Supporting the Synthesis of Information in Design Teams

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ABSTRACT

User-centered designers often seek to synthesize data from user research into insights and a shared point of view among team members. This paper explores the synthesis process and opportunities for providing computational support. First, we present interviews with novice and expert designers on the common practices and challenges of synthesis. Based on these interviews, we developed digital whiteboard software support for sorting individual segments of user research. The system separates out individual and group activity and helps the team externalize and synthesize their different views of the data. Through a case study, we explore two computer-supported approaches: a structured condition that externalizes the different perspectives on the data of each team member and an unstructured condition that allows each member to organize data into clusters. Novice designers tended to prefer the structured synthesis process, while more experienced designers preferred to freely arrange information segments and create clusters on their own. We provide implications for design education and support tools for user research synthesis.

Author Keywords

Synthesis; sensemaking; user research; design process

ACM Classification Keywords

H.5.2. User Interfaces: User-centered design, Evaluation/methodology; H.5.3. Group and Organization Interfaces: Computer-supported cooperative work

INTRODUCTION

Conducting in-depth user research is a vital part of user centered design processes [2,11,33]. User research usually produces large amounts of data, which can be difficult to integrate into actionable design insights [3,21]. Paper-based affinity diagramming provides a tangible method of organizing observations and interview results according to semantic similarity [2,9,12,16]. Usually, this is a team-based activity with the goal to "make sense out of the data" [21,29]. Many practitioners recognize this as a "magical" part of the process where raw information is synthesized to generate new knowledge [16,21,29]. It is particularly difficult to develop a *shared* understanding of user data among all team members, because people have diverse individual perspectives that guide their interpretations [14,28].

DIS '14, June 21 - 25 2014, Vancouver, BC, Canada

http://dx.doi.org/10.1145/2598510.2598545

Several prior research projects sought to transfer the process of synthesizing qualitative data with paper notes to the digital world, e.g. [12,18]. However, little research focuses on team-based interactions around qualitative user data. Our goal was to understand the challenges for design teams to "make sense" out of their user research data and how we can support a team's synthesis of information.

In this paper, we present results from seven interviews with designers of different levels of experience regarding information synthesis. Based on their needs and combined with findings from other research, we developed a tool (referred to as the "Synthesis Guide" in this paper) to support the collaborative synthesis process for design teams. In this tool, each team member works with the data individually and applies tags to the research data. The tool then generates overviews that include the tagging results of all team members. The tool gathers input from the whole team and guides users through the synthesis process.

In a case study with six design teams, we studied how the tool affects team synthesis compared to an unstructured synthesis condition where participants could freely organize information on a pane, like sticky notes on a whiteboard. The study compares a method for unaided, spatial arrangement versus a sequential, guided way of working with information. We found the tool helps users externalize their different points of view and that users perceived the synthesis as more balanced among team members. However, other users – mainly the more experienced ones – preferred the unstructured version because they could decide on their own how to arrange the data. Across conditions, users appreciated the individual working phase to begin the process.

BACKGROUND AND RELATED WORK

We use the term *synthesis* to refer to the practice of integrating, organizing, filtering and evaluating information as part of a design process [21]. In related work, this understanding of synthesis also may be referred to as collaborative synthesis [32], framing [13,14,35], sensemaking [25,30], collaborative sensemaking [27,39], or information analysis [17].

Sensemaking describes the act of "making sense of user research information", although many interpret this term even broader as "the process of searching for and organizing information" [34]. Many research projects focus on helping analysts make sense of large amounts of data on the internet [31,37], or to conduct network analysis [4] or document analysis [40]. The described data are often "hard facts" that need to be combined, such as facts about digital cameras [37,38] or neighborhoods characteristics [5]. In this understanding, the term also involves the seeking and searching for information [30] and not just the act of condensing information to create new knowledge.

This creation of new knowledge and insights from user research data can be cognitively demanding for design teams [1]. Filtering, organizing and making sense of uncertain and ambiguous information is complicated and exhausting [13,20]. Teamwork can help support this critical phase of the design process, but it also introduces the difficulty of creating a common ground and making decisions that all team members support [14]. Based on prior experience, people form individual *frames* that consist of implicit knowledge structures [14,35]. Difficulties often arise when aligning individual frames to create a collective understanding [14]. This can be especially challenging when dealing with ambiguous information from user research. Collective understanding is complicated by group processes such as "groupthink" where teams can focus too much on consensus building and disregard the opinions of the individual team members [26].

To combat these issues, Dow et al. [10] showed that sharing multiple designs – versus sharing a single design – can help designers better understand their partner's perspective. This led to an increase group rapport and better results. Other researchers also showed that discussions play an important role and teams that synthesize their knowledge into a shared understanding tend to have more successful design processes and outcomes [13,15]. Our research seeks to embody these findings into computational support for data synthesis.

Most tool support for sensemaking focuses on searching for and visualizing huge amounts of data. Novak [27] and Umapathy [39] also highlight the importance of knowledge exchange in interdisciplinary teams and studied how teams come to a shared understanding during sensemaking. This research on shared sensemaking suggests that visualizing implicit knowledge structures improves the knowledge exchange among team members [27].

A few research tools focus on the synthesis of qualitative user research data. For example, Judge et al. [18] study how multiple display environments can improve affinity diagramming. Harboe et al. [12] augment paper notes with barcodes for locating the notes via text search. While these approaches improve the mechanics of creating affinity diagrams, they do not emphasize the problem of helping a team condense data and develop a shared understanding. This is particularly challenging for design teams that often deal with qualitative data and leverage tacit knowledge to form an understanding. Andre et al. [1] addressed the synthesis of qualitative data with the help of crowdsourcing. In their studies, crowdworkers without domain knowledge created categories from subsets of text datasets. They found that seeing several data items and labeling them produced better categories than grouping the items and then labelling the groups. Although the authors have shown that online crowds can perform synthesis, we want to focus on supporting the design team itself. Dealing directly with user data is important for designers as it helps them better understand the problem they are trying to solve [21].

INTERVIEWS ON INFORMATION SYNTHESIS

We interviewed seven designers with different levels of experience on how they manage the information overload and how they synthesize their insights as a team. We conducted interviews with two design students, four professional designers (graphics and interaction designer) and one design professor. The interview length varied between 20 to 45 minutes. We used interview guidelines focusing on how people condense, select and decide when synthesizing information and how they evaluate their approaches. Interviewees were asked to report on their prior experience and synthesis practices. We were especially interested in open-ended design challenges such as "How could the airport check-in and boarding process be improved?" In most cases designers gained their information through user research. The size and corporate structure of the organization affected whether our interviewees conducted user research and synthesis alone or in teams of two to five people.

All interviews were audio recorded. We used open-coding techniques to discover patterns and recurring topics [7]: For each interview, we wrote various memos on sticky notes, clustered them on separate boards, and analyzed similarities and differences between the interviews afterwards.

No Standardization around Organizing Data

We found most designers start with communicating their user research results to other people – either to one colleague or a whole team, depending on company or school structure. During these conversations, people usually take notes, either on normal paper or sticky notes. Afterwards, they try to find similarities of what they have heard and try to group them by general terms (i.e., clustering). Important topics are sometimes displayed in different frameworks or diagrams, such as a process diagram to show workflows or relationships between the topics. For example, the designer might visually represent when one topic is a superordinate concept or a specialization of another. In the end, people write down their most important insights or principles. This relates to the course of action other researchers have observed [16,32] and to Kolko's methods of synthesis as e.g. "prioritizing" or "concept-mapping" [21]. However, not everybody follows an elaborated structure when synthesizing information, but pursues a rather intuitive, coincidental sequence of steps.

A Crucial Point for the Entire Design Process

The expert designers described how they assimilated information "on the fly", and most of the time on their own. In contrast, other interviewees stated that the synthesis was a very crucial point within the whole design process and its importance should not be underestimated, as it helps to identify general statements, principles, trends, needs and requirements with regards to the design task.

> I think it is the fundament for everything that follows […] it is important that the whole group has a shared language and a shared collection of insights.

Synthesis Decisions Guided by Intuition

Decision making occurs when designers have to prioritize or select between different pathways. We learned that intuition plays an important role for decision making in information synthesis. When we asked our interview partners how they identify and define insights or decide on their priority, no one could give a clear answer. In particular, experienced interviewees said they follow their intuition, which they had built up over time through various projects. Novice designers also stated that decision making is important, but difficult as they do not have as many experiences to inform their intuition.

> That's the way it is: a team decision making process that is super difficult. Super dry, long, and exhausting.

> I think it is just experience, the experience to have the feeling: "these are insights I can work with."

Literature also suggests that people develop intuition through experience [2,8,21]. This experience provides tacit knowledge about different situations and implications.

Amount of Discussions Varies Among Teams

Our interviews suggest that discourse between the members of a design team is seen as a decisive part of information synthesis. An interviewee even defined synthesis as "a team process with a lot of discussions". On the contrary, other interviewees stated that they collect and synthesize information in general on their own and only talked about their observations with a few people, generally expert designers, later on. Thus, we could observe that the amount of discussions varies with teams and design situations. In the literature, discourse among design teams is seen as rather important for user-centered design [15,22,24].

Analog Forms of Media Predominate

Our interview partners use different kinds of media to communicate and process information, though analog media such as paper, sticky notes and traditional whiteboards are the most commonly used. Nevertheless, the interviewees from companies—as opposed to academia—stated that they used digital media in form of word processors, presentation programs, or even wikis.

Extent of Convergence Depends on Experience

Converging information and finding design principles with a higher degree of abstraction is one of the goals of the synthesis phase. However, we observed different levels of information trade-off among our interview partners. Some interviewees try to keep and externalize as much information as possible, partly because they are afraid to lose information and partly because their stakeholders set these restrictions. Others stated that it is not possible and also not desirable to keep all information in the design process, as it is important to quickly focus on the most important points. Most interviewees agreed that it depends on the level of experience to decide which and how much information is important to process in the design process.

Team Dynamics & Dominant People Strongly Influence

We observed through the interviews several incidences in which implicit team dynamics influences the synthesis process rather unconsciously. For instance, interviewees mutually agreed that team members can only reach joint decisions if they share a common ground of trust and respect (cf. [36]). In another example, an interviewee stated that people who impose their own view strongly influence the whole synthesis process.

> It's a critical phase in the team process because dominant people often prevail and then their user research data prevails, too. …all user research [should be] worth the same.

This illustrates how groupthink processes [10] play a role in design synthesis and that its success depends on team dynamics as well as the motivation and biases of individual team members.

Teams Struggle to Communicate Synthesis Results

Interviewees who are working in companies stated that customers and stakeholders complain that they hardly see what happens during the synthesis phase (cf. [21]). Several clients want to understand where the design ideas and solutions originate from and whether the budget for user research has been spent reasonably. However, this generally assumes one can see the relationship between design solutions and user research data, which is normally only possible towards the end of the design process. In particular, in early stages of the design process, designers often struggle to communicate about the design process' progress. In this context, information synthesis can help to create presentable states of knowledge. However, our interviews suggest that this seems to be less of a problem for the more experienced designers who nurture a trusting relationship with clients. This shows that external communication requirements depend on the relationship between designers and clients and how much they confide in the respective design approach.

Organizational Circumstances May Hinder the Process

Often in companies where people work on several projects simultaneously, there is not enough time for an extensive synthesis process. Interviewees agreed that synthesis usually needs more time than allocated. Additionally, teams in companies face the problem that one or more team members are missing and it is difficult for them to catch up afterwards. Sometimes there are strict rules on how the synthesis should be done. Other times the research goals are not clearly defined and lead to problems between the designers and clients.

In sum, the interviews revealed key insights about information synthesis: synthesis is important and necessary, but also difficult and exhausting or – as one of our interviewees said – “a necessary evil”. It is a stressful team process that depends on having good team dynamics. For beginners, synthesis is especially challenging because it depends heavily on experience and intuition. The process is usually nonlinear and produces ambiguous results. The tediousness of the work is often not visible or tangible to outside observers. Last but not least, synthesis takes a lot of time, which is often not provided or scheduled.

SYNTHESIS GUIDE

Based on what we learned from interviews and related work, we sought to improve the process and outcome of design synthesis. We created the *Synthesis Guide* for a digital whiteboard system, which structures the synthesis process by letting people work individually first and then externalizing the team members' points of view in the end. In this section we describe the design of the Synthesis Guide. It is followed by our design objectives related to the interview findings.

The main instrument of the Synthesis Guide is the act of applying different “perspectives” or “tags” to user research data. The process is similar to the crowdsourcing approach in Cascade [6] where workers generate tag categories for a set of items. Then other workers select the best tags for each item and this produces a hierarchical organization of the data. In our research, we focus on how to support members of a design team who bring implicit knowledge from their user research. Importantly, they will use the knowledge they generate during synthesis for later idea generation and prototyping.

We see a “perspective” or “tag” as a frame or point of view that can be applied to situations or data [21]. This is based on the assumption that different people in general have different mental models [19,23]. These mental models are based on what we have learned and experienced and we see the world from this perspective [14,21]. With the task of applying perspectives to pieces of information, the different perspectives of team members are externalized and shall make them aware of the different views they have (especially in interdisciplinary design teams [3]). During discussions, we noticed that the term “perspective” is not understood immediately and instead of “applying perspectives”, people preferred the term “tagging”. Therefore, we continued to use “tags” instead of “perspectives”.

In the first step of the Synthesis Guide, each team member shall get an overview of all sticky notes that were written by the whole team after conducting user research. In order to reduce the overload of seeing all sticky notes at once, the notes are presented in groups of three on each page. With the help of the next button users are supposed to go through all notes, see Figure 1, Step 1. This example shows sticky notes from the case study described below. In the second step, each user is supposed to create a perspective or tag

Figure 1. The three steps of the Synthesis Guide. First, each user reads all sticky notes. Second, each user creates a tag that should be applied to the sticky notes. Third, each user tags every sticky note with the tags of the team. The important tag is provided by the system for highlighting notes that should get special attention afterwards.

related to the sticky notes they have seen. Alternatively, example tags are offered and they may choose one of these. Each user creates an own tag that he or she considers interesting. During pre-testing, people said they were unhappy when they created tags very similar, yet still different from their team members' tags and so they asked for a way to prevent this. Therefore, users will see tags already created by their team members to avoid duplicates and foster a broader range of tags, see Figure 1, Step 2.

After all team members entered one perspective, the Synthesis Guide will lead to the last step, the tagging view, see Figure 1, Step 3. Each sticky note will be displayed on one page together with all tags the team has chosen. Additionally, the tag “important” is offered to indicate that a note is important even though it does not fit to any of the chosen tags. Users shall now select all tags that fit to the displayed sticky note. They can select as many tags as they like and may also select none. After pressing the next button the tags are saved and the next sticky note is displayed. Each team member is supposed to do the tagging individually. By going through the steps of the Synthesis Guide everybody is

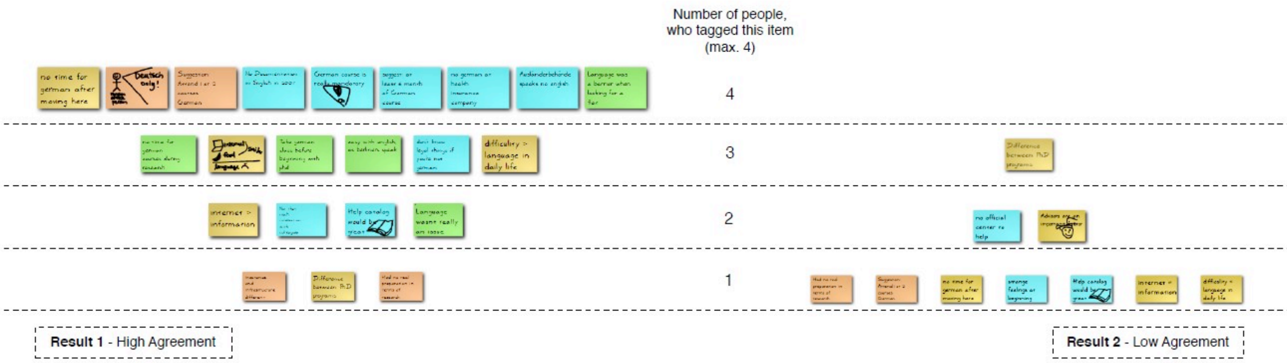

Figure 2. Two examples of results screens after tagging (from the case study described below). On the left, the team has a very similar understanding with regard to this tag ("communication barrier"), because several sticky notes have been tagged by all team members. On the right, the understanding is pretty diverse, as the majority of notes were only been tagged by one person (with the tag "important").

"forced" to engage with the data and cannot leave this to other team members. Additionally, the point of view of each member is collected.

After each team member completed the three steps, the system offers a result view for each tag, see Figure 2. Sticky notes that were selected by all team members appear on the highest level and they are enlarged. Depending on the number of selections, the other notes are displayed on a lower level and smaller. Sticky notes that were not selected at all are not displayed. The result pages shall give an overview how the team understands the collected information. The more notes displayed on the highest levels, the more similar is the team members' understanding of what the collected information represented. When there are only few notes on the highest levels, the team members generally have a different understanding of the information and should talk to each other about the differences.

Support for Collaborative Synthesis

With the help of the Synthesis Guide we wanted to address the following difficulties people face during synthesis.

Improve Understanding of Information

Through the interviews, we learned that people have a hard time making decisions about the importance of particular bits of information. We want to help team members to get a better understanding of the information they have collected during user research. Each team member shall have time to individually familiarize and engage with collected data, especially notes written by other people. While applying tags to the sticky notes, users have to think about the relationship of the respective tag with the data set. This way they are forced to look at the data from another angle or frame. While people contemplate about the data and try to view it from angles they engage with the data in a way they would not do during standard clustering. This in-depth engagement with the data may lead to a better understanding of the data.

Improve Shared Understanding Among Team Members

The interviews revealed that team dynamics and mutual understanding among team members play a decisive role in the synthesis process. To support teams in forming a shared understanding, the Synthesis Guide creates explicit representations of knowledge structures [39] and lets the team compare and analyze different representations. If the team is not aware of these differences before a decision, this may result in conflicts that hinder the ongoing progress and it is important to understand each other's perspectives [13]. When people apply tags individually, they do it without being influenced by their co-workers. On the results pages of the Synthesis Guide, the different opinions are visualized. We assume that people are often not aware of their different points of views and with the help of the results pages of the Synthesis Guide the team sees the similarities and differences of views with regard to the different tags. Based on these views they shall start a discussion and come to one shared point of view.

Ensure That All Team Members Are Equally Involved

We learned that in some teams certain team members can dominant the whole synthesis and decision making process. As a result, the outcome does not necessarily reflect the opinion of the whole team, which may lead to conflicts and disregards the advantages of multidisciplinary teamwork. Therefore, we want to assure that all team members are involved equally and show the contribution of each person. When each team member is tagging the notes, they are forced to engage with the data and cannot leave it to their team members. Furthermore, the input of all team members is counted equally and displayed on the results pages.

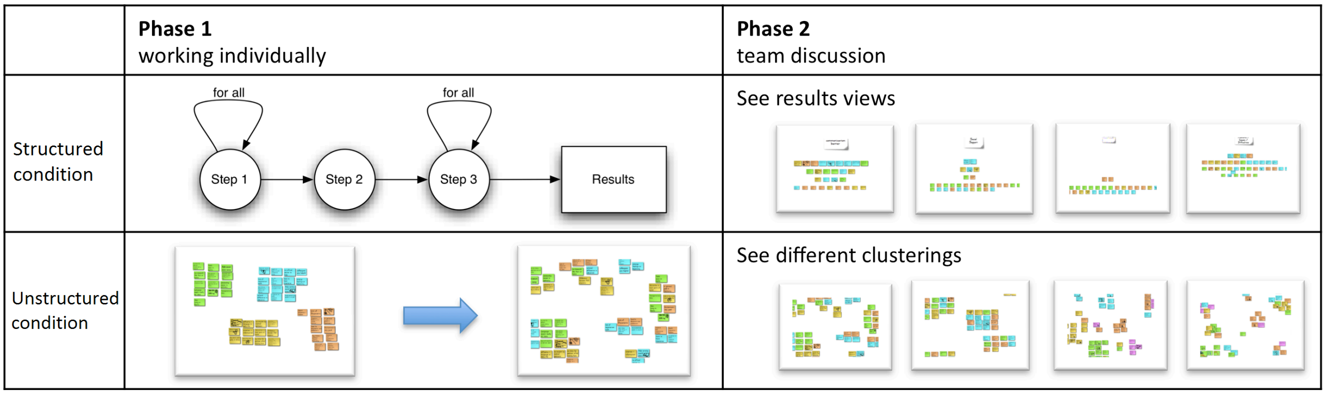

Figure 3. Study setup for evaluating the difference between a structured process of doing the synthesis with the help of a Synthesis Guide and the unstructured clustering where each user could arrange the sticky notes freely. In both conditions, the team members were working on their own in the first phase. Afterwards, they created a point of view of the given data in a team discussion.

Give Guidance for Novices

Many novice designers do not know how to proceed in the beginning. Therefore, we want to give them more guidance and encourage them to work with the data. They should have support in getting started instead of discussing how to deal with the huge amount of sticky notes as we have often observed in student teams. Through its predefined steps, the Synthesis Guide shall give guidance to the team and help them to get started with synthesis.

EVALUATION

We refined the design of the Synthesis Guide through a number of pilot studies. We learned for instance, that users did not want to see all sticky notes on one screen, but rather have them separated to reduce information overload. They also wished for a way to mark particular data as "important" and we included this for the case study.

The case study evaluated how the Synthesis Guide affects the synthesis process and whether it helps a team form a shared understanding. We ran a within-subjects study with two conditions, Structured and Unstructured (see Figure 3). In the Structured condition, participants followed the process from Figure 1. First, each team member read all sticky notes by clicking through all data. Then, each person created one or more tags or perspectives. As a last step, each member tagged all notes with the tags created by the group.

In the Unstructured condition, participants interacted with data as they might with paper. Each team member could view the entire sticky note dataset in a digital whiteboard application on a laptop. The sticky notes were denoted by color (based on the interview person). People could move the sticky notes around with their mouse and cluster them as they liked. They could zoom in and out. All other functions of the whiteboard application were turned off, in order to make participants focus on the content.

Participants

We recruited 24 participants into six teams. Three out of the six teams started with the structured condition, three with the unstructured clustering condition. All participants had previous experience with design thinking [3] and synthesis, but with different levels of experience. All teams were interdisciplinary, i.e. participants had different academic backgrounds and consisted of four people each. From the 24 participants, 14 were female, all teams were mixed-gender. The average age was 28 years. Most participants did not know each other previously.

Procedure

In both conditions, the teams got a dataset of sticky notes and were asked to create a point of view (POV), a sentence that summarizes the most important findings from the sticky notes. In a real design setting, the team members themselves would write the notes. Due to time constraints we offered notes created previously by other design teams on two challenges: 1) how to improve the arrival experience for foreign researchers going to a foreign university, and 2) how to improve the airport check-in and boarding process. The datasets consisted of 50 sticky notes each.

In the structured condition, the teams had 15 minutes to complete the Synthesis Guide. Afterwards, they looked at the results pages and had 13 minutes to discuss these results and to create a team POV from the data. In the unstructured condition, each team member had 15 minutes to work with the data individually. We gave the instruction: "get an understanding of the information on the sticky notes." Afterwards, the team sat together and had 13 minutes to discuss what they had learned from the data and to create a team POV, as in the structured condition.

In the first phase of both conditions, when the teams worked individually at their laptops, they were sitting around a table and could not see the team members' screens. In the second phase, when they were instructed to discuss their findings and create the POV together, we made them orient their laptops in one row. This way, everybody could see all screens at the same time and they could point at sticky notes on the screens.

After each condition, the team members separately filled in three forms: one with his or her most important insights from the data, one with comprehension questions related to the respective challenge, and a post-task questionnaire. After conducting both conditions, each participant also filled in a post-test questionnaire. The post-test questionnaire included Likert-Scale questions and free response questions. Each session lasted about two hours.

Results

Teams in all conditions created POVs within the given time frame. All team members participated, though some were more active than others. In the Synthesis Guide condition, each team created a perspective as instructed. Some participants did this very quickly, while others needed some time. Some teams asked each other clarifying questions about the perspectives, especially to differentiate between them.

We ran an analysis of variances (ANOVA) on the Likert-Scale questions of the post-task and post-test questionnaires in order to find differences between the conditions regarding common ground, satisfaction, effectiveness, fun, etc. Additionally, we analyzed the questionnaires with regard to the general quality and similarity of insights among team members. To test a team's comprehension of the given data, we created five sample questions for each data set. Each correct answer received one point and we calculated the amount of points a team earned per condition.

For all of these measures, we found no significant differences between conditions. Therefore, we focused our analysis on the free response questions of the post-test questionnaire. We asked which condition the participants preferred and for what reasons. We also asked which advantages and disadvantages they saw for each of the conditions.

Both Methods Can Help Form a Shared Understanding

Some participants said the tagging overviews in the unstructured condition helped them to find a common ground faster because they could see others' POVs and this required less discussion:

> I think it can demonstrate common ground very easily and doesn't lead to so much discussion which post-it should go where. (T4P1)

> You see the most tagged post-its. This way you get a quick overview and a faster common ground with the team members. (T4P3)

Others saw advantages in using the Synthesis Guide (structured condition) because it gave them focus and clarity on important facts:

> Maybe it was just the example, but the clustering felt quite natural. We had the most important facts immediately. (T2P4)

> In the end, it seemed to be more clear what the interviewees said and how the others think about it. (T2P3)

Two participants also acknowledged their use of the "important" category, even highlighting information without a special reason:

> Especially the important tag is interesting, 'cause you sometimes have a feeling this is important, but don't know why. (T5P1)

However, six participants had problems with creating the tags and misunderstanding them. They disliked that they were limited to four and that they could not change them afterwards. Although they were able to ask their team members questions about the tags they saw problems of misinterpreting them: "There was some confusion about the tag-categories" (T5P4) and this user was afraid that it was "just the least common denominator." Other participants generally saw more advantages in the unstructured clustering condition. They felt that the information sharing and discussions were more vivid and personal. "It was much more organic and invited dialogue" (T5P2). Overall:

> I felt that the team reached a better common understanding of the challenge even though we didn't talk about it like with the [system], but the building of clusters seemed to give us better tools to share our understanding (T4P1).

More research is needed to examine whether tagging generally helps teams come to a shared understanding. For some teams it did, but for others, simply clustering the sticky notes was more useful.

Showing All User Data Supports Overall Comprehension

There appears to be value in allowing designers to see all information at one time, as in the unstructured condition. Participants appreciated the ability to structure sticky notes on their own in as many clusters and hierarchies as needed:

> Everyone can use as many clusters as he likes for his own sensemaking and not just 4/5 tags. (T4P1)

Participants also pointed out that they liked having an overview of the information on all sticky notes at a glance and that it is always visible:

> It is an advantage to arrange post-its directly on the screen while having all the post-its in an overview and on the same screen. (T6P3)

> During clustering you see groups emerging and in the end you try to find a name. When you have to tag notes beforehand, you kind of have to know the names first. (T3P1)

In the structured condition, when only seeing a few information items at a time, some participants were afraid of forgetting or mis-categorizing information:

> The facts people vote for most don't have to be the best or most important ones (T5P4).

> It implies that the insights that can't be categorized so well are not so good, which isn't true. (T5P2)

Having an overview of all sticky notes and being able to cluster them freely, helps people gain a better understanding of the user research. In their comments, people did not point out that the tagging had an influence on seeing the data from another point of view, as we had anticipated. The tags were rather seen as fixed categories equivalent to cluster names. In this sense, people found it problematic to define the tags before they had worked with the data.

Participants Felt Structured Synthesis Provided Balance

Several people pointed out that the Synthesis Guide shows the overall team opinion and involves everybody:

> The [system] makes it pretty clear, what is the team's opinion, also from the people which were not so "loud" and gives a good overview. (T2P2)

> More fair, everyone's opinion counts. (T5P1)

> Balances team members dominant vs. introverts as you mostly consider what you ALL agreed on. (T6P3)

Furthermore, they liked that people are not influenced by each other:

> People are not that much influenced by others, because the rating was done secretly. (T1P2)

In the unstructured clustering condition, they thought it was interesting to see different clusterings of their team members and to compare them to their own way of clustering:

> First you can cluster it your way and then see with what the other team members came up with. (T4P3)

> You can cluster and think first on your own and create a picture in your mind, so you can discuss in team better, because you already thought about it and talk only about essences. (T4P4)

> You can really see how people work and how they organize their findings. (T2P4)

On the other hand, two people saw the danger that it is easier for a dominant person to take the lead:

> A dominant person can push her view on the topic harder, when explaining her way of clustering. (T6P3)

> It is easy for somebody to get in control of the process alone. (T2P2)

Structured Synthesis Provides Scaffolding for New Users

The participants of the experiment had different levels of experience. In their comments after the test, people who had just finished design school pointed out that the Synthesis Guide was helpful. In the free form responses participants also commented that they liked the guidance of the tool: "With a program like this it's more structured and always clear what to do" (T4P3). Several more novice participants perceived the process as easier and more structured: "It is easier to concentrate on the single post-its" (T6P4). "You are not overwhelmed" (T3P2). "The use of a proper interface to choose among the topics made it easier to visualize it" (T3P1).

Participants Divided on What Method They Prefer

In the post-test questionnaire, we asked the participants about their general preferences, i.e. which way of doing the synthesis they preferred. From 24 participants, 12 participants chose the structured Synthesis Guide condition and 12 participants the unstructured clustering condition. These divided opinions can be seen in the overall comments:

> So all in all the [system] saves you a lot of clustering and cluster-discussion time that you can spend later to create a better PoV. For me, the [system] makes the process more based on individual ratio and choice which I like a lot. (T2P3)

> The "tagging" method is efficient but makes synthesis very scientific. There could be a danger that people just go for insights that were very clear to categorize. (T3P4)

> There was a lot of guidance, but also the feeling that one loses information, e.g. if a category is missing. (T2P2)

> I don't like the tagging, I like to see my clusters and to think while shifting the post-its around. (T4P4)

Summing up, some people prefer the new guidance and tagging result views of the Synthesis Guide because it creates an equally balanced process involving all team members and helps to come to a shared common ground. Other participants preferred the unstructured clustering condition because they could freely cluster the sticky notes in a way they liked and this way get a better overview and common understanding with their team members.

Limitations

As a qualitative study with a relatively small number of teams (six), we were not able to identify statistical differences between these approaches. Future work will focus on refining the quantitative measures and recruiting many more participants, including a mix of novice and expert designers to understand what kinds of scaffolding make sense for relative novices. Also, our study primarily focused on teams of people who did not know each other. Future work will look at recruiting existing teams to examine how social structures interact with the synthesis process.

DISCUSSION AND IMPLICATIONS

While we did not find statistical differences, we learned a great deal about the broad perspectives on the synthesis process. Through our diverse participant pool, we witnessed a range of different strategies and preferences. For example, we learned that some people – typically novices – preferred the "neutral" tool that calculated the result views from the opinions of all team members. Others preferred the unstructured condition because it gave them more freedom to use their knowledge. For them, the ability to create spatial arrangements helped them make sense of the information; others preferred a more sequential way of working. While there may not be a "swiss army knife" solution that supports all users, we have compelling evidence that digital support for synthesis practices should adapt to individual preferences and experience levels. Such a tool could offer different structuring options according to the users' preferences, based on what we have learned through our study. Afterwards it could merge the data of the different users, e.g. with clustering algorithms. It could also be effective for teaching design students and helping them get more experience with the synthesis process.

We learned that an individual clustering phase in the beginning of the synthesis helped to get acquainted with the data. Tagging each sticky note did not necessarily help them gain this broad overview, and for this, several users disliked the structured condition because they could not see all notes at once. On the other hand, participants thought the individual tagging helped to equally involve all team members into the process and see the different points of view. Seeing different clusterings of each team member in the unstructured condition also gave insights into the views of the others, but it required extra work for the team to merge these POVs.

Based on the case study findings, we suggest that teams generally include a phase of individually engaging with the data in the beginning of the synthesis process, even without tool support. Each team member may also note down how to structure the data and then they share the different views.

Tool support would have the advantage that team members could individually prepare location and time-independently. With the Synthesis Guide, they could use smartphones or tablets and e.g. tag the notes from user research on their way to the group meeting. Hence, everybody would be acquainted with the notes written by their colleagues before a synthesis meeting and the team could save time overall.

From the feedback on the tagging functionality, the tags were mostly interpreted as fixed cluster categories and therefore often seen as too rigid for the process. To improve the process, people should be allowed to create more tags and maybe the system should introduce "meta tags" such as Important, Surprising, or MyFavorite, to let people highlight more "fuzzy" sticky notes. Another idea for future work is to introduce structures that would intentionally affect the perspective of each individual while they review and synthesize information, for example "focus on emotion" versus "focus on technology". If every team member proposes one of these perspectives (or has one imposed on them), the team might be encouraged to think more broadly about their user research. Future work will also consider how to convey the meaning of tags or perspectives and which words to choose.

In our research on synthesis, we have focused on team dynamics and shared understanding among team members. But synthesis support tools could also focus on other areas. We have learned that teams often struggle to communicate the synthesis results to customers and stakeholders. Future tools could help to visualize the process, in order to give team and stakeholders an overview of the flow of information. They could show how user research data is included in the design process and how the team has interpreted it.

Another area of future work could focus on investigating how to cluster information automatically or with the help of crowdsourcing. Clustering algorithms that are based on standard text similarity measures may not perform well due to data sparseness on notes written during storytelling. Most texts are very short (between two to ten words) or they only consist of fragments and not real sentences. If they contain drawings and scribbles, automatic interpretation is even more difficult. Therefore, crowdsourcing provides a promising approach for synthesizing qualitative data, as Andre et al. [1] have shown.

CONCLUSION

In this paper, we analyzed the difficulties of synthesizing user research data in order to form a shared understanding as a team. Through interviews, we found that synthesis is perceived as a stressful team process, especially for novices, because it depends on experience and intuition. Furthermore, it is an ambiguous, nontransparent process that takes a lot of time.

This paper has shown that the synthesis phase of design is complex and there is no straightforward way of doing it. Our research explored a tool that structures the synthesis process by asking individual team members to first tag the user data and then automatically generating visualizations of how information relates. The case study improved our understanding of what works and does not work for the process of collaboratively synthesizing user research. We highlighted some areas of future research and tool support for design teams during information synthesis. In particular, synthesis support tools could focus on novice designers who could benefit most from such scaffolding.

ACKNOWLEDGEMENTS

We thank all study participants for their time and valuable comments. We also thank Lutz Gericke and Matthias Wenzel for technical support and feedback. This work is supported in part by NSF awards IIS-1208382 and 1217096 and the HPI-Stanford Design Thinking Research Program.

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