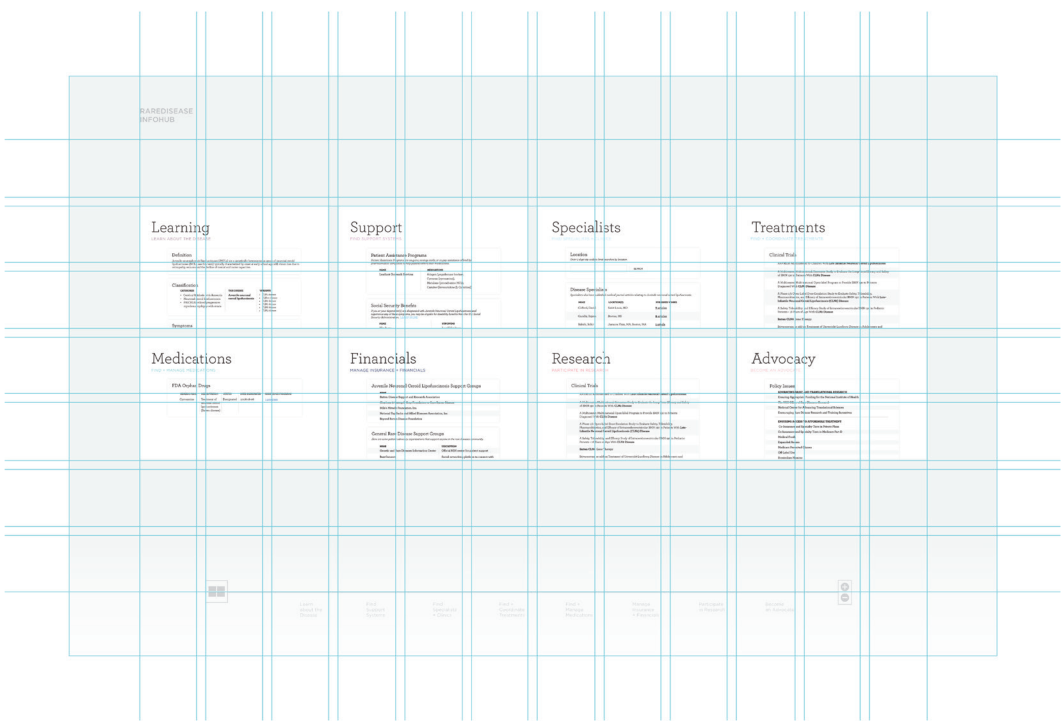
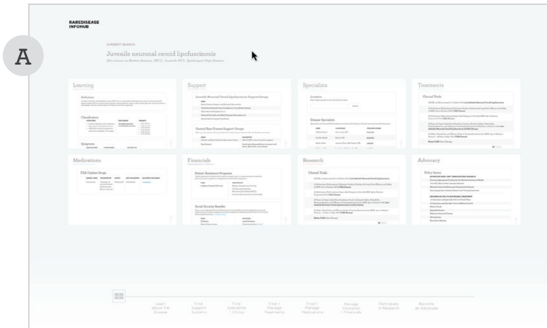
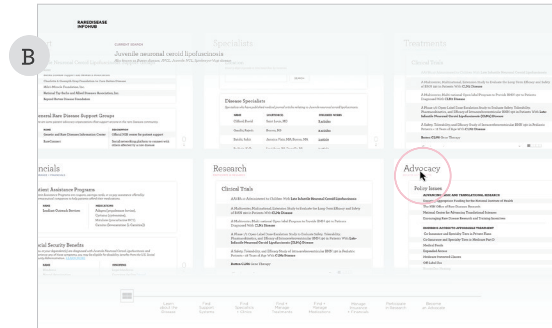


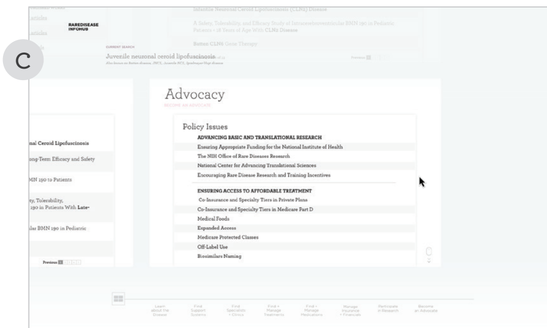
FIGURE 4.14: *Here the eight focus spaces have been populated with appropriate content regarding the disease Juvenile Neuronal Ceroid Lipofuscinosis.*



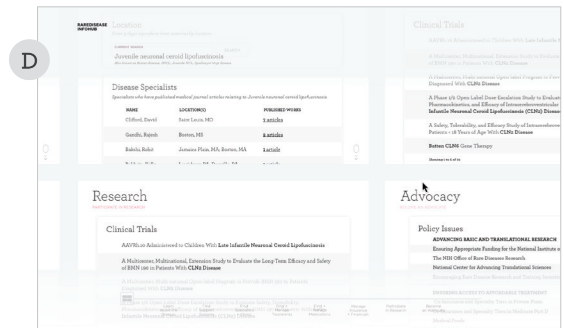
system overview



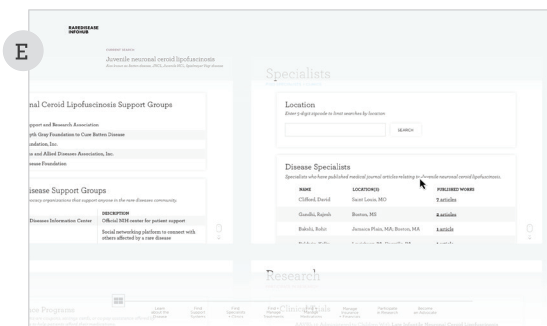
user clicks on the "Advocacy" focus space to zoom in



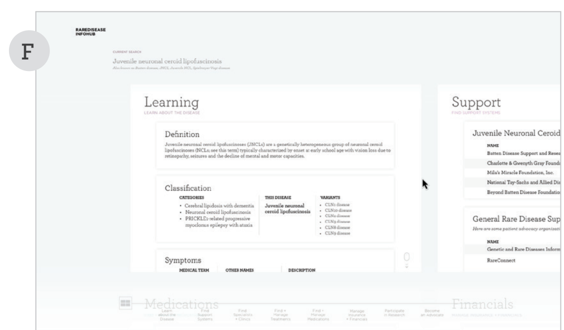
user sees animated zoom, which aids in maintaining orientation



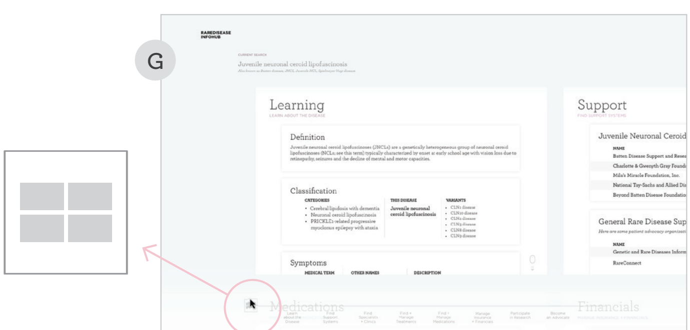
user can scroll amongst the focus spaces



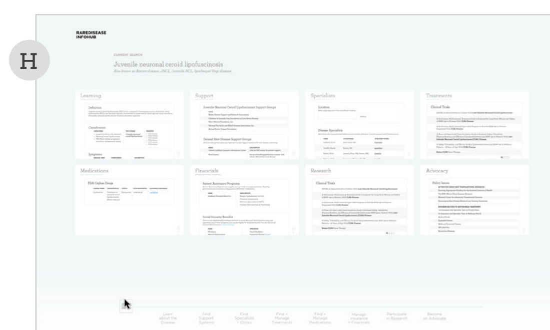
scrolling provides easy jumping from space to space



when in focus area it appears to be a single, scrollable webpage



icon is designed to represent the homescreen of eight focus spaces



clicking the icon user returns to the overview of the system

FIGURE 4.15: *Screens A through H represent a user interacting with an information space via a Cartesian coordinate inspired navigation system.*

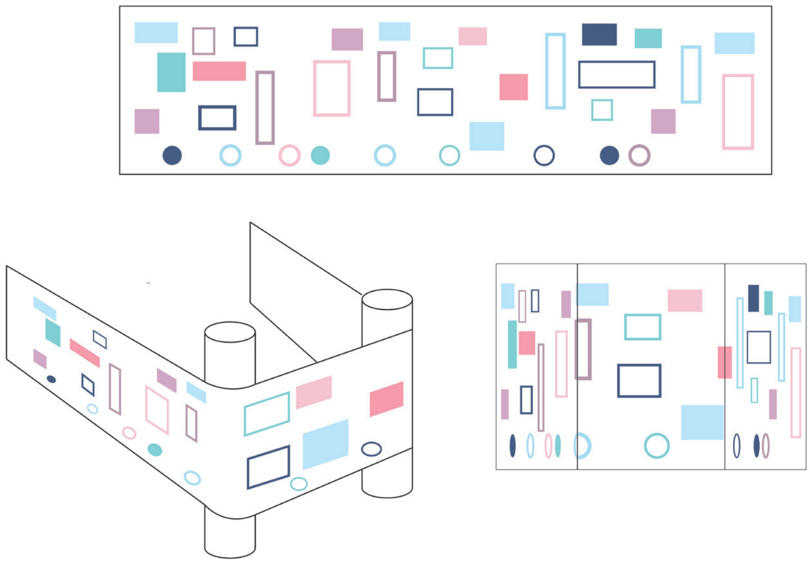


FIGURE 4.16 *(adapted from Robert Spence and Mark Apperley's bifocal display concept): Principle of the bifocal display: (a) information space much larger than the screen containing documents, email, etc., (b) the same space "wrapped" around two uprights and viewed as shown, and (c) the view seen by a user from an appropriate direction, and scrollable as suggested in (b) (Spence, 1999).*

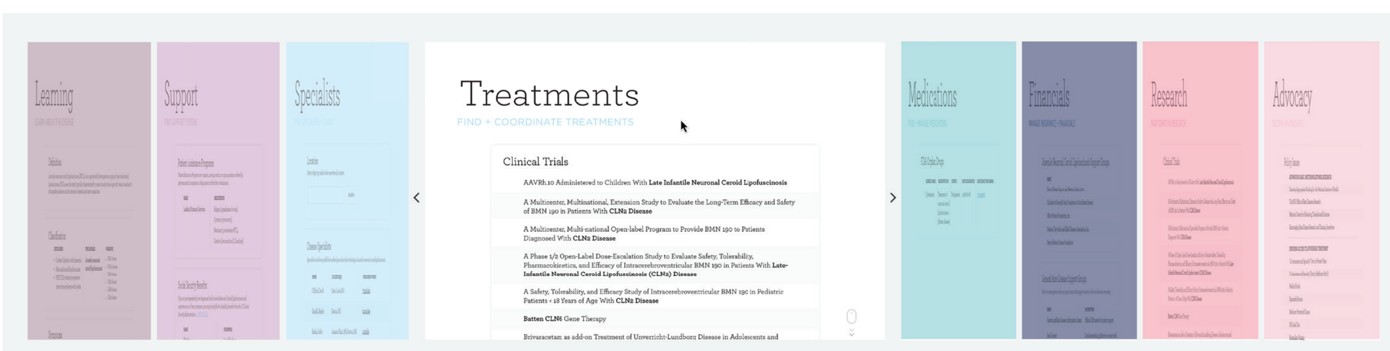


FIGURE 4.17: *This study is showing the use of the bifocal display presentation technique with greyed out content.*

MENTAL MAP NAVIGATION: STUDY TWO

BIFOCAL DISPLAY

Farrand *(as cited in Soeggard & Dam, 2011)* observed that "an effective transformation [of data] must somehow maintain global awareness while providing detail." This observation is used often in the field of human-computer interaction when discussing concerns of facilitating a user's contextual awareness in cases where all the information cannot fit on a screen. Spence and Apperly *(Spence, 1999)* created a solution to this problem with their information presentation technique known as the bifocal display.

The bifocal display allows a large information space to be viewed as a whole while showing only a portion in full detail. The user sees the detail in context of the whole. Seen in Figure 4.16, parts of the information space are "bent backwards" at an angle to allow everything to fit into the display area. Spence *(1999)* describes the information presentation technique as follows: "Since items in the peripheral areas would be unreadable because they are 'squashed', their text and similar small detail is automatically removed; nevertheless, the color of each item is still discernible. Thus, a red rectangle towards the left edge of the information space denotes a [type of information], an item that can be scrolled into the central region, there to expand horizontally and become readable. Such a display offers a clear indication of sensitivity in the sense that the user now knows the approximate distance of the [information] from the central region, and hence the distance it has to be moved to make it readable."

For my bifocal display study, one of my focus spaces visibly fits in the display area. In Figure 4.17, "Treatments" is in full detail. While distorted, the other seven focus areas still appear to the user. The color transparencies overlaid on the squashed sections are fulfilling two purposes. First, the color is a navigational cue for each focus space. Second, the color is serving to "gray out" irrelevant content—another one of Spence's suggestions *(Spence, 1999)*.

Creating sites that externalize the mental map can reduce the cognitive load of the user, but in cases where a full externalization is too complicated, this can be overwhelming and distracting *(Spence, 1999)*. For this study, I am employing both the bifocal display and the graying out of irrelevant content to allow the user to focus on the information at hand (Figure 4.17).

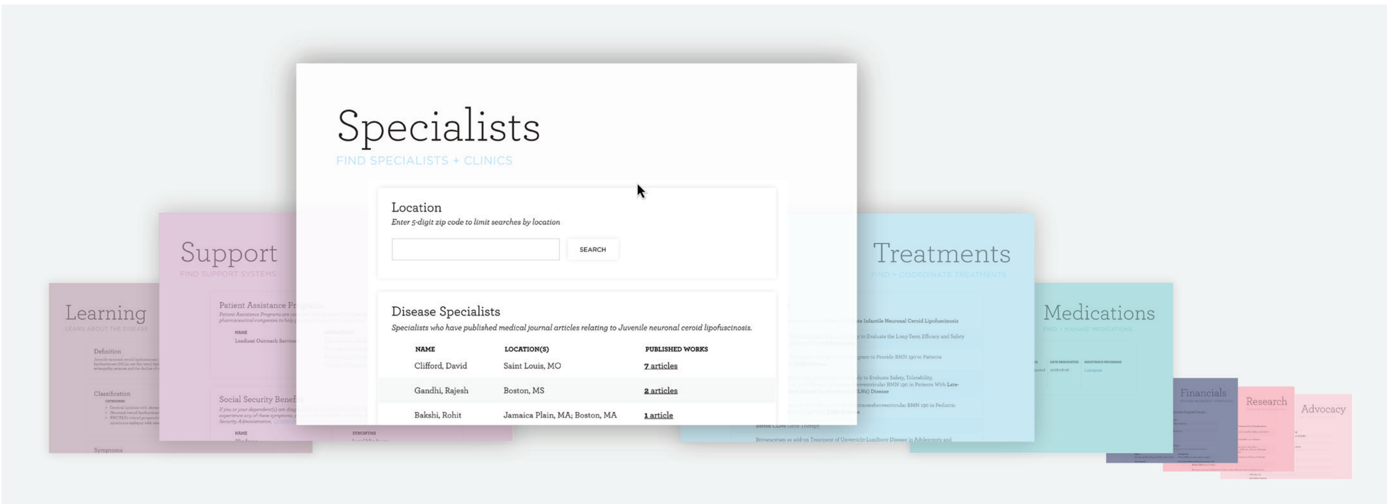


FIGURE 4.19: *In this study, I explored the use of both the bifocal presentation technique and graying out content. Pictorial depth cues (interposition, shadow, relative size) are employed to signify "Specialists" as being the information the user is currently interacting with.*

FIGURE 4.20: *Iteration two of fisheye technique further exploits the distortion of secondary content. The increased distortion lowers the likelihood that these focus spaces will distract the user from the "Specialists" content.*

MENTAL MAP NAVIGATION: STUDY THREE

FISHEYE TECHNIQUE

A variant interpretation on the bifocal display is the fisheye technique (Figure 4.18). An example familiar to many graphic designers is the animated display of application icons in the Mac OSX operating system. In the fisheye technique, an information object responds to a user's scroll-over by enlarging dynamically. To the left are two iterations that employ the fisheye technique and the graying out of secondary information (Figures 4.19–4.20). Interacting dynamically to the user's scrolling, the focus space under the cursor would enlarge dynamically and come into focus.

FIGURE 4.18: *In the fisheye technique, an information object responds to a user's scroll-over by enlarging dynamically*

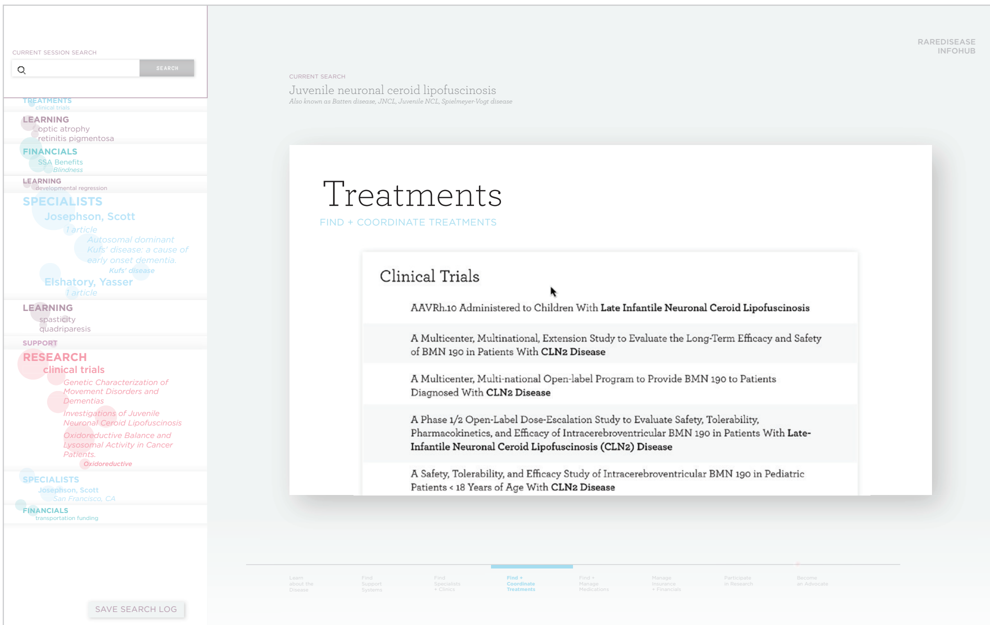


FIGURE 4.21: *As the user participates in information-seeking behaviors, a feed tracking search activities appears in the left-hand navigation panel. The feed provides at-a-glance information about search activity.*

CONTINUOUS ANNOTATED SIDE NAVIGATION

When a person approaches a search engine with an urgent need for health- and life-saving information, the search episode may consist of a user sporadically jumping from link to link. In such instances, traditional back-and-forward navigation buttons fail to support the user's current search behaviors. Additionally, as stress impairs memory function, the user will have increased difficulty remembering where they encountered specific information within the search episode. To better assist the cognitively-strained user in searching, researching, and wayfinding behaviors, I am proposing an ongoing, rolling history sidebar that provides at-a-glance information about where the user has been and what information they have interacted with during their current search episode.

As the user participates in information-seeking behaviors, search activities feed into the left-hand navigation panel (Figure 4.21). The information is dynamic, allowing the user to manipulate it through moving material in the panel, deleting information or adding annotations. Giving the user the ability to interact with the data spatially, adapting the interface as they proceed, further enhances their mental map of the site *(McCall, 1998)*, reducing the effort it takes to navigate the information space.

The recorded information appearing in the activity feed is designed to provide context to the user about their search episode. Activity is listed chronologically, with the newest activity at the top. Search events will appear in clusters, corresponding to each focus space. Clusters contain words looked up, files selected, and information saved. These levels of information take on a particular hierarchy. First, the more items a user looks up or searches in a focus space, the longer that portion of the list will be. Second, the longer the time spent on that page, the larger the font. By providing these levels of hierarchy in the design of the activity feed, a user will be able to see at-a-glance the significance each focus area played in the search episode. In Figure 4.21, after the user spent a significant amount of time searching for a new doctor in the "Find Specialists and Clinics" focus space, this information and corresponding color holds an increased hierarchy in the side panel.

In addition to providing at-a-glance information about a search session, users will have additional control over this panel. Users can add annotations to any item appearing in the activity feed, making notes for future reference (Figure 4.24). Affordances include the ability to delete unwanted clusters of information from the feed, drag-and-drop clusters into a particular order (Figure 4.22-4.23), the ability to collapse to minimize a cluster and expand when the user wants to refer to the information later. A focused search field isolated only to the contents of the side navigation appears at the top of the panel; a user can look for information they remember seeing but are unable to find upon first glance. At the end of each search session, the user has the option to save the search history, including collected annotations, for later use.

By providing a user with a continuously updating side navigation, supplying context for a search session and the ability to self-annotate, the interface is assisting the user with finding and re-finding information. Often hampered when stressed, re-finding information is a vital search activity. The visual nature of the Continuous Annotated Side Navigation provides the at-a-glance visual context the user needs to trigger the memory of where information was seen, increasing the likelihood of re-finding when required.

ANNOTATION
a note of explanation or comment added to a text or diagram

RESEARCH
diligent and systematic inquiry or investigation into a subject

DYNAMIC
capable of action and/or change

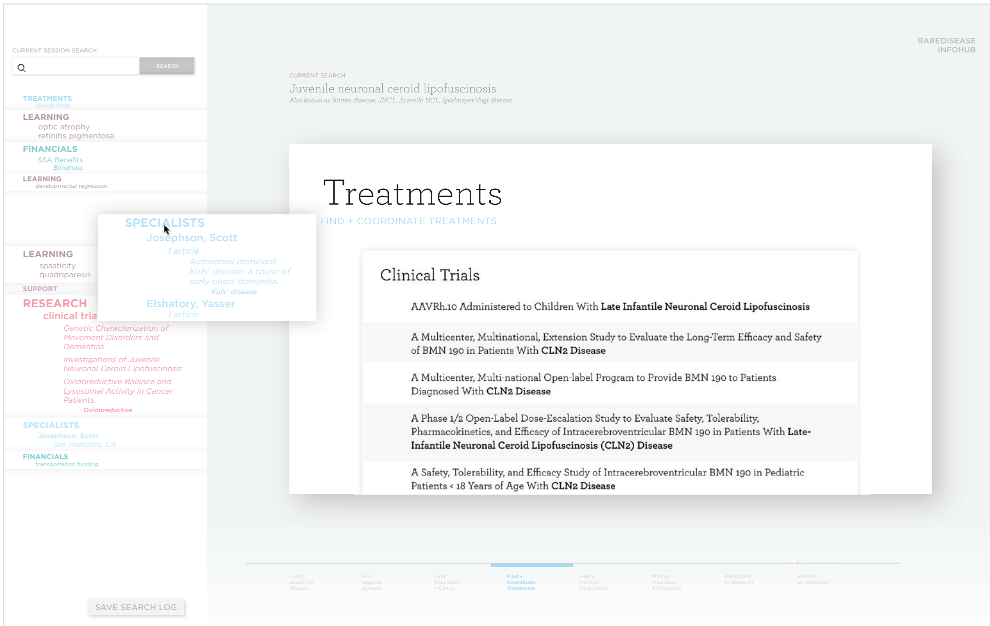


FIGURE 4.22: *The user has the ability to drag-and-drop clusters into a particular order. In this screen, the user is pulling the "Specialists" cluster from its current location.*

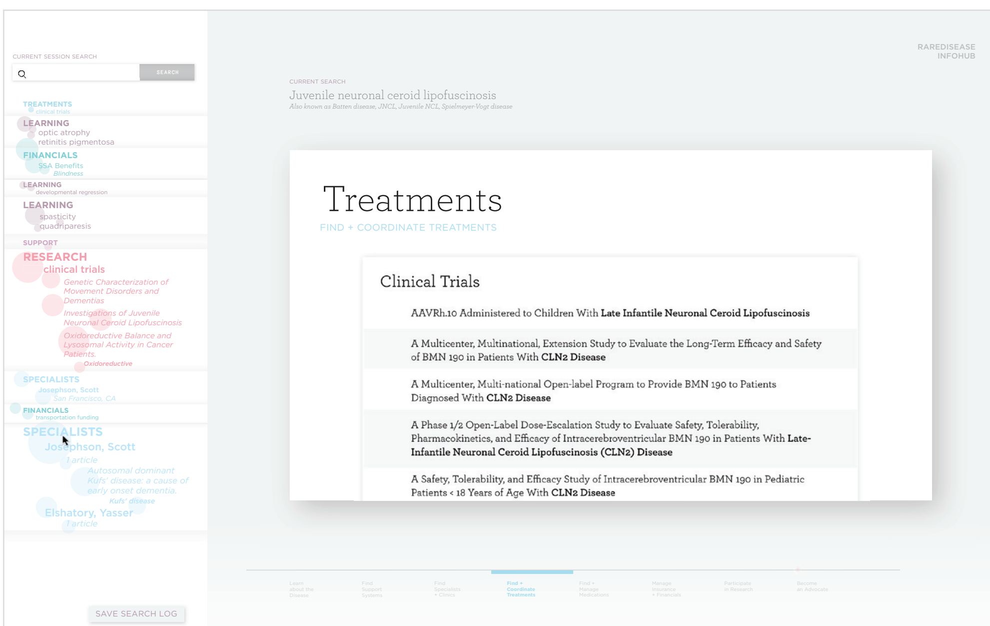


FIGURE 4.23: *After the user pulls the "Specialists" cluster, they drag it to the bottom of the list and drop it under "Financials."*

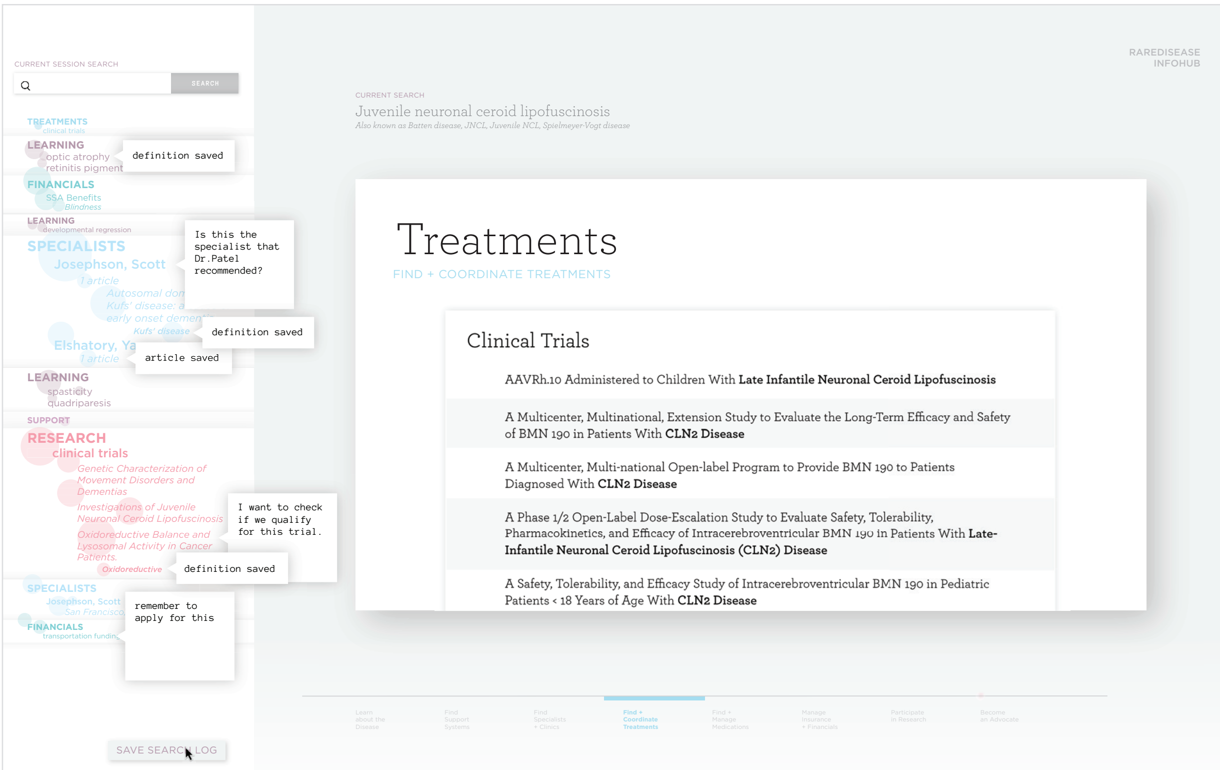
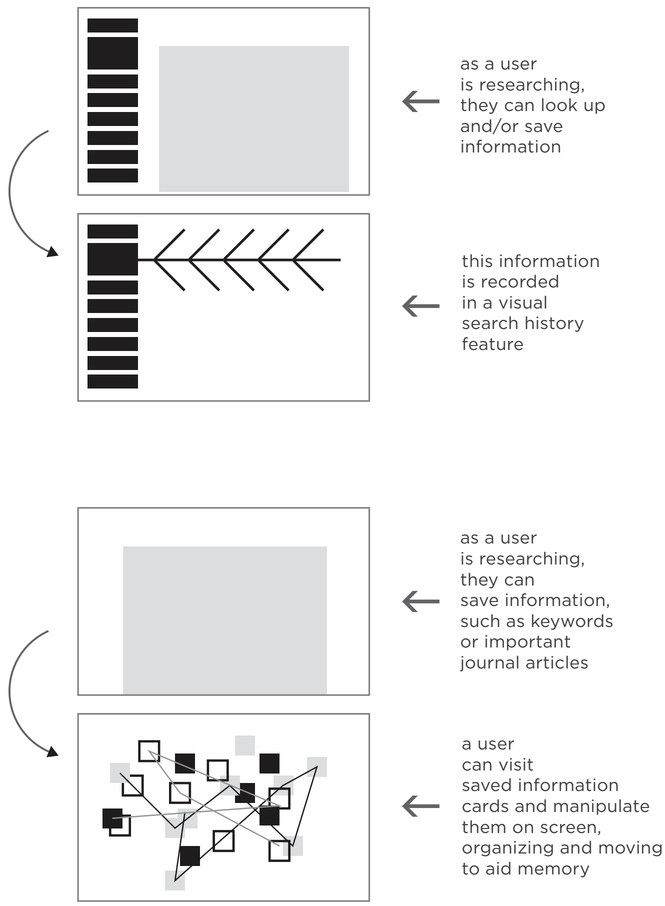


FIGURE 4.24: *Users can add annotations to any item appearing in the activity feed, making notes for future reference*

SCENARIO

The parent is collecting as much information as he can about his child's rare disease diagnosis. He has conducted the majority of his research on one website he trusts to have reliable information. He's been searching non-stop for hours. Each time he reads a new chunk of information, he comes across an unfamiliar term or a new resource. He immediately starts a new search. As he clicks and reads and clicks and reads, he has little hope to find his way back to information he viewed earlier.

How could this series of interactions be aided by a visual search history feature? Can the visualization represent the way people follow learning trails while navigating online?



TOOLS
FOR STORING

final feature four

With a parent's stress-related cognitive challenges after a new diagnosis, finding, understanding, and remembering critical medical information can be a challenge. In the scenario that follows, the user is visiting the interface with information-seeking goals. For this study, I used the Data, Information, Knowledge, and Wisdom (DIKW) Hierarchy to develop knowledge acquisition trackers that serve as ongoing personal reference tools for a user engaged in incremental learning about their changing medical, profession, and social situations. The final feature that appears in this storing category is "Visualized Past Searches." This study was designed using Juvenile Neuronal Ceroid Lipofuscinosis information.

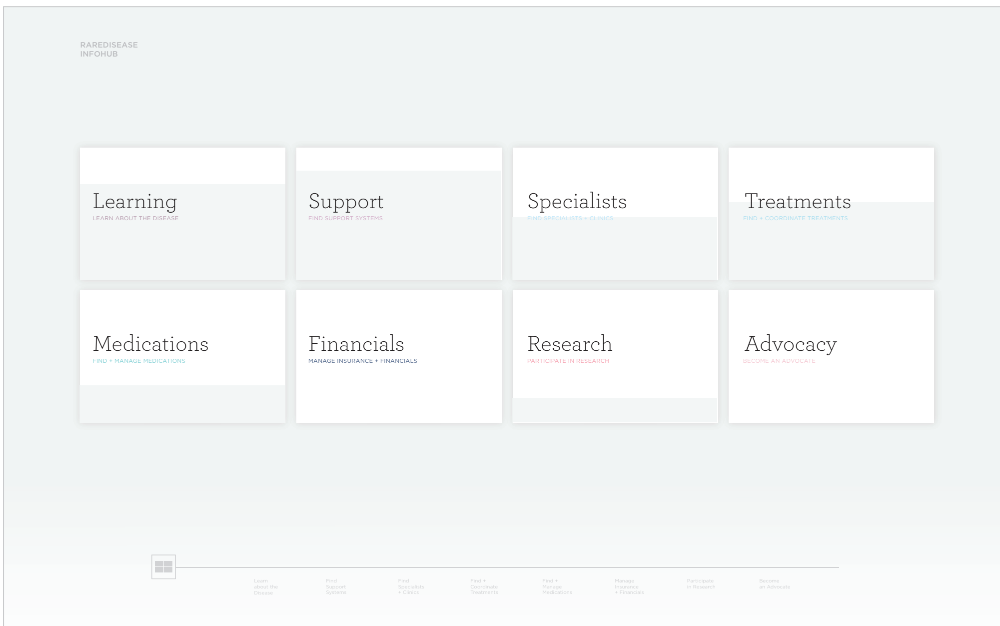


FIGURE 4.30: *The user has completed nearly all available learning tasks in "Learning" and "Support", however, they have not yet started exploring "Financials" or "Advocacy." This visualization informs the user of the quantity of new knowledge available to explore in each area.*

VISUALIZED PAST SEARCHES

Three small studies make up the exploration of the Visualized Past Searches feature. In the first study, I was interested in looking at a visualization of user saved information from previous search episodes. During searching, the interface offers to "remember" information. Perhaps a caregiver wants to record a doctors contact information or a journal article for future reference. Figure 4.25 shows the saved items in card form on a user's private dashboard. The cards are organized according to corresponding focus spaces. Two memory triggers are happening here. First, by having the collected data appear as cards, the visualization is fitting a common flashcard schema. The flashcards serve to chunk the information into smaller references, reducing the overwhelming nature of the content. In Figure 4.26, the user selects one card to see in-depth details. In this case, it's an abstract for a journal article. Second, by continuing to save the information according to the focus space category, the user is reminded of the learning path they took during the search session, which triggers a memory of the initial interaction with the information.

The user has additional opportunity to interact with the information flashcards. The viewer has the option to move the cards around on the workspace (Figure 4.27). If at any point they need to see the information connected back to the focus space, they select that focus space from the lower navigation and a path lights up the associated cards (Figure 4.28). In Figure 4.29, the user has selected all of the focus spaces, showing a visualization of the user's collected knowledge from all past search sessions.

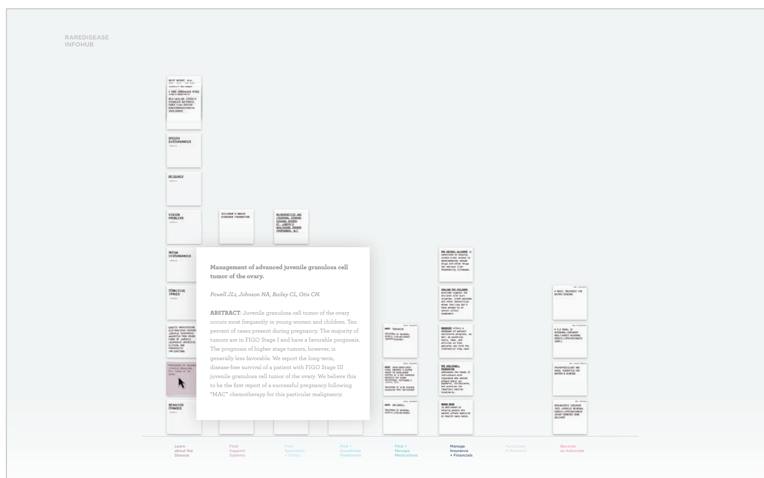
Figure 4.30 demonstrates another possibility for visualizing past search behaviors. In this study, I was looking at an interface's ability to track knowledge acquisition through spatial navigation visually. Taking the Mental Map study from page 88, the box for each focus space would visually "fill" as a user reads or learns the information available in that space. In the screen shown, the user has completed nearly all available learning tasks in "Learning" and "Support", however, they have not yet started exploring "Financials" or "Advocacy." This visualization informs the user of the quantity of new knowledge available to explore in each area.

SCHEMA
a mental structure that describes a pattern of thought or behavior and the relationships among them

In the last study for Visualized Past Searches, I was interested in creating something similar to mini study three on page 68. I created a visual history panel which records a trail of past search activity (Figure 4.31). When a user saves an item during a search session, the interface files it under the corresponding focus space in the past search dashboard. Colored boxes back the information items a user looked up. These colored boxes create the learning trails. The user has the option to revisit any past learning trail (Figure 4.32) or to start a new learning trail (Figure 4.33).

FIGURE 4.25: *During searching, the interface offers to "Remember" information, which is saved in the form of flashcards in the user's private dashboard.*

FIGURE 4.26: *The user can click on a card to see additional detail about the information saved.*



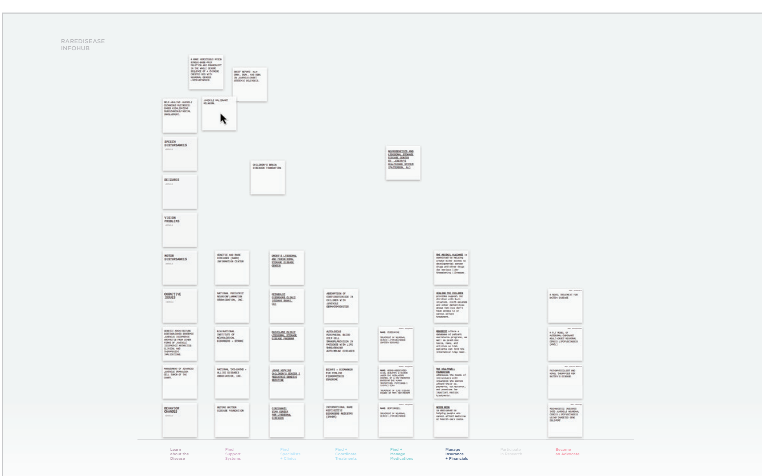


FIGURE 4.27: *The user has the option to move the cards around on the workspace. They can keep them organized according to the focus spaces or move them into any other categorical structure they choose.*

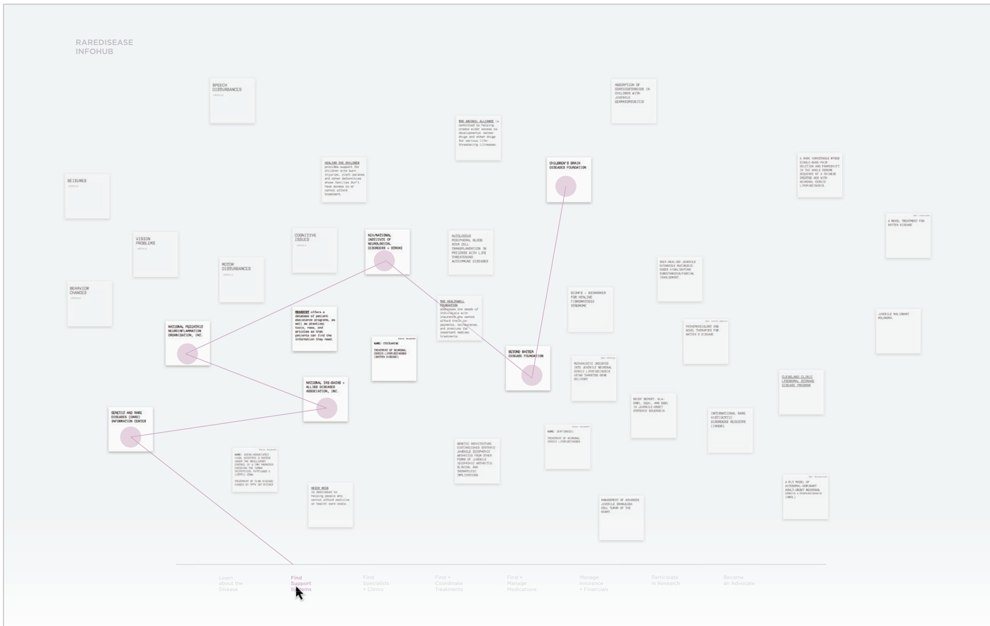


FIGURE 4.28: *Once moved around the workspace, the user can select a focus space heading in the lower navigation and all corresponding information cards will light up.*

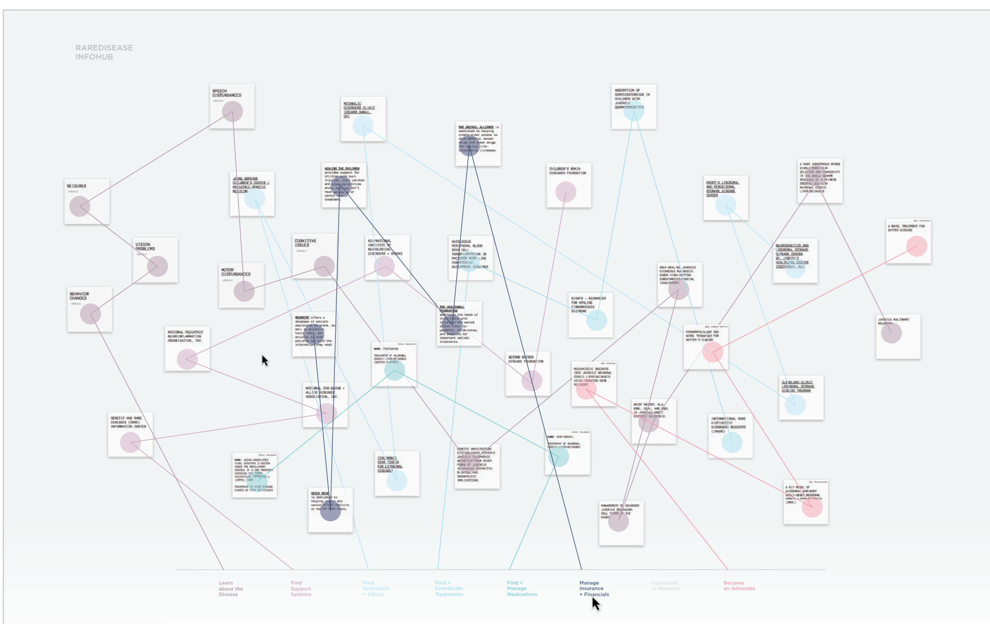


FIGURE 4.29: *If a user selects all focus space headings, they will be able to see all of the connecting information from each focus space.*

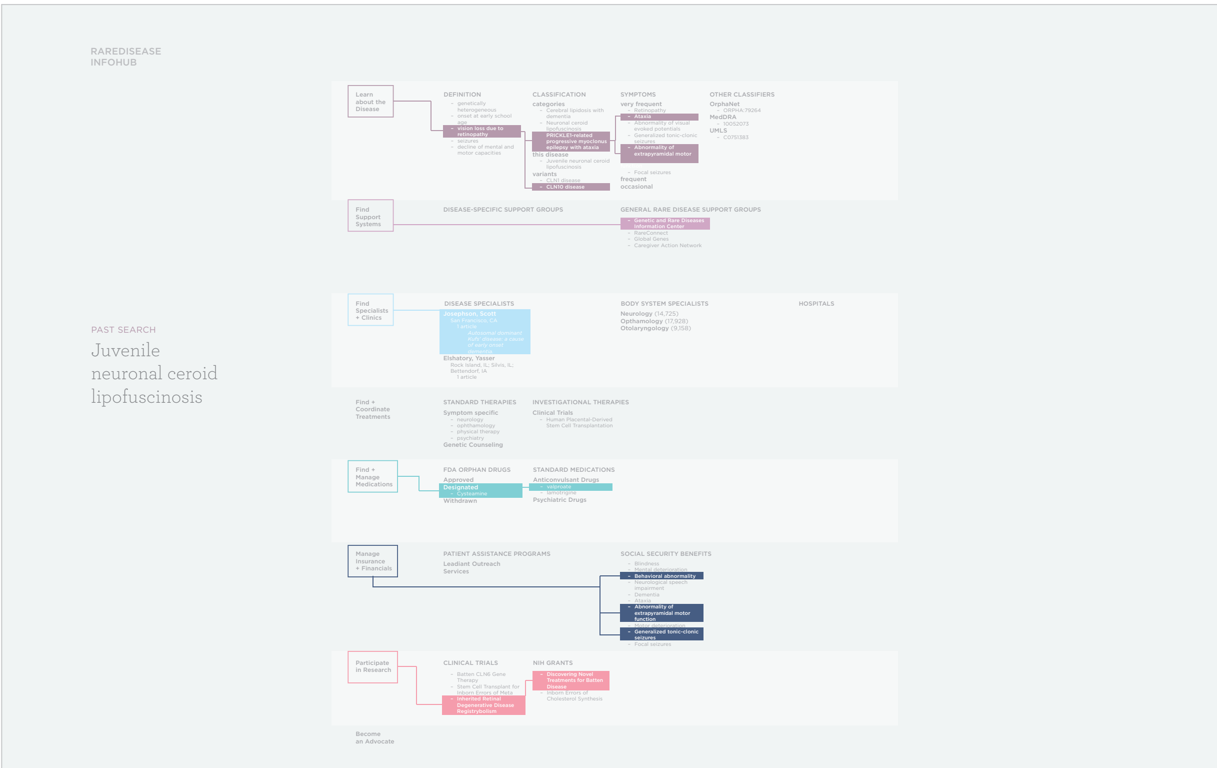


FIGURE 4.31: *The user has access to a visual history panel which records a trail of past search activity.*

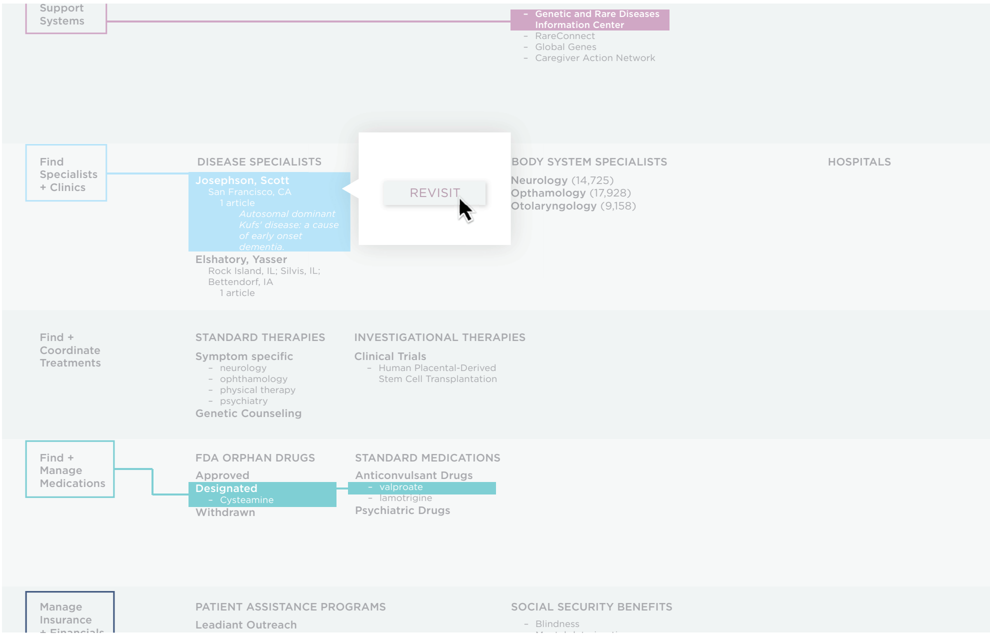


FIGURE 4.32: *(zoomed in screen) The user has the option to revisit any past learning trail.*

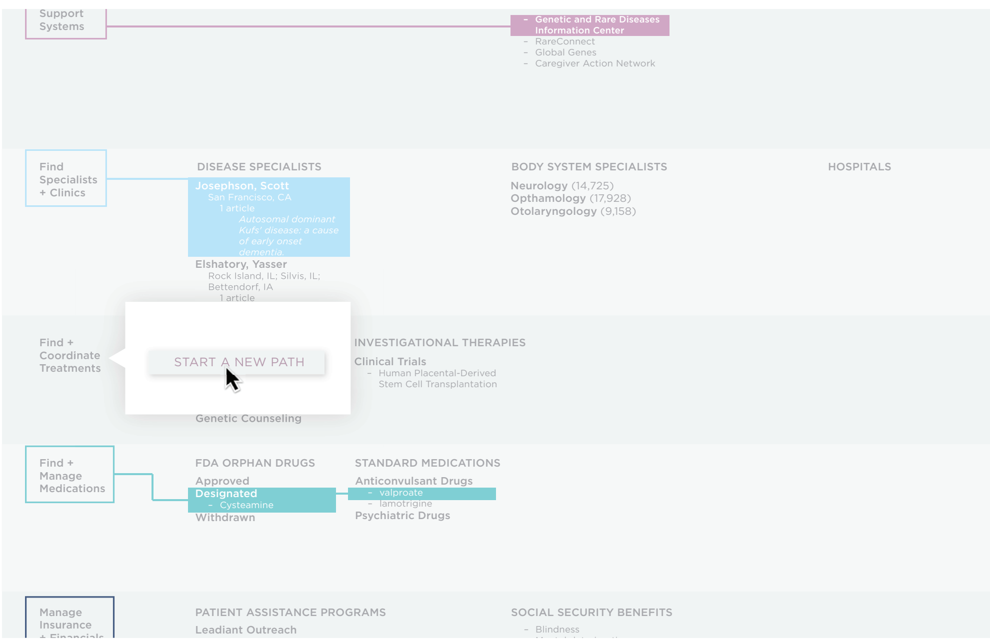


FIGURE 4.33: *(zoomed in screen) The user has the option to start a new learning trail from any connecting point in the past search activity.*

SCENARIO
After receiving news of her child's recent diagnosis with CLN3 Disease, the parent returns home with an immediate thirst for knowledge. She begins searching online for information about CLN3 disease. When first finding articles, she understands so little of what she reads. How was she supposed to comprehend the main point if she couldn't read the majority of the words? The task quickly proved overwhelming. She hadn't needed to learn challenging material in this type of process since college, and that was a long time ago. What was the best method to tackle learning about CLN3 disease?

This feature proposes teaching the parent effective research behaviors in a scaffolded manner. The task of learning about a disease is overwhelming. The parent's stress-level and the unfamiliarity of the medical content increases the paralyzing nature of the job. By aiding a new user with this feature, over time, the parent will no longer need the assistance of the interface. They will have developed the necessary research skills and the expert disease knowledge to navigate future learning opportunities.

a user has selected to read material that contains unfamiliar, advanced medical terminology

to aid the user in learning the material, the interface greys out unnecesary, advanced wording

the interface automatically highlights and records important keywords for the user to learn

the user has space to add personal annotations

TOOLS FOR DECIDING

final feature five

As the primary caregiver to a child with a rare disease, a parent is responsible for making medical decisions. It is imperative to find and learn an immense amount of information to guide the decision-making process. A parent will quickly take on the role of researcher. This tool is considering how an interface can bridge the gap between current ability to necessary ability. For this study, I used Scaffolding Theory and Cognitive Continuum Theory to develop instructional aids for research behaviors that aid in effective and autonomous decision making. The final feature that falls into this deciding category is "Automatic Research Behavior Scaffolding." This study was designed using CLN3 Disease information.

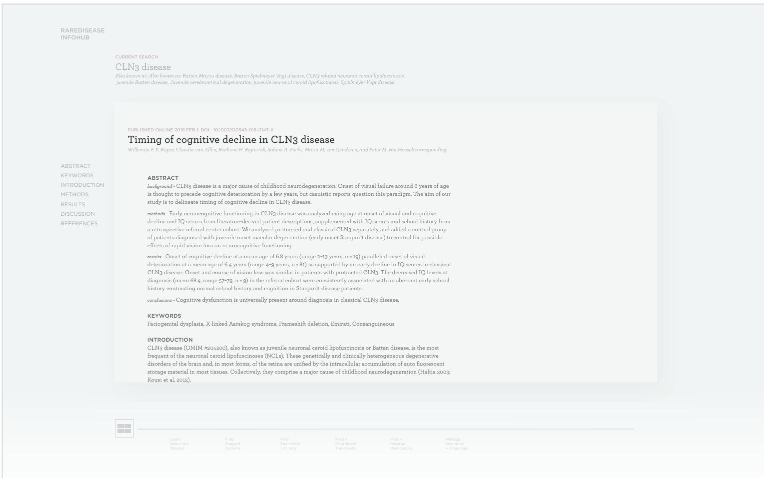


FIGURE 4.34: *In the unaided view of the material, the page is text heavy and contains advanced medical terminology. A novice user with limited disease familiarity would struggle to comprehend and learn this material.*

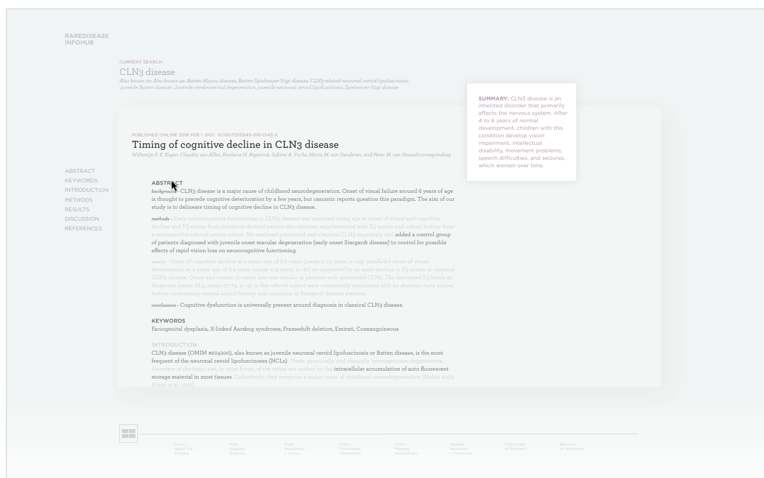


FIGURE 4.35: *Often when a researcher is reading large bodies of text, it is good practice to write a short summary. Here, the interface is offering a plain-language summary of the text to the user.*

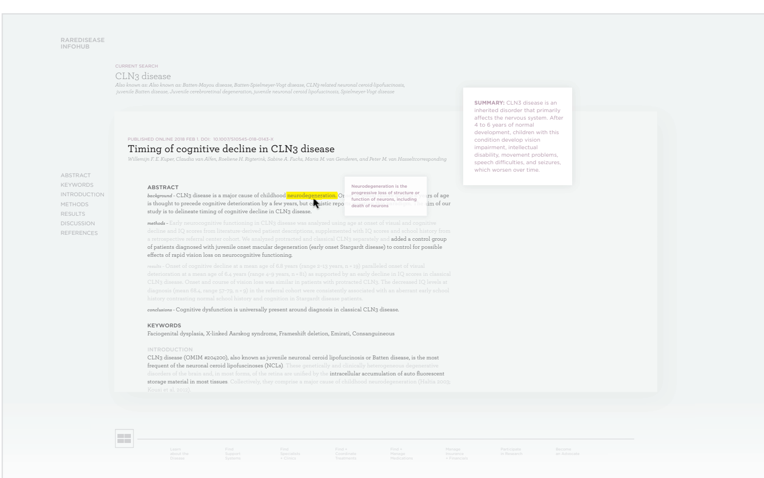


FIGURE 4.36: *As a user moves through the material, important words will automatically be highlighted for their review. If they click on a word, a definition pops up.*

AUTOMATIC RESEARCH BEHAVIOR SCAFFOLDING

When meeting the patient advocates for the NC rare disease council, they spoke with the knowledge of an expert. This knowledge comes from years of research. In the beginning, most parents of recently diagnosed children are not researchers by trade. They are parents desperately seeking to find, understand, and remember complex medical information.

In what ways can an interface support the caretaker in effectively learning about their child's rare disease? Can an interface assist with research techniques in a scaffolded manner to empower a novice user to perform like an expert?

For this feature, the system facilitates the novice (visiting recently after diagnosis) user to behave like the expert. The system automatically highlights and saves keywords. Information is tagged and filed to accommodate the user's impaired ability to remember accurately. The user observes these behaviors happening in real time. The system is bridging the gap to demonstrate expert research behaviors.

The system demonstrates the following expert research behaviors: access to summaries of the text in everyday language, highlighted key terms with pop up annotated definitions, and a right click feature for additional user-initiated annotations. When a document refers to a doctor or hospital, the text is color coded to its corresponding focus space. The same is true for information about treatment options, medications or financial information. Each is color-coded according to focus space.

For comparison, Figure 4.34 shows the same text-heavy page without research assistance. In viewing this page, consider two facts about a person who has expert knowledge of CLN3 Disease. First, the majority of the complex terminology will be familiar. Second, it's fair to assume a person with specialist disease knowledge has experience researching. Concurrently, if a user in this class comes across new material while reviewing the published article "Timing of cognitive decline in CLN3 disease", it would be safe to assume they would be well-adept to performing research behaviors. However, a person with limited knowledge about this disease would be overwhelmed with the same presentation of information. Filled with advanced medical terminology, the paragraphs have little meaning to a non-familiar reader.

The proposed feature shown in Figures 4.35-4.38 suggest how an interface can facilitate research behaviors similar to those taken by the expert. As the user moves through the report with their cursor, the system offers assistance. When hovering over the 'Abstract' heading, a plain language summary appears in the sidebar (Figure 4.35). Guidance is given to accommodate a user's missing technical vocabulary. The system recognizes that essential facts may be missed and highlights key terms (Figure 4.36). When a user clicks on a key term to view the definition (Figure 4.36), the definition is saved in the sidebar for future reference (Figure 4.37). For advanced wording that isn't currently pertinent, the interface grays it out for the time being. The interface is guiding the user to learn vital information up front, leaving other information for the future. The user also has the option to add personal annotations or notes to the page by right-clicking (Figure 4.38).

SCAFFOLDING
providing sufficient instructional support to promote learning when concepts and skills are being first introduced to a user

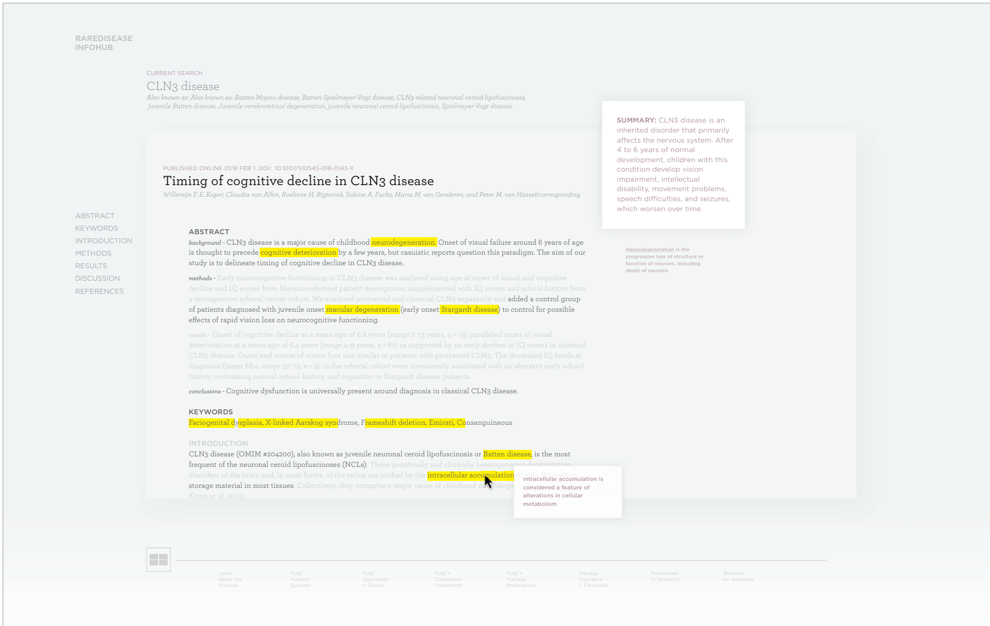


FIGURE 4.37: *Similar to how a researcher might write a definition in the sidebar of a text, definitions the user has reviewed appear in the side panel under the text summary.*

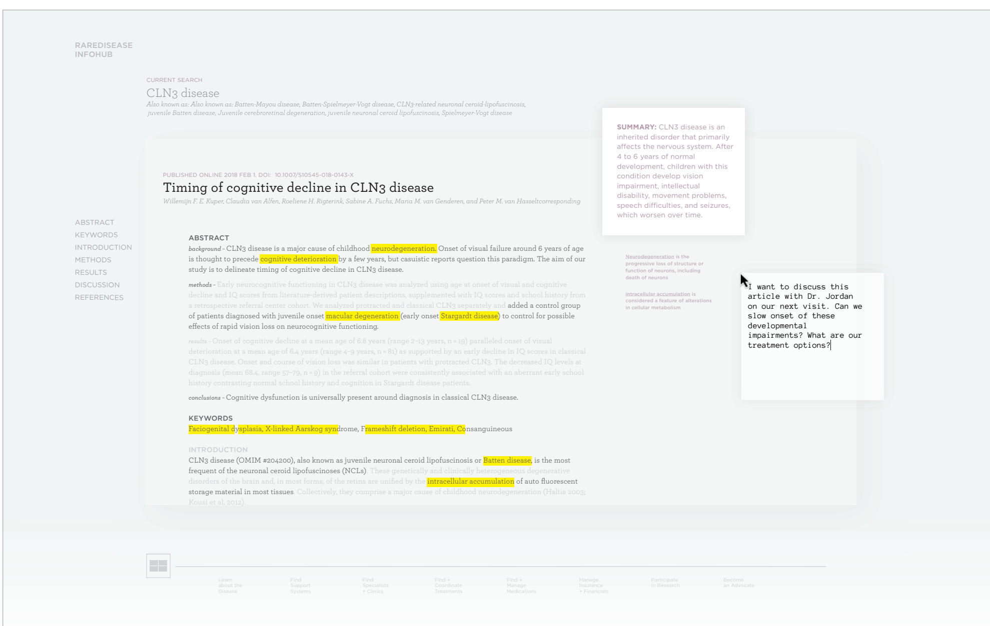


FIGURE 4.38: *The user also has the option to add personal annotations or notes to the page by right-clicking.*

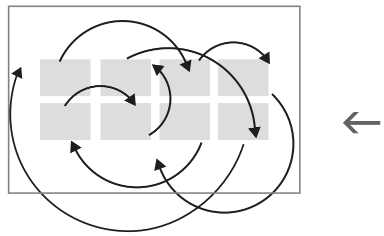
The Automatic Research Behavior feature allows the system to bridge the gap for the user. The new user doesn't have the skill set, knowledge or cognitive aptitude to perform the advanced research behaviors required. In the beginning, the interface will perform a large number of automatic interactions for the user. Over time, the user will have increased opportunity for direct manipulation. By scaffolding the research behaviors in such a way, it aids the user to commit to memory the mental models of the tasks required *(McCall, 1998)*.

This tool is helping the user to work smart, not just work hard. Research conducted by Perkowitz and Etzioni *(as cited in Weld et al., 2003)*, showed that automatic personalization may significantly enhance user productivity. They designed a machine learning Web searching assistant that tracked the "information-goal seeking" behaviors of users to determine site modifications. "Because users find it hard to specify their preferences and goals, it is often more effective to induce them from user behavior." For storing, it is essential that the tool tracks the current and past sessions and can guide the user through automatically highlighting texts, collapsing unnecessary content, adding pop-ups for definitions or descriptions, and filing information as needed.

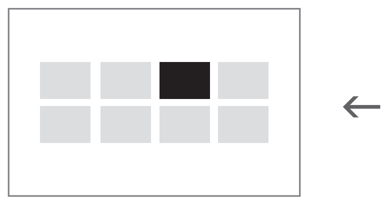
SCENARIO
When searching for information on disease symptoms, a parent may fail to think of connecting topics. Every time a new question occurs to the parent, they begin a separate query. There are two downsides to this disparate method of searching. First, a user increases the number of visits to the search engine, an inefficient task. Second, the parent could potentially go without much-needed information until they think to search for it.

Can an interface assist a user in asking the right questions at the right time? How can an interface gather pertinent information for a user, delivering it in a prioritized manner? By what methods can information be visually prioritized to infer just-in-time and over-time needs?

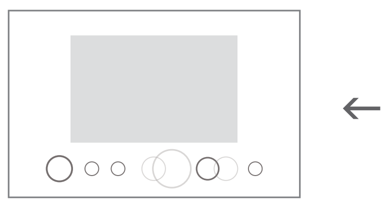
The interface automatically gathers, prioritizes, and delivers information to the user. The interface will notify users of connecting information and new knowledge.



the interface facilitates explorations by offering connections to other focus spaces



this is accomplished through automatic gathering of information into various focus spaces



the interface signals the user of the available information gathered

TOOLS FOR NOTIFYING

final features six + seven

As technology begins to perform many of the cognitive tasks previously performed by the user, it is imperative that the interface sends notification for these actions. The combination of aiding in the task while sending clear communication of actions will allow a user to feel confident in the information-seeking circumstance. For this study set, I used Connectivism Learning Theory to develop a data-aware notification system that will alert users to changes in information and knowledge in both just-in-time and over-time delivery approaches. The final features that appear in this notifying category are "Visualized Gathering" and "Looping Connections." For each of these studies, actual rare disease information for Juvenile Neuronal Ceroid Lipofuscinosis has been used.

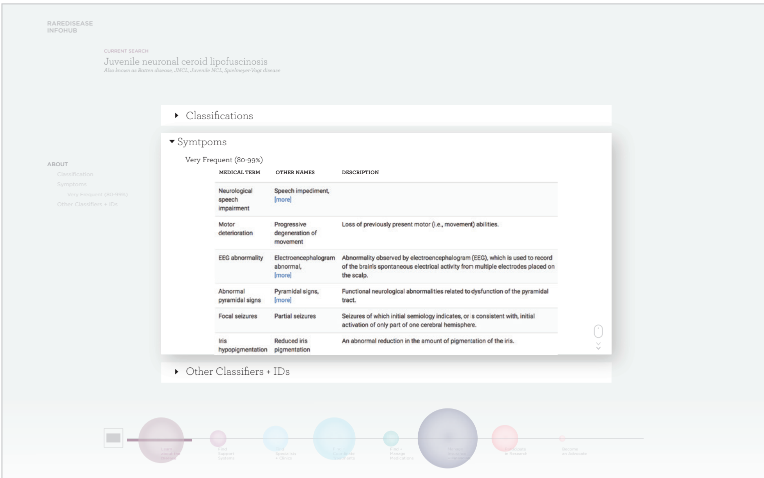


FIGURE 4.39.a: *When a user is browsing information in the main focus space – for example, "Symptoms" as seen above – the interface subtly draws attention to the availability of connecting information with the appearance of colored-coded spheres. The spheres grow over the names of the other focus spaces in the lower navigation and the colors are the secondary navigation cues for those information zones. The size of each sphere indicates the quantity of connecting information in the other areas.*

FIGURE 4.30*: 4.39.b: The above illustration is representative of the screens in the animated sequence. The spheres fade in while enlarging and subsequently fade out while the next sphere begins to grow. Although used to alert the user's attention, the method of doing so is subtle. The visual cues of the system serve to communicate without overwhelming the user.*

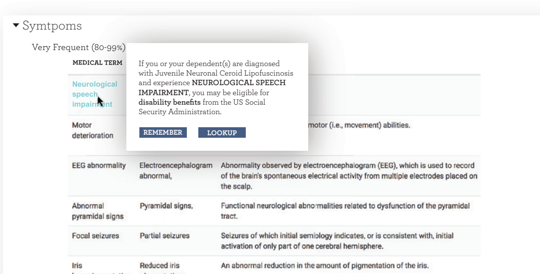


FIGURE 4.40: *When the user has a predefined task, the interface can suggest an appropriate alternative. Above, the user is researching the symptoms of Juvenile Neuronal Ceroid Lipofuscinosis. The interface suggests the alternative (related) task of finding out if the patient is eligible for SSA benefits for the symptom of neurological speech impairment.*

LOOPING CONNECTIONS

Consider a caretaker of a child with a rare disease. After receiving the diagnosis, they immediately have questions regarding symptoms about the condition. The parent proceeds to use a search system to ask those questions. It does not occur to the parent until nine months later to check if there are Social Security (SSA) Benefits available for those symptoms. By this point, the parent has already lost months of financial support. Why? Because people do not always ask the right questions at the right times.

Technology can assist a user in recognizing and synthesizing connections among information sets *(Siemens, 2005)*. In this study, I explore drawing connections across various information sets. An adaptive interface can monitor what the user is looking for and recognize when they are missing an essential connection. The interface can respond by offering the related resource or information.

In Figure 4.39, the interface notifies a user that connecting information is available other focus spaces. The light colored spheres grow over the other information zones in the lower timeline navigation. These spheres signal the user to visit the corresponding areas when ready. The size of the sphere indicates the quantity of connecting information available in that particular focus space.

Another option for developing looping navigation is what McCall *(1998)* refers to as "incidental interactions." When a user has a predefined task, the interface can suggest an appropriate alternative or addition to that task (Figure 4.40). For example, as the user is viewing the symptoms of Juvenile Neuronal Ceroid Lipofuscinosis, they will be alerted to check for SSA benefits for blindness, mental deterioration, behavioral abnormality, and neurological speech impairment. The search engine serves as an intelligent agent for drawing just-in-time connections.

Often, people do not know all the correct questions to ask up front. This is particularly true in situations with a steep learning curve, such as after a recent medical diagnosis. A search engine with visual notifications (Figure 4.41) to browse related information allows the user access to material they might not have known was available.

FIGURE 4.41: *A close up detail of the visual indicators indicating connecting information.*

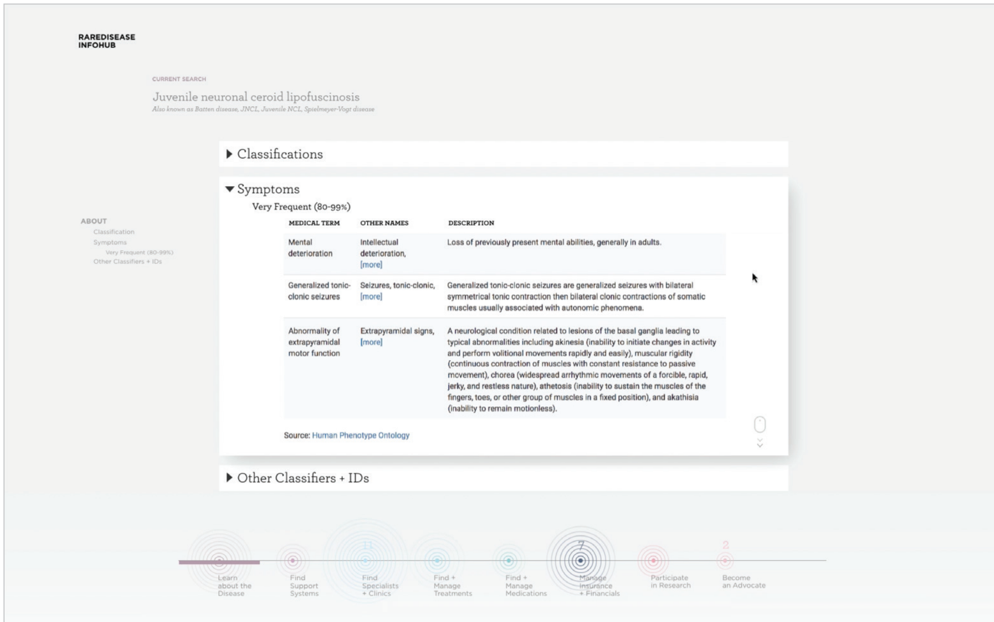


FIGURE 4.42.a: *The radial visualization along with the numerical ticker serve to notify the user that newly culled information is being gathered and placed into the various user focus areas.*

FIGURE 4.42.b: *The above illustration is representative of the screens in the animated sequence.*

VISUALIZED GATHERING

The exploration for Visualized Gathering looks very similar to Looping Connections, however, this feature is performing a different function. When the user is participating in a search session, the system is simultaneously conducting an autonomous focused crawling of all connecting databases looking for information pertinent to the users current search. The user is able to see these newly culled results being gathered and placed into the various user focus areas along the bottom of the screen (Figure 4.42). The size of the circles along with the ticking numbers communicate at-a-glance which other focus areas contain the most new relevant results.

Micarelli et al. *(2007)*, describe a system similar to what I envision my Gathering feature will do. "Abandoning the "one-size-fits-all" method... Personalized search aims to build systems that provide individualized collections of pages to the user, based on some form of model representing their needs and the context of their activities."

Gathering will help mitigate information overload *(Micarelli et al., 2007)*. Search results will be more accurate, satisfactory, and reliable. An adaptive interface can gather the best information based on the users actions, browsed data, and past queries to find and deliver the best information to meet a user's long-term and short-term information needs.

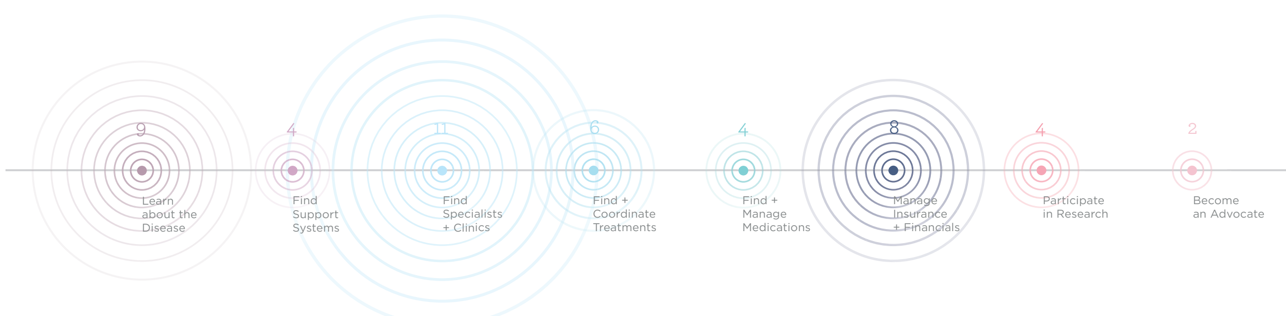


FIGURE 4.42: *The user is able to see web results being gathered and placed into the various user focus areas along the bottom of the screen. The size of the circles along with the ticking numbers communicate at-a-glance which other focus areas contain the most new relevant results.*

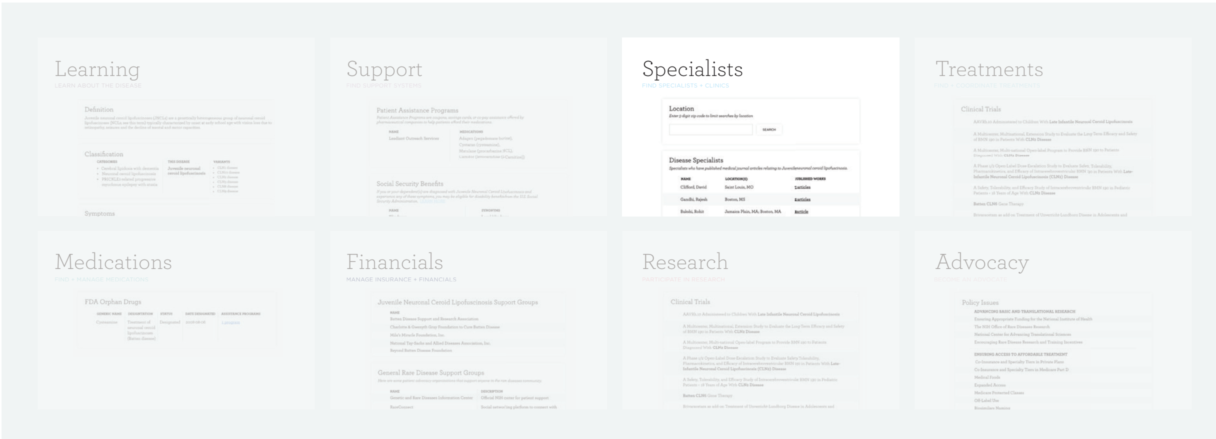
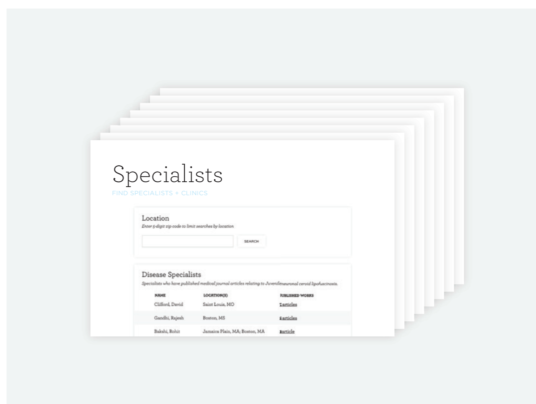


FIGURE 4.44 *The relevance-based content presentation technique of dimming deemphasizes less relevant content by fading its color, allowing "Specialists" to take priority.*

FIGURE 4.46: *The relevance-based content presentation technique of sorting deemphasizes less relevant content through sorting of fragments, moving more important information (i.e. "Specialists") to the most prominent positions.*



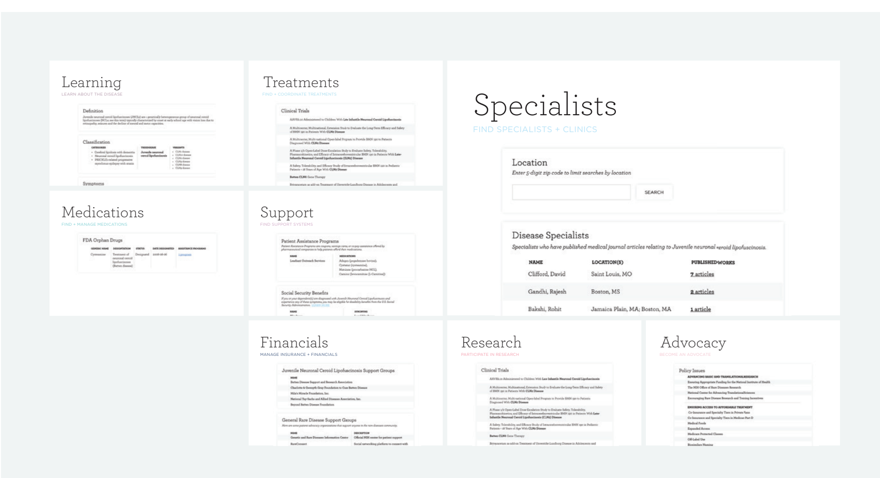


FIGURE 4.47: *The relevance-based content presentation technique of scaling deemphasizes by size-reduction, allowing "Specialists" to take priority.*

VISUALIZED
GATHERING

PRIORITIZING

Traditional search engines show results to the user in long, ranked lists of how similar content is to the query. The user then sifts through these results looking for information that best matches their needs *(Micarelli et al., 2007)*. The Gathering feature will go one step further by prioritizing the collected results before presenting them to the user.

The iterations below are examples of the information presentation strategy, prioritizing, discussed on page 59. This strategy states that the information gathered will be organized and presented to the user in an urgency-based or time-based fashion. Prioritizing content is a way of adaptively structuring content based on a degree of relevance for an individual user.

For the following visual studies, I explored four techniques to deemphasize the less relevant information to enhance the user's focus on the priority information. At the same time, the less relevant content remains visible to allow the user to maintain understanding of context. According to Bunt, Carenin, and Conati *(2007)*, it's imperative to find a balance between maintaining context and maintaining focus. "Context is more easily maintained if much of the original content is visible to the user. However, the more content is shown, the higher the chance of generating information overload and reducing attention to the most relevant information, defeating one of the very reasons for having adapting hypermedia in the first place."

By choosing the methods of dimming, coloring, sorting, and scaling *(Bunt et al., 2007)* to prioritize information, the interface is maintaining both context and focus for the user (**Figures 4.44-4.47**). The addition of prioritizing the gathered information for the stressed user creates a more human-like, assistive interaction.

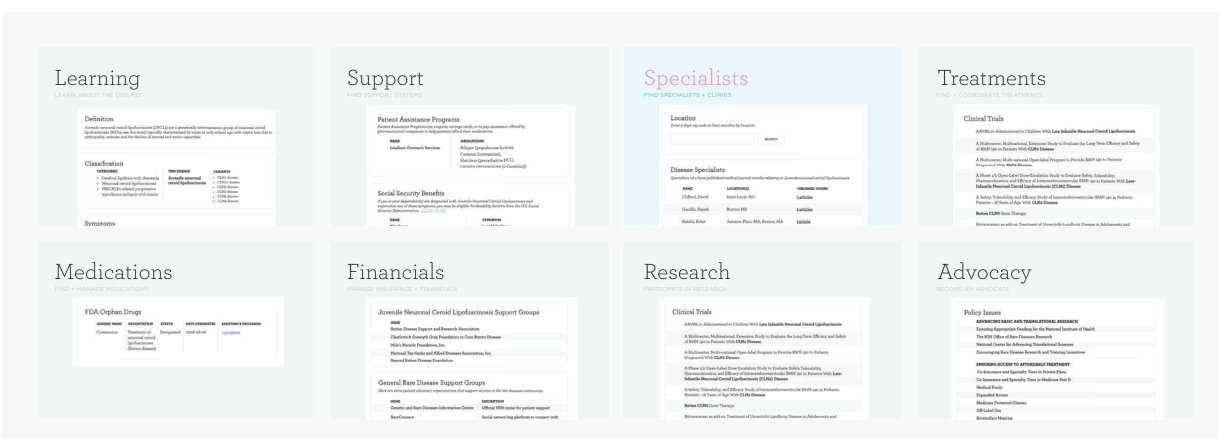


FIGURE 4.45: *The relevance-based content presentation technique of coloring (traditionally used to support adaptive navigation) highlights the more relevant "Specialists" section in color.*

CONCLUSION

The current landscape of design is ripe with new technologies. Machine learning, augmented intelligence, and data fusion create opportunities for designers to develop experiences for one individual rather than for all users. No longer restrained by old technological limitations, we can create one interface which will adapt to each individual. By creating adaptive interfaces, we can communicate with a user based on a meaningful characteristic, such as their cognitive state.

As I considered designing an intelligent interface that tailors information presentation by responding to a user's cognitive state, I broke the problem down into several potential solution sets. I derived a collection of information presentation strategies aimed at presenting information to people under duress. I proposed a method for developing a looping series of user interactions which promotes discovery. I introduced seven sets of potential features for a responsive graphical user interface.

I've explored each of these features individually. Some have shown great potential. I suspect they'd be useful. Future research may consider looking at developing a system that incorporates all or some of these features cohesively. I estimate that all features together would create an overwhelming system.

The project presented here is a small part of a long-term study. The ultimate goal is to create a semi-working prototype that responds to a user's cognitive state. This project has allowed me the opportunity for interdisciplinary collaboration. To create the working prototype, I've partnered with students in the Computer Science department at NC State University. Computer Science students are experts in back-end development, machine learning, augmented intelligence, and data fusion. As a master's level graphic design student, I offer expertise in user experience, user interface, and visual design. Computer Science experts write the algorithms for what information is presented to the user. I assist with determining how the information is displayed to support user interaction, experience, and comprehension. Poor functionality on either end will render an adaptive interface useless.

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