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I, Yunyi Zhang, hereby submit this original work as part of the requirements for the degree of Master of Design in Design.

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Influence of Navigation Structure on People with Different Prior Knowledge: Performance and Preference

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Influence of Navigation Structure

on People with Different Prior Knowledge:

Performance and Preference

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ABSTRACT

Shared Decision Making (SDM) started from the concept focused on informed consent. Decision Aids are the most common tools used to support SDM in clinical encounters, and they have been shown to positively affect decision quality. (Flynn, Knoedler et al. 2012) This project is to create a digital decision aid for the return of Whole Exome Sequencing (WES) results so that families better understand the issue and their options.

In the digital context, different navigation structure might boast different outcome for the audience considering that potential audience may vary in their level of prior knowledge on WES. The goal of this study is to find out what will be a better navigation structure for people with different level of prior knowledge.

In this study two designs, one with linear navigation and the other network navigation, were tested. Data collected included: correctness of pre-reading questions, time for the participant to read through the tool, time for taking post-reading questions, and correctness of post-reading questions. The participant used one design primarily and was shown the other design. The participant was asked how do they think about the two designs. Qualitative data was collected for this answer.

People across different levels of prior knowledge took significantly less time answering post-reading questions when using the linear design. Strong influence of navigation structure on the correctness of people with different prior knowledge has not been found.

Keywords: Navigation Structure, Interaction Design, Medical Design, Decision Aid
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1. **INTRODUCTION**

1.1 **Shared Decision Making (SDM) and Decision Aids**

The concept of Shared Decision Making (SDM) started from the concept of informed consent involving an information exchange between clinicians and patients that encompasses not only the risks and benefits of treatment options but also the patient’s values and preferences. (Gionfriddo, Malaga et al. 2014)

For cases of chronic diseases, the treatment decisions need high level of patient engagement to carry out the treatment plan. Studies have proved that enabling the patient to play the role they prefer in decision making may have important consequences for carrying out the decision in the patient space after the consultation. (Montori, Gafni et al. 2006) Acute care decisions are usually happen in a short window, but often entail irreversible outcomes for the patient and family. In both cases, promoting patient participation in the decision making process improves quality of life.

Decision Aids are most common tools used to support SDM in clinical encounters, and they have been shown to positively affect decision quality. (Flynn, Knoedler et al. 2012) Decision Aids are also valuable outside clinical visits. Decision Aids can inform families of their options ahead of time, provide work for the family to reflect back on, and support family members that are not present.
1.2 Problems and Opportunities of Shared Decision Making in Pediatrics

Charles et al. defined SDM in this way: SDM involves at least two participants—the physician and patient; both parties take steps to participate in the process of treatment decision making; information sharing is a prerequisite to SDM; a treatment decision is made and both parties agree to the decision. (Charles, Gafni et al. 1997) Considering the nature of pediatrics setting, the “patient” party has additional layer of complexity.

<table>
<thead>
<tr>
<th>Analytical stages</th>
<th>Paternalistic model</th>
<th>Shared model</th>
<th>Informed Model</th>
</tr>
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<tr>
<td>Information exchange</td>
<td>Flow</td>
<td>One way (largely)</td>
<td>Two way</td>
</tr>
<tr>
<td>Direction</td>
<td>Doctor→Patient</td>
<td>Doctor⇌Patient</td>
<td>Doctor→Patient</td>
</tr>
<tr>
<td>Type</td>
<td>Medical</td>
<td>Medical and personal</td>
<td>Medical</td>
</tr>
<tr>
<td>Minimum amount</td>
<td>Legal requirement</td>
<td>Anything relevant for decision making</td>
<td>Anything relevant for decision making</td>
</tr>
<tr>
<td>Deliberation</td>
<td>Doctor alone or with other doctors</td>
<td>Doctor and patient (plus potential others)</td>
<td>Patient (plus potential other)</td>
</tr>
<tr>
<td>Who decides what treatment to implement?</td>
<td>Doctors</td>
<td>Doctor and patient</td>
<td>Patient</td>
</tr>
</tbody>
</table>

Table 1. Models of decision making about treatment (Greenfield, Kaplan et al. 1985)

In the pediatrics world, even for young adults, that “patient” party becomes combination of patient and parent/legal guardian. There is no doubt that the “shared model” in Table 1 becomes even more crucial. Getting not only the parent but also patient in the loop will help the decision making and benefit treatment. Generally, parents and providers are engaging one another in decision making about child’s chronic condition. (Lipstein, Brinkman et al. 2012) However, few pediatric SDM practices have attempted to empower
children with a voice, with only 7% of intervention targeting the pediatric patient alone and 19% targeting the pediatric patient with another party. (Wyatt, LeBlanc et al. 2015)

The decision aid being developed keeps the idea in mind that preferences and values of both parent and patients are considered.

1.3 What is Whole Exome Sequencing

The following explanation is an excerpt from the application for SDM collaborative from the Center of Human Genetics.

“Whole Exome Sequencing (WES) interrogates the protein coding regions of all known and suspected genes (about 1% of the genome). At Cincinnati Children’s Hospital Medical Center (CCHMC), WES is clinically used to find the genetic cause of a child / family’s rare disorder when other available test options have failed.”

WES decision making is in certain ways similar with acute care decision making in a sense that the decision is not reversible. However, since whether to conduct WES and whether or not to receive secondary findings are not related to a particular treatment, it is different from acute care decision making in nature. Based on the “Simplified distinctions between acute care and chronic care decision-making” from Montori et al., outstanding characteristic for WES decision making are categorized as follows: a) Patient Role: Sick role is acceptable over a brief period. Yet if a genetic cause of the disease is found by WES, new treatment plan might emerge. b) Social Impact of Decision: Results returned might increase economic/social burden of
caring for patient for an extensive time after decision; family member might also get a heads up about genetic conditions. c) Timing of Outcomes: Long term. Might even inform reproduction.

WES may find genetic variants not related to the patient’s presenting signs and symptoms. The complexity of the informed consent process, including ethical issues and analytical challenges, has been outlined in a CCHMC White Paper and the literature. A genetics team at CCHMC propose to engage patients and parents to understand how best to present these options for secondary and incidental findings in a way that matters to families.

1.4 Prior Knowledge
Prior knowledge influences design especially if the material is educational or instructional. It is not surprising to point out that designers work differently when the audience is naive or mature. A typography textbook, though with the same content, might be constructed differently for a freshman or communication graduate student based on how much do they know about design.

In research of icon design, Professor Mike Zender at University of Cincinnati found that design of icons will be different based on what the audience know. He refers to his icon comprehension study done in rural Tanzania and the United States of America. Most poorly comprehended icons failed due to lack of medical knowledge or unfamiliarity with technology, while few poorly comprehended icons failed due to cultural differences. (Zender and Cassedy 2014)
What is the case for interaction design? In an information retrieval task, users have to bear a lot of information in mind: the goal, the path just taken, information acquired, the path yet to be explored. Does prior knowledge have influence on the performance of users? Does people with different level of prior knowledge have a preferred navigation structure?

A high prior knowledge person may be defined as an individual with formal training and experience in the area under investigation, whereas a low prior knowledge individual could be defined as having little or no formal training/experience in the area examined. (Farag and Shemy 2011)

While prior knowledge consists of both prior experience knowledge and prior domain knowledge, prior domain knowledge is discussed in this paper. Evidence has been found for the use of conscious reasoning or knowledge-based exploration during interactions with daily products. (Langdon 2009)

However, study shows that people who enjoyed using the Web have less frustration with navigation compared with those who do not use it as much. (Mitchell, Chen et al. 2005)

My testing proposed to use UC students as participants. Considering that most college students use computers, the effect of prior experience knowledge might not be significant.

1.5 Navigation in Interaction Design

Navigation through digital media occurs at multiple levels: among multiple windows, views, or pages; among panes or frames within a window, view, or
page; among tools, commands, or menus; within information displayed in a pane or frame (for example: scrolling, panning, zooming, following links). In a broad sense, navigation means any action that takes a user to a new part of the interface or which requires him to locate objects, tools, or data. (Cooper, Reimann et al. 2007)

“Just wait, Gretel, until the moon rises, and then we shall see the crumbs of bread which I have strewn about; they will show us our way home again.” from *Hansel and Gretel*.

Just like there are signage system to help tourists find places, routes, and see the attractions, users need to understand where they are in an interactive system and figure out where they want to go to. Navigation among multiple windows, views, or pages deals with the overall navigation structure of the system. I am interested to see if by using different navigation structures for the same information, the learning outcome of people will be influenced.

The structure of information defines the primary ways in which users can navigate. Hierarchy helps users easily and quickly understand information environments. They are able to develop a mental model of the environment's structure and their location within that structure. (Rosenfeld, Morville et al. 2015)

There are several common practices of navigation structures for interaction design. The linear and hierarchy structure are more restricted, and the concurrent and network structure offer more flexibility to users. The following patterns in part referred to Elizabeth Boling’s work from Indiana University.
Linear. (Figure 1) One display at a time, with few options for branching to anything but the next display. Often a linear structure allow both backward on step and forward one step. The end of a sequence may exit the program, or loop back to the beginning.

Hierarchy. (Figure 2) Users have to make good decisions about where to place each display so that the relationships in the hierarchy make sense to them. Navigation in a strict hierarchical structure requires that users return to a higher level before they can move laterally and make another choice at that level.

Concurrent. (Figure 3) This structure is probably the most common on the web today, or at least it is the most common basis for structures on the web. It is essentially a hierarchy in which persistent connections have been provided between all of the main levels.
Network. (Figure 4) Users can navigate to any other content allowed. Displays exist with limited relationship to each other. This structure is interesting and has its place in some kinds of situations.

2. HYPOTHESIS

People with lower level of prior knowledge have a better learning outcome when using a more structured tool.

People with higher level of prior knowledge are more efficient using a more flexible tool.

3. METHODOLOGY

3.1 Overview of Methodology

In order to test the hypothesis, there are three main things that needs to happen: 1) determine the level of prior knowledge, 2) design the tool, and 3) measure the outcome.
This is how a session would look like: the participant is told that they will have five true or false questions at the beginning, read through a digital material, and do another five true or false questions. If the participant agrees to participate, he will be told what the study is about. The participant will be shown the three tasks without questions and answers to start with. The participant can take as long a time as needed to view the tool. The participant will answer several questions afterwards without referring to the tool. At the very end, questions will be asked about why the participant jumped through contents or skipped contents, and if there are remaining questions he wants to ask the genetic counselor if he takes his child to the clinic the next day. The participant will be shown the other prototype that he did not go through, and be asked about his opinions on the two designs.

3.2 Measures of Prior Knowledge

As explained in Chapter 1, this study assumes relative prior knowledge. Therefore, the idea is to ask participants five multiple choices before showing them the tool. Relative level of prior knowledge is determined by the number of correct answers.

Questions are developed to test prior knowledge in general genetics like basic concepts on DNA, genes, chromosomes, and heredity. The questions are developed with help from a genetic counselor, Kathleen Collins Ruff at CCHMC.
3.3 Measure of Outcome

The two outcome measures are: efficiency and accuracy. Efficiency refers to the duration it takes for the participant to put down the answers. Accuracy is determined by the number of correct answers. Participants will be given five true or false questions directly related to the testing task. Open-ended questions will follow.

4. STUDY DESIGN

4.1 Context for Decision Aid

This decision aid is developed parallel to a paper-based prototype at Shared Decision Making (SDM) Collaborative at CCHMC Anderson Center of Excellence with the CCHMC Center of Pediatric Genetics. Decision aids will be developed that promote adolescents’ and parents’ value-based decisions regarding whole exome sequencing (WES).

Due to the complex nature of the WES, the digital decision aid is designed to be used before a clinic visit. This provides opportunity for access to this decision aid ahead of the WES visit. If the patient is referred from the genetics division, information can be sent out together with the appointment reminder. It will either be mailed with an online link or updated in MyChart which is a patient portal for hospital updates.
4.2 Decision Aid Development

Content was developed collaboratively with specialists and families. I initiated the content based on the needs I found in collaborative sessions. I was referring to the booklet “EXOME SEQ, Whole Exome Sequencing, A Guide for Families” developed by the Molecular Genetics Laboratory at CCHMC. The team approached several families and received feedback on the content. Specialists modified the content based on family feedback and professional suggestions.

4.3 User Scenarios & Testing Tasks

The goal of the decision aid to be used before a clinic visit is for the parent, adolescent, and family members to 1) gain basic understanding of WES, 2) develop questions to bring to the clinic, 3) understand pros and cons of options of returning WES results. These goals are used as user scenarios. Ultimately, the decision aid helps the family make an informed decision in confidence.

The testing tasks (see Appendix A) are designed to go in accordance with the user scenarios. The first tasks is to look for the specific term “gene” because the audience would have to understand what a gene is in order to digest the rest. The second task is to browse information about how the return of WES results would impact on the patient’s health. The third is to understand what secondary findings are.
4.4 Decision Aid Design Elements

In order to better understand what kind of navigation design might provide better performance, I chose two very popular and distinct navigation structures. One is a linear structure where users are able to go back and forth following a certain path. The other is a network structure where users are able to navigate to any content at will. The prototypes are made in Axure.

Figure 5. Design A, linear navigation structure

In a linear structure, or Design A (shown in Figure 5), a linear navigation bar appears in the left side of the screen. The content is divided into three parts based on how the content is organized. Take a look at one of the categories: each section has its own a number and title. The numbers in this section are then connected with a vertical line that reinforces the linear structure of the content. At the bottom of each page are navigation bars for “previous page” and “next page”. Users can only follow sequential path through the tool.
In the network structure, or Design B (shown in Figure 6), a network navigation bar is at the top of the screen. The sense of equality is emphasized by putting the numbers and titles in a three by five grid. Different color indicates different categories. When a user hovers over a section, the outline of circle changes into a color fill and the user is able to click on the desired content. This enables the user to read any content at any time.

5. RESULT

A total number of 37 people participated in the study to help me understand which navigation structure or interface design might be more effective and preferred under this circumstance. They are all students that agreed to the
session that I found in DAAP and the library at the medical campus. 21 of them used Design A and 16 used Design B.

Table 2 shows the number of participants with different level of prior knowledge across the two designs. The participants all get more than one question correct. As can be seen from Table 2, most divisions has around five people. The number of people that scored 3 in prior knowledge and using design B is one. It is obvious that people who got all 5 questions correct can be considered as high prior knowledge, and 2 as low prior knowledge. Participants that got 2 and 3 questions correct has lower level of prior knowledge, and those got 4 and 5 correct has higher level of prior knowledge.

<table>
<thead>
<tr>
<th></th>
<th>Number of people that score 2 out of five (n)</th>
<th>Number of people that score 3 out of five (n)</th>
<th>Number of people that score 4 out of five (n)</th>
<th>Number of people that score 5 out of five (n)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design A</strong> (Linear)</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td><strong>Design B</strong> (Network)</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 2. Number of participants with different level of prior knowledge across the two designs.

During my session with them, I first explained to the participant that this study is to help with a design project. More specifically, by comparing the two structures, the study is hoping to find if for different people one design is better than the other. After that, I handed over the participant a sheet of the tasks (Appendix A) as I orally explain to them what they need to do. After the participant knows what they can expect, I will give him a sheet with five true or false questions (see Appendix B). These are the five pre-reading
questions to determine their level of knowledge. Their level of prior knowledge is indicated by how many questions they get correct here. As shown in the Table 2, five people using Design A got two questions correct, five people got three questions correct, seven people got four questions correct, and four people got all correct. At the beginning, all the participants were using Design A, hope to get at least five people at a certain level of prior knowledge with each tool. After the four kinds of prior knowledge all exceeded five people for Design A, I moved to use Design B. A miscalculation occurred with one participants using Design A, and that is the reason why the number of people get all the answers correct and use Design A is four instead of five.

After the participant answered the five true or false questions, I showed them one of the designs. I asked them to go through it at will and takes as long as they want. When they said they started, I started the timer at the Clock app on my iPhone. I observed the participant as he uses. I took note of how the participant navigated the decision aid. For example, a participant using Design A went back from section 1.3 to section 1.2, and a participant using Design B started with section 1.5 and followed the default path. I made special notes if they did not follow the default order or skipped content.

I stopped the timer when they let me know they are finished by saying the words like “okay, that’s it”, “done”, “I’m ready”. The timer runs again after I hand over to them the sheet of post-knowledge (see Appendix C). These five true or false questions determine how well they learned from the decision aid. I stopped the timer when the participant told me they have finished answering the questions.
Follow-up questions were asked. The first is to ask the participant what questions they have for the genetic counselor if they were to take the child to clinic the next day. This question is not for the purpose of this study, so it is not discussed in this paper. As I observed how the participant navigated through the decision aid, I made note of their navigation patterns. Therefore, I asked them questions like why did they jump from section 1.3 to section 1.2, or why did they go directly to section 1.5.

Participants using Design A are then shown Design B, and vice versa. I explained to them that in Design A, users can only go back and forth following the default path; in Design B, they can read any content at will. I then asked them what do they think about the two designs.

I made notes for all of the participant's answers. Audio recordings were obtained for participants #26-37 with their permissions. The recordings were transcribed verbatim and included in the data.

Overall, numerical data collected include: correctness of pre-reading questions, time for the participant to read through the tool, time for taking post-reading questions, and correctness of post-reading questions.

Qualitative data is collected for the open-ended questions.

5.1 Effect of Navigation Structure on Performance

The first part to look into is the performance of the participants. In this study, performance is accuracy and efficiency. Accuracy is determined by the
number of questions people get correct; efficiency is determined by the time taken to complete the tasks.

As can be seen in Figure 7, the four categories on the x-axis shows the prior knowledge of this group of people; the y-axis shows the average correctness for that group. Instead of comparing the prior knowledge and post knowledge of the same group of people, this study compares the post knowledge of different groups of people using two different designs. Participants using design B has an increase of post knowledge with the rise of their prior knowledge. However, when it comes to participants using Design A, the trend is not clear. People with prior knowledge level of three had better outcome compared with prior knowledge level of four and five.

Let us take a look at participants with prior knowledge of two and five. For participants with prior knowledge of two, five participants used Design A,
their average correctness for post-reading questions is 2.8; four people used Design B, and their average correctness for post-reading questions is 2.75. For participants with prior knowledge of five, four people used Design A, and their average correctness for post-reading questions is 3.25; six people used Design B, and their average correctness for the same questions is 3.5. Participants with low prior knowledge scored slightly higher using Design A than using Design B, while for participants with high prior knowledge scored higher using Design B than Design A. We can see that for Design A, the difference of post-reading scores between people with prior knowledge of two and five is 0.45, an increase of 16.07%. For Design B, the difference is 0.75, which is 27.27%. People with high level of prior knowledge learned better when using Design B (network) compared with Design A (linear).

Figure 8 examines the duration for people to read the decision aid and complete questions followed. Two paired t tests are conducted for the data set via GraphPad.com. The first paired t test examines the average time that participants take to read through the two designs. Through calculation, the p value equals 0.1536. This difference is considered to be not statistically significant. The second paired t test examines the average time for the two groups of participants to answer the five true or false questions after reading the decision aid. Through calculation, the p value equals 0.0031 (<0.005). This difference is considered to be statistically significant. From the graph we can tell that participants using Design A generally spend more time reading the decision aid compared with those using Design B. However, the time difference is not considered statistically significant. The different designs for the two decision aids is what made the time of answering questions
different. Participants using Design A, the linear one, took almost less than half the time for participants using Design B, the network navigation.

5.2 Different Navigation Patterns Observed

How each individual used the decision aid and their paths are documented. Their navigation patterns fall into four different categories: 1) followed default content and order, 2) not followed default order 3) skipped content and followed default path 4) not default order and skipped.

The data is visualized in Figure 3. For each level of prior knowledge, the diagram shows the overall performance of participants as well as how people using Design A and Design B navigate. A lighter color indicates the participant followed default content and order, the color gets darker as the
participant skips content or order. The color for not default order and skipped is darkest. If we compare the columns for how people with prior knowledge of two and five navigated, following the default content and order is dominant for people with prior knowledge of two. A main reason for the participants not to follow the default order is that they wanted to go back to previous contents when the participant encounters a terminology that was explained before. Participants with higher prior knowledge tended to navigate in a more flexible way. Some participants with prior knowledge of five thought they already knew some concepts. Participants using Design B tends to be more flexible than those using Design A.

**Figure 9. Prior Knowledge and Navigation Patterns**

![Figure 9](image_url)
5.3 Analysis of Qualitative Responses

Qualitative data was collected based on notes and verbatim transcription. Information was typed into the computer and coded according to different themes. Each quote or quote group was assigned a code. Repetitions of codes indicate an important area of opinions.

Insights that draw from the qualitative data included reasons why the participants navigated the decision aid in that certain way, as well as their preference on the two designs.

The participants using Design A explained why they followed the default order. (At the beginning of the quote is the number of the participants. The participant's prior knowledge is written in the bracket. The participant got this number of questions correct for the five pre-reading questions.) In theme A7, the participant explained that it logically makes sense to go through the information in order. He also does not want to miss any content.

#34 [4] So I think this one (Design A) would allow me to see the information in order maybe…in stead of me clicking wherever I wanted to go, I would miss something…so if it's given to me in a specific order, it will make sure that saw something important that would lead to the next thing.

They also explained they reason why they went back to previous content in theme A4. The participant wanted to make sure that a content explained previously was understood correctly.

#22 [4] I wanted to make sure what is the different between primary and secondary findings. Like I see 3%–5% for secondary findings…I want to see the percentage for primary findings, so I went back and compare.
Participants using Design B liked the ability to control wherever to jump to (theme B1). In fact, participants using Design B used the decision aid in a more flexible way. Four of the participants said that they did not want to spend a lot of time going through (with prior knowledge four, four, four, and five). One participant said he skipped content because he already knew about it (theme B13).

In terms of preferences, A7 shows that participants wanted to receive information in order (#32 [2], #9 [3], #34 [4]).

#9 [3] I prefer A because it is in order. Even if I know something about it, I decide to read it.

At the same time, six people recommended that Design A be more free (#24 [4], #30 [4], #10 [5], #19 [5], #21 [5], #23 [5]).

Three excerpts in theme D1 wanted a combination of both Design A and Design B (#13 [2], #18 [2], #37 [5]). The three excerpts in D4 wanted to go with Design B (#31 [2], #18 [2], #36 [5]). The five excerpts in D7 thinks Design A is more affordable (#6 [3], #8 [4], #10 [5], #19 [5], #21 [5]). It seems easier to them and it is more clear to them what they should do.

6. CONCLUSION

6.1 Conclusion

Hypothesis: people with lower level of prior knowledge have a better learning outcome when using a more structured tool.
From the data that I have so far I cannot give a confident conclusion for the first half of the hypothesis. According to Figure 7, the correctness of post knowledge gain for participants using Design A was greater than people using Design B for those with prior knowledge level two, three, and four, but the result is flipped for people with prior knowledge of five. There is also no explanations for why the curve of participants using Design A is an upside-down “V”. More study is needed to find out how might people with prior knowledge get more points in learning materials like this.

Hypothesis: people with higher prior knowledge are more efficient using a more flexible tool.

Figure 8 showed that people with lower prior knowledge spent less time using a more structured tool. In fact, participants across different levels of prior knowledge spent less than half the time answering questions when they used a more structured tool than a more flexible one. Figure 8 also shows that participants generally spent more time reading the material when they used a more structured tool compared with a flexible one. Yet statistic analysis showed this difference is not significant.

Figure 1. Design A, linear navigation structure

Figure 2. Design B, network navigation structure
There are several explanations for the reason why people answered questions faster when using Design A than Design B.

1) A linear structure in this particular graphic presentation provides a mental map that helps people form knowledge out of information. We might all remember our biology teacher drawing evolution trees to explain how life started with simplest cells. Teachers can promote long-term retention of information presented in lectures by using concept map. (deWinstanley and Bjork 2002)

2) Graphic presentation reinforces the structure of the contents more clearly in Design A than Design B. Design A is designed in a way that emphasizes sequence while Design B offers a sense of equality. Take the Genetics 101 as example. The five minor sections are each represented in a circle with number and linked with a single line line through the middle. It is easy to understand that section 1.1 is the start of this major section, and ends in 1.5. Also, 1.1–1.5 are built in a way that the reader follow the order. At the same time, Design B intentionally weakens the sense of sequence. Though each major section is assigned a particular color with a horizontal line running from left to right, Design B does not highlight the relationship between neighboring major sections and minor sections. The hierarchical relationship between main section and sub section is minimally indicated.

3) Participants spent more time reading the material in Design A than Design B. They also tended to refer to the task sheet more often and jump to contents based on the sheet. This may have influenced the duration for them to go through the task.
6.2 Implication for the Design Challenge

If a choice has to be made between the two navigation structures, Design A work better for people to really understand the material. Since the families coming to Whole Exome Sequencing need to understand the content in detail so as to have meaningful conversation and make decisions in confident, Design A might be helpful for them. On the other hand, other medical specialist might be better off using Design B. These people though not as familiar with the content as WES specialist, they might know roughly what they are looking for in this decision aid. It will be easier for them to go to random content based on the title and explore the decision aid as a whole.

Suggestions came out of the quantitative data lead to additional implications. Design A will be a good base to start with because of the clear navigation bar at the left side of the screen. Here are four design possibilities.

1) Set the left buttons as clickable. Figure 10 shows that all the section
buttons at the left side are in color, which indicates the ability to click to any part at will.

2) When people first go through Design A, the order is strict. Individual sections become clickable after the first time through. Figure 11 shows that at the bottom of the navigation bar a sentence will tell the user about the flexibility when he finishes reading it the first time.

3) Important terminologies could be highlighted and provide an excerpt of explanation in the current screen. In Figure 12, when the mouse hovers over the concept genes that was explained earlier, a short explanation appears.

4) Similar to the previous one, a hyperlink to the particular screen can be provided. The user will be able to go back to the section for genes.

Figure 11. Design implication 2
Figure 12. Design implication 3

Figure 13. Design implication 4
7. FURTHER STUDY

The proposed Design A and Design B as decision aids for Whole Exome Sequencing needs iteration. It will be helpful to make suggested changes and then take back to the family to ask their preferences. Since we have already examined performance together with preference, it will be fine to just ask for preference in the next stage.

There are limitations due to small sample size. Comparisons between linear and network pattern can have contributions to other design and research.


Langdon, P. H., Joern (2009). "Is Prior Experience the same as Intuition in the context of Inclusive Design?".


APPENDIX A. TESTING TASKS

Task 1
Search for the specific term “gene” and understand “gene”

Task 2
Browse information about how the return of the test results would impact on the patient health

Task 3
Understand what are “secondary findings” and what are the implications of secondary findings
APPENDIX B. PRE-READING QUESTIONS TO DETERMINE PRIOR KNOWLEDGE

1. A gene is on a chromosome that codes for a specific trait. (Answer: T)
2. There are 23 genes in a typical person. (Answer: F)
3. Gene plays a most important part in a person’s physical appearance. (Answer: T)
4. Genetic testing looks at every gene of a person. (Answer: F)
5. From genetic testing, health doctors can know everything about a person’s health. (Answer: F)
APPENDIX C. POST-READING QUESTIONS TO DETERMINE KNOWLEDGE GAINED

1. Genes are chemical instructions that tell a cell what job to do. (Answer: T)

2. Whole Exome Sequencing (WES) looks at all the exons of all genes. (Answer: F)

Whole Exome Sequencing (WES) is a genetic test that can find the cause for the genetic problem. (Answer: T)

Findings of Whole Exome Sequencing (WES) may or may not change the patient care. (Answer: T)

Health insurance companies can deny a person's health insurance based on genetic test results. (Answer: F)
APPENDIX D. OBSERVATION OF PARTICIPANTS USING DECISION AIDS

#1 (A) returned from 1.4 to 1.3
#1 (A) looked at 2.1 when jumps to that page
#2 (A) 2.1–1.2–2.1, the rest followed default path
#3 (A) 1.3–1.2, the rest followed default path
#4 (A) followed default path
#5 (A) 1.3–1.2, 2.5–2.4, the rest followed default path
#6 (A) followed default path
#7 (A) 1.3–1.2, 1.5–1.2, the rest followed default path
#8 (A) followed default path
#9 (A) followed default path
#10 (A) followed default path
#11 (A) followed default path
#12 (A) followed default path
#13 (B) 1.2–1.1, 1.3–1.2, the rest followed default path
#14 (B) followed default path
#15 (B) 2.1–1.5–1.4, the rest followed default path
#16 (B) 1.1–2.1–2.2–2.3–1.4–1.5–3.1–3.2
#17 (B) 1.1–2.1–2.2–2.3–2.4–2.5–2.2–2.5–2.4–2.3–1.4–1.5–3.1–3.2–3.4–2.2
#18 (B) 1.1–2.4–2.3–2.1–2.4–2.3–2.5–2.4–2.3–2.1
#19 (B) followed default path
#20 (B) 3.1–3.2–1.1–1.2–1.3–1.4–1.5–2.1–2.2–2.3–2.4–2.5–3.3–3.4
#21 (B) 1.5–2.1–2.2–2.3–2.4–2.5–3.1–3.2–3.3–3.4
#22 (B) 2.3–2.2, the rest followed default path
#23 (A) followed default path
#24 (A) followed default path
#25 (B) followed default path
#26 (B) followed default path
#27 (B) 2.5–2.2, the rest followed default path
#28 (A) followed default path
#29 (B) 1.1–2.1, 2.4–2.3, the rest followed default path
#30 (A) started with 1.3, 1.3–1.2, the rest followed default path
#31 (B) started with 1.5–2.1–2.4–3.1–3.2–3.3–3.4.
#32 (A) followed default path
#33 (A) followed default path
#34 (B) 1.1–2.2–2.1–2.2–2.3–2.5–2.1.
#35 (A) followed default path
#36 (B) 1.1–1.4, the rest followed default path
#37 (B) 1.4–2.1, the rest followed default path (he just over looked 1.5…)
APPENDIX E. CODED ANSWERS OF OPEN-ENDED QUESTIONS

OTHER

Other

#12 [3] I’m not good at too many options, like the option to go to the next or the previous one you just saw. Where I’m at 2.2 and I’m lazy so I went to 3.3.

#27 [3] If I don’t get an overview of everything, I have to click this to go back.

(B)

DESIGN A

A1) A doesn’t allow navigating to different places at will

#2 [2] I tried to navigate from the nav, but it is not allowed.

#1 [4] (A) it’s a little annoying not being able to go back to any desired content directly from the side nav

#16 [4] A doesn’t allow the freedom to go wherever I want to.

#23 [5] (A) can’t click at free in the left side

A2) A provides sequence for the material, can go through the information at ease

#2 [2] I like the sequence of the decision aid (A) because it is in a sequence; I can go through the information at ease.

#5 [2] (A) I can read and learn in sequence; it is very helpful to me
#13 [2] (A) I liked the simple graphics… going on on one, and then jump to the other

#25 [2] I like A better. I also do things in order

#3 [3] I prefer A because it is instructed. I don’t know what I need to know so I would follow it.

#12 [3] If I have to really understand this information, I’ll probably go with the first.

#27 [3] It makes sense to click on it for parents to look through and gather information. The order of the information is extremely important.

#1 [4] I would want to read in sequence because this is an instructional and everything is built in a sequence.

A3) Now that I don’t know about the topic, I would want to follow through at not to miss something

#2 [2] Now that I know nothing about the topic, I would want to follow through and not to miss something.

A4) I went back because I want to make sure what I understand about this concept is correct

#5 [2] I went back because I want to make sure it’s correct.

8#1 [4] (A) I went back because… Some of the concepts are easy to understand… I encountered some words that appeared previously. I wanted to make sure I understand the concept correctly.
#22 [4] I wanted to make sure what is the different between primary and secondary findings. Like I see 3%-5% for secondary findings…I want to see the percentage for primary findings, so I went back and compare.

A5) At the very end I think there can be some kind of conformation at the end to tell me that I finished

#5 [2] (A) At the very end I think there can be some kind of conformation at the end to tell me that I finished.

A6) A makes me more inclined to go in order

#32 [2] With this one (A), it makes me more inclined to go in order.

#15 [5] A partially forces me to read through.

A7) Taking it in order kind of makes sense…if you skip around, that might miss something so I think that makes sense

#32 [2] I think taking it in order kind of makes sense…if you skip around, that might miss something so I think that makes sense

#9 [3] I prefer A because it is in order. Even if I know something about it, I decide to read it.

#34 [4] So I think this one (A) would allow me to see the information in order maybe…in stead of me clicking wherever I wanted to go, I would miss something…so if it’s given to me in a specific order, it will make sure that saw something important that would lead to the next thing.

A8) I would want to go back to wherever page I want to look at when I need to learn any particular page
#1 [4] I would want to go back to wherever page I want to look at when I need to learn any particular page

A9) A looks very daunting


DESIGN B

B1) Like having the ability to control wherever to jump to

#5 [2] (A) Like having the ability to control wherever to jump to. If I use B, I might not read everything, I will click randomly. I would probably still go through the content one after another.

#7 [5] I prefer B because I can jump (to different contents)

#29 [5] B is more appealing to me. It doesn’t make sense if like I am towards the bottom of context and then I want to read the previous content.

B2) I feel that I’ll need to know what I’m looking for

#13 [2] B is more general, I feel that I’ll need to know what I’m looking for.

B3) With different things at top, I might click around and not do it in order

#32 [2] With this one (B)…with different things at top, I might like click around and not do it in order.

B4) Having color coding is good

#18 [2] B, having color coding is good

#24 [4] B, the color coding looks like they are in sequence
B5) The graphics and texts look confusing

#18 [2] B, the graphics and texts look confusing

#19 [5] For B, I have to read both horizontally and vertically.

#23 [5] (B) the navigation is colorful, it’s distracting.

B6) I don’t know which information is important and what to click

#12 [3] In B I don’t know which information is important and what to click.

#23 [5] B, the structure is not very clear compared with A

B7) I can see there’s a sequence

#12 [3] (B) I can see there’s a sequence.

B8) I wonder if I jump around and miss the story

#12 [3] I wonder if I jump around and miss the story.

#14 [5] (A) I didn’t end up reading all of them… I didn’t know what they are so I didn’t jump around to miss some information that are pertinent to my child

B9) The colors make it less clinical and medical

#27 [3] The colors make it less clinical and medical. (B)

B10) I jumped because I don’t want to spend a lot of time going through.

#16 [4] (B) I jumped because I don’t want to spend a lot of time going through. I want to know what does it do, how is it related to genetics, how might it affect us. I was not very much concerned about implications
because I can choose not to tell my kid the results. Therefore, I didn’t finish reading the first several sections.

#28 [4] I don’t want to go over all the content. I want to go to WES section first.

#28 [4] I can get most idea from the WES section so I won’t read the genetics 101 section. I’ll also read the emotional implication part. I get it so I read it very fast. The second section is very important. I can have an idea of what I should consider by going through the second section.

#34 [4] I was kind of looking for keywords… and based on the questions, it was a little confusing on what exactly I was going to find…but…mainly I was looking for keywords and if the keywords really lead me to the right answer.

#36 [5] Based on the question, the first genes page it gives me a lot of information, so I think it not super necessary for me to look at this information (skipped 1.2, 1.3) since I already remember it to some extent. So from there I just want to take the tasks. From there I went to mutation…this page I think it’s very mutual…it’s a very good way to explain that concept.

B11) I realize the content went in sequence…I could go all over the place but each one built on the previous information

#20 [4] Then I realize the content went in sequence…I could go all over the place but each one built on the previous information

B12=A4 A4) I went back because I want to make sure what I understand about this concept is correct
#29 [5] For this, I was not sure about what does “exon” mean, so I went back. It would be nice if there’s some kind of hyperlink in this page… this is an unfamiliar terminology… I know that one is “ex…”, the other is “in…”. I was a little bit confused so I went back and check.

B13) I jumped because I already know about it

#21 [5] I leaned those (1.1–1.4) in biochemistry so I went directly to 1.5

GENERAL

C1) The illustrations are very helpful

#5 [2] (A) The illustrations are very helpful

#13 [2] These (images) are very helpful

#13 [2] (A) I liked the simple graphics… going on on one, and then jump to the other

C2) Recommend image before text in each section

#13 [2] I like in some of the books that shows images first of all. I almost think the image before the text will go along

C3) Recommend repetition of information

#13 [2] some of the information will be helpful if it's repeated a little bit like exome are coding genes… so that there is a way for you to remember… like what you have for most of them
C4) Content is effective…it’s looking out for you like a person

#13 [2] (B) section 2 is very clear. section 3 is very effective, I don’t feel it’s like a sale… it’s looking out for you like a person

C5) I clicked on this part because it’s a scary word, I want to know—if anything goes wrong

#31 [2] I clicked on this part (1.5 mutations) because it’s a scary word, I wanted to know…if anything goes wrong… the scary word pops up to you a little bit

C6) The task makes me want to go in order

#25 [2] I think one thing is that the tasks are in order. Task 1 and 2 followed Genetics 101 and the next primary findings and secondary findings section. Task 3 is like the third part. It makes sense for me to go that way.

#6 [3] (B) I don’t like B because I don’t know about the content; the content seems confusing to me

C7) It’s text heavy

#26 [2] I am a visual person…I think (B) it’s too text heavy.

#33 [4] I kind of like this, because this shows me the next page. When I naturally just went through this, I didn’t even tried to do this (click on A at the left) except the next button. I'd rather have it just be like next… because it's less intrusive…And then I get to an end and I wanted to go back to this…

C8) I don't want to skip content

C9) The task makes me want to jump to that content
#18 [2] the task was secondary findings so I went straight to that

C10) Was confused if 1.4 has more content

#6 [3] I was a little confused by 1.4 because I needed to scroll down to see the “previous page” and “next page” buttons. I was wondering if there is more content on other pages

C11) Recommend that keyword highlighted

#1 [4] (A) keywords can be highlighted

C12) Recommend be handed content table and choose what to see

#16 [4] I will prefer to be handed content table and choose what to see.

C13) I didn’t need the insurance part because I didn’t know that much about it.

#17 [4] I didn’t need the insurance part because I didn’t know that much about it.

C14) I first went to the sections that are more familiar to me

#20 B [4] I'm a therapist so the sections of emotional and insurance implications make more sense to me…they are more familiar

C15) Recommend that A be more free

#24 [4] I think A will be nice to have the option if I want to know something specific I can go straight to that

#30 [4] I like it if A is clickable.

#30 [4] Its easier if its clickable to anywhere. There might be chances where I want to go back, but not immediate back…like several steps back.
#10 [5] It is nice to be able to go back with A once you want to go back to look at anything

#19 [5] I prefer A. If A is linkable to other content it will be more helpful

#21 [5] For A, it will be better if I can adjust the buttons.

#23 [5] (A) it’s better if they are clickable

PREFERENCE/COMPARISON

D1) Almost a combination of both. I like it to work both ways

#13 [2] Almost a combination of both

#18 [2] prefers combination

#37 [5] I would want it to work both ways…if someone skips…then don’t have to go over it one by one. If I knew about this topic, I don’t have to read all of them…I can just go to this section.

D2) It’s easy to click a button versus clicking on the circle

#13 [2] (B) it’s easy to click a button versus clicking on the circle

#26 [2] When you are going through his, maybe there’s an arrow. (B)

D3) Would prefer A because I can learn about it little bit by little bit

#35 [2] I would prefer A because…this concept for me…it’s a professional thing; I can learn about it little bit by little bit. Even if you give me B, I might still click one by one, so basically the same thing.
D4) Definitely B because I don’t want to be limited to only going next page or the other page. Definitely want to go wherever I want

#31 [2] I liked the first one definitely…I don’t want to be limited to only going next page or the other page. Definitely want to go wherever I want…be free with that.

#18 [2] if I can pick the order on my own, I will feel more at ease

#36 [5] If it’s me that I have more choice, I would probably pick the one that give me more control…but it might be a lot smarter to set this design because I think if this is the one that only available, I won’t miss having the choices…like I won’t think that I wish I would click on any of these…and it will make my child better, I maybe should look at all of them…they are all information to have.

D5) If it’s my first time reading this, I will read it in order; if I visit it the second time, I might go directly to “health implications” or “insurance implications”

#25 [2] If it’s my first time (reading this), I will read it in order; if I visit it the second time, I might go directly to “health implications” or “insurance implications”

#15 [5] After reading A, maybe I can do B so that I can only read important parts.

D6) Don’t like B because I don’t know about the content; the content seems confusing to me

D7) A is easier to understand what I should do
#6 [3] A is easier to understand what I should do

#8 [4] I am fine with A because it leads me in order

#10 [5] A is more clear because no need to jump around or anything

#19 [5] A is simper and easier

#21 [5] A, I don't have to guess what is inside

D8) I can navigate with B faster

#9 [3] I can navigate with B faster

D9) B is scary because you think you know everything

#9 [3] B is scary because you think you know everything

D10) I like the linear one because A guides me through different levels—from basic to complex to basic

#12 [3] Between the 2, I like the linear one because it guides me through different levels—from basic to complex to basic. If I didn't know anything at all the linear makes more sense to me.

#34 [4] So I think this one (A) would allow me to see the information in order maybe…in stead of me clicking wherever I wanted to go, I would miss something…so if it's given to me in a specific order, it will make sure that saw something important that would lead to the next thing.

D11) A is more visually appealing

#18 [3] A is more visually appealing
D12) I prefer B because I might forget what I read before so that I can jump to that part at ease. Basically, I want to have an overview of everything than go in depth into it.

#4 [4] I prefer B because I might forget what I read before so that I can jump to that part at ease. Basically, I want to have an overview of everything than go in depth into it.

D13) B will be good if I want to go back and talk with somebody else

#8 [4] B will be good if I want to go back and talk with somebody else. For example, if the father was not with me, after I see it I can introduce what is WES to him. In this case. B will be more helpful

D14) I feel like I would like going from page to page

#20 [4] I feel like I would like going from page to page because I thought I would start from anywhere…so I went for the terminology that is more familiar to me.

#7 [5] I want to go in order

D15) B is better because… I went to there when I forgot something

#22 [4] B is better, like you have just seen. I can see this and this, I can see the meaning of this, I went to there when I forgot something. (referring to jumping section 2.3–2.2)

#22 [4] For this one (A), you have to go from beginning to end…if you want to see what’s WES, you need to go back and back…it’s not convenient

D16) It seems better to have the nav at the left
30 [4] It seems better to have the nav at the left.

D17) I think B is better because of the content and context.

21 [5] I think B is better because of the content and context. I can go through each, it’s obvious.