Multimedia in Cognitive-Intensive Practices: a case with ATLAS.ti supporting HCI Qualitative Research

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***Abstract*—Human-Computer Interaction (HCI) area uses qualitative research methods to guide its user experience studies. These methods involve collecting and analyzing large amounts of empirical materials registered in different multimedia contents. Qualitative Data Analysis (QDA) tools support HCI qualitative research activities in some level, but the cognitive-intense work of producing structured and related data, building meaningful knowledge from it, and making decisions based on this knowledge is mainly the HCI researcher's duty. We present a case with Atlas.ti 7, a QDA tool, and in that scenario, we identify and assess key features that support HCI qualitative research. We discuss how those features could evolve to augment human capacity and understanding throughout the qualitative data analysis, considering the cognitive computing approach. We considered multimedia concepts to discuss the evolution of QDA tools as potential investigation paths for research in multimedia and cognitive systems.**

Cognitive systems, qualitative research, HCI research, cognitive multimedia, capture & access

I. INTRODUCTION

Qualitative research involves collecting and analyzing a heterogeneous set of empirical materials registered in different media such as, audio, video, images, texts, diagrams, interactive and visual materials, software artifacts and so forth. This data may represent different moments and situations including, observations, interviews, interaction with artifacts, case studies, personal experiences, introspections, descriptive narratives, history and others [11]. Qualitative research is a challenging research methodology, in which the researcher (or researchers) needs to have a clear view of the whole process, from defining the research questions, and the associated hypothesis, to plan the data analysis. ([22] pp. 90)

HCI (Human-Computer Interaction) researchers combine different methods in their studies, particularly those originated in the social and psychological fields. Since people (users) are one of the main investigation's subject in the HCI field, qualitative methods are frequently used to investigate the interaction phenomenon between people and technological solutions, like new software, devices, smartphones, etc. It focuses on analyzing people's choices, paths and rationale while using technology [10]. Qualitative methods have resources to examine the "whys" and "hows" of decision-making, not just what, where, when, or who ([22] pp. 166), so they comprehend a complete class of methods for HCI.

There are several QDA (Qualitative Data Analysis) tools available to support common analytical activities in qualitative research. Generally, they offer features such as, project management for handling analysis continuity and to build an audit trail, data organization, note writing, data annotation, searching for strings, coding (creation, retrieval and recoding of broader categories), hyperlinking between data, data mapping (with diagrams) and exporting reports [19]. The analysis's phase of any qualitative study involves cognitive-intense activities such as, interpretation, association and correlation of data by researchers, whom must define and assign meaning to categories for their data ([22] pp. 312). Data coding, annotation and grouping are some of those cognitive intense activities, where researchers need to do most of the intellectual work for organizing and analyzing the collected data. Generally, QDA tools provide the infrastructure to organize data, but only researchers can assign meaning to that structuring.

The qualitative analysis process is a sequence of decisions the researcher makes regarding data signification, association and relevance. He makes choices by setting goals, identifying and gathering information, reflecting and choosing alternatives to take actions. An important aspect of cognitive computing is that it also offers a number of possibilities to augment human capacity and understanding in decision-making processes. In this context, multimedia could also play a key role in the signification process of unstructured and heterogeneous set of data necessary for making decisions.

Therefore, we selected Atlas.ti, a QDA tool, to compose our scenario for the discussion about qualitative analysis support presented in this paper. The case aims at discussing the potential of using cognitive computing and multimedia to "tune up" functionalities to support the researchers' intense intellectual process while performing qualitative research. In our case, we explore an HCI research scenario, which is the main research area of the lead author in this paper. Thus, she has experienced that intellectual-intense process on a daily basis for some time.

We divided this paper in four sections. In Section II, we present some key characteristics of qualitative research that was applied in the case and present related work to qualitative

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research and multimedia approaches. In Section III, we present the case with Atlas.ti in the HCI qualitative research scenario. Finally, in Section IV, we present our final remarks and future work for our research agenda.

II. QUALITATIVE RESEARCH

Qualitative research claims to describe lifeworld's 'from the inside out', from the point of view of the people who participate in the research. By so doing, it seeks to contribute to a better understanding of social realities and to draw attention to processes, meaning patterns and structural features. The communicative nature of social reality permits the reconstruction of realities to become the starting point for research. ([22] pp. 90)

Qualitative analysis is an approach, where researchers go from data (from particular cases or instances) trying to develop a theory or broad explanation, which can be further evaluated with qualitative or quantitative methods [11]. Reflexivity plays a central role in qualitative inquiry. Researchers are an important part of the process because they design and execute the research plan. Their bias and previous experiences influence all the process, to a greater or lesser extent depending on their awareness and purposes in the study [19].

Trustworthiness is another central issue in qualitative research, sometimes discussed in terms of credibility or dependability. There are many different ways of establishing trustworthiness for qualitative research, such as auditability. If a third party can check the researcher's data, line of argumentation and different evidence material, the research's results may be considered more reliable for a community. In order to do that, the data needs to be auditable, so anyone can check if the researcher hypothesis and conclusions have a solid foundation.

Qualitative research has an extensive list of characteristics ([11] pp. 130-131) that can be explored, but we are focusing on a subset of them. The characteristics considered on this paper are:

> Researcher as key instrument
> Multiple sources of data
> Interviews, observations, documents
> Building bottom-up patterns, categories, and themes; from concrete to abstract info units
> Participants' meanings
> Researchers make an interpretation of what they see, hear, and understand

We focused on those characteristics considering studies in HCI, which is a multidisciplinary field of research. It uses knowledge form different areas, particularly psychology, human and social studies, since HCI research is, most of the time, considering the human in the human-computer interaction as the primary provider of data in any study [10]. In that sense, we have two types of people to consider when regarding HCI research: study's ***participants*** (users of some technology or system) and ***researcher*** (person responsible for research's design, execution and analysis). The ***researcher*** needs to analyze data from all ***participants*** and get insights, identify patterns, categorize data, get evidences to support his assumptions and conclusions.

A. QDA tools and Qualitative Research

There are several QDA (Qualitative Data Analysis) tools available commercially for researchers like QSR NVivo [18], QDA Miner [17], MAXQDA [15] and Atlas.ti [4]. There are some expectations regarding the use of QDA tools. Firstly, less time-consuming handling, managing, searching, and displaying data and related items like codes, or memos, in links to the data. The potential gain of time tends to be more noticeable in the end, in bigger projects with bigger data sets, rather than in the short run, with smaller amounts of data. Secondly, expectation is that the use of QDA tools will increase the quality of qualitative research or at least make quality easier to demonstrate. Here, the gain of consistency in analytic procedures is mentioned or the extra rigor in analysis. Lastly, increasing the overall transparency of the research process; therefore, facilitating communication in a research team. For example, a researcher can check how a colleague created relations or links between any media and codes while analyzing the data ([22] pp. 328).

The CAQDAS Networking Project [21] defines that a QDA tool should support at least one of the following qualitative research's activities: content retrieval, coding (categorization) of data or data parts, connection among data (or parts of it), data mapping, structured search, data annotation. However, data collection is not a common functionality on those tools. The only functionality not supported by the QDA tools mentioned above is content retrieval. This indicates the separation between the data collection and data analysis, which can point some opportunities for cognitive computing and multimedia to assist researchers.

B. Multimedia and qualitative research

Brandão [19] proposed an approach to structure all the procedures undertaken into hypermedia documents with analyses and validations, allowing the representation in a theoretical Capture & Access (C&A) model to provide in detail all the decisions and evidences considered in the course of a qualitative research. This proposal was validated with qualitative HCI methods. It considers the data collection (capture) and the data analysis (access) in the research design process, which differs from QDA tools approach. It also differs by regarding multimedia synchronization. The synchronization of multimedia files in QDA tools is generally restricted to videos along with transcripts and annotations. In his prototype solution, Brandão provides a strong connection with temporal information, since analyses in HCI evaluation greatly benefit from continuous media. Synchronization plays a key role in his proposal, researchers can record an arbitrary number of parallel audiovisual media and the system performs their synchronization automatically. Regarding "coding", QDA tools only provide means to simply associate a tag with a data segment or time interval of audiovisual media. Coding

process is a relevant part of the interpretative analysis. Through Brandão's procedure, the researcher classifies or categorizes evidence systematically according to his current conceptual map.

To the best of our knowledge, there is no work published regarding improvements in QDA tools with a cognitive approach to support qualitative data analysis. We also looked for cognitive systems for qualitative research, but we also did not identify any reference that we could explore and compare during our research for this study.

III. ATLAS.TI CASE

For this paper's case, we selected Atlas.ti 7 [4]. The before mentioned QDA tools are very similar regarding functionalities, particularly the defined set that we will detail later. Atlas.ti was selected considering the results of an evaluation performed by the first author for the purchase of a QDA tool (not published; only used as internal report for a corporation). This evaluation considered a set of desired functionalities to support qualitative studies performed in a research group. This group already had a large amount of audio data and different kinds of artifacts collected during fieldworks in a real project scenario. The evaluation also considered the price to purchase the QDA tool for that research group. We used Atlas.ti in this paper as a representative of QDA tools, but the discussed features are present in all the aforementioned tools.

A. HCI scenario

The HCI scenario considered in this case is a user experience study, where the HCI researcher has interviewed and collected interaction videos from ten participants. The goal is to get insights for the design of an application related to life coaching. For that purpose, the researcher prepared a web application with some images and videos, along with interview questions. Then, the researcher asked for the participants' inputs by performing an interview parallel to the interaction with the web application. As collected data, the researcher had interaction videos, interview audio and text inputs from all ten participants. In his analysis, the researcher aims at identifying the terms, images and relations the participants made regarding the theme "happiness".

B. QDA selected functionalities

We selected functionalities of QDA tools considering the HCI research context: studies involving people and human-computer interaction evidences. We focus on functionalities used to relate data and people that provided that data (user-evidence). Therefore, we selected Coding and Quotation functionalities. Coding is a categorization process by which researchers relate data (or segments of data) to a concept or attribute represented by a code (string with a word or short phrase). Commonly, researchers combine categories forming broader concepts. Quotation in qualitative research are usually portions of audio or text related to a person statement about some matter. It is often used as evidence of some observed phenomenon, pattern or characteristic that a researcher decided to separate and identify for further analysis [11].

In the multimedia context, we focused on presenting the case considering video and audio tracks as collected data. On these media, the researcher needs to identify the participants (create a code for each one), identify and code relevant data (text or video quotations, artifacts, fragments of video, images, etc.) and relate relevant data to participants, to keep the analysis process traceable.

We used figures from the ATLAS.ti 7 User Guide and Reference [3] and ATLAS.ti 7 Quick tour [2] to illustrate the functionalities we explored on the trial version of the tool. Since qualitative data are sensitive regarding people's anonymity and privacy, we decide to avoid using private data. In addition, the content is not our focus in the presented case. The images illustrate our discourse to enable readers to understand the case's context.

C. Case presentation and discussion

Our HCI scenario has one researcher collecting and analyzing data from ten participants. After interviewing participants, the study collected the data summarized in Table 1. The researcher used the same interview script and user's activity description for all ten studies. They were defined as guidelines for each study, so he could compare and analyze the results considering the same activity executed by users and the interview script. However, the interview script was developed with an open-ended question [1] approach, very common for exploratory studies like the one in the scenario. Therefore, for each interview the researcher needs to analyze the interview considering the similarities (related to questions answers) and differences (follow-up questions, comments and any other knowledge generated from the interview dynamics).

TABLE 1. COLLECTED DATA FROM HCI STUDY

Media	Quantity of input
Interview script	1
User's activity description	1
Interaction- interview audios/videos	10
Input text in web application	10
Researcher notes	1

In Atlas.ti, the researcher goes over each participant video and separates interesting quotes looking to identify happiness (**Figure 1**). The video identifies the participant (relation file-participant) and each quotation is associated to a time interval in the video, tagged by the researcher. For each participant, the researcher performs an intra-participant analysis (considering only that one participant's data) looking for patterns, similarities, repetition of terms, discrepancies and any other interesting data related to the study's goal. The researcher goes over all ten video files.

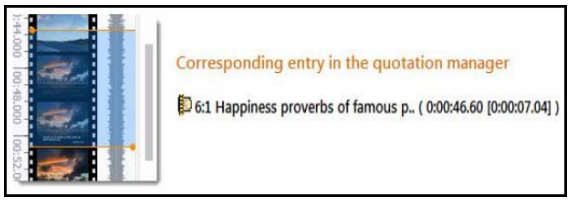

Figure 1. Display of video quotation ([3] pp.155)

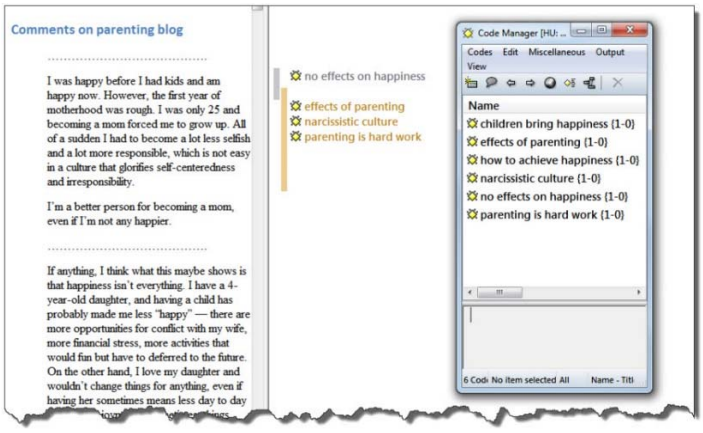

Figure 2. Coding text ([2] pp. 36)

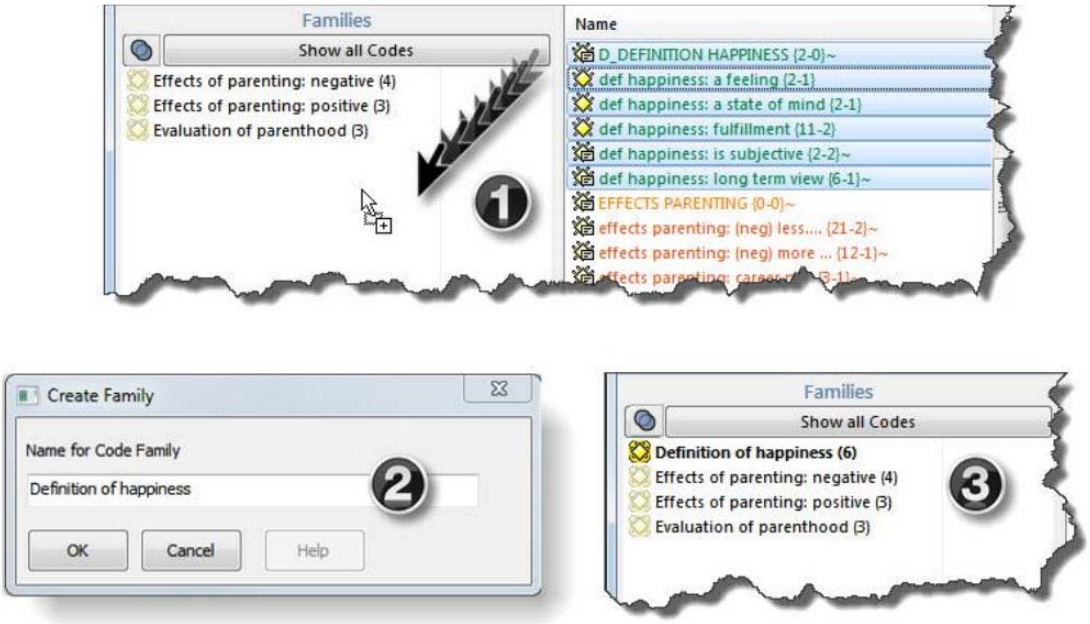

Figure 3. Organizing codes in families. (1) Grouping codes, (2) Define a name for a code family and (3) Codes grouped in a family ([2] pp. 44)

Considering the described scenario, we identified potential points (**PP#**) for cognitive computing to augment the researcher's capability and understanding in the decision-making processes of coding and quoting the data. We selected three of those potential points to discuss in this study.

During the analysis of videos, the researcher needs to be aware of potential inter-participants relations, i.e. the relation of findings in different participant's data. This is a cognitive-intensive activity, where the researcher is the center point for data correlation (**PP1**).

The researcher goes over all participants' text input in the web application utilized. He codes all the files, one by one, considering the intra-participant and inter-participant analyses (**Figure 2**). He probably needs to relate quotation in the text, with quotation in the video, associating them with the same code. (**PP2**)

After the researcher tagged all the data, he may organize the codes, solving possible redundancies, similar codes, identify families of codes, etc. (**Figure 3**). In this step, the researcher tries to organize his data coding, looking to associate meaning to codes and codes' families to apply in his research report. (**PP3**)

D. Potential for a Cognitive QDA

The scenario described might not seem so complicated once we read those few paragraphs, but anyone who ever performed any qualitative research, knows that it is not an easy or mechanical process. It demands attention, time and focus. It is a cognitive-intensive process, but the results are usually rich and detailed, offering many ideas and concepts to inform the research. Qualitative methods can tell you how people feel and what they think. Particularly for exploring new research spaces, it is an ideal research methodology.[11]

We explored the specification of a cognitive solution offered on IBM's Bluemix platform, a cloud platform with intelligent services for diverse projects. We selected three service APIs [9] that could be used to potentially improve QDA features to support cognitive-intense processes related to qualitative research analyses. The so-called Watson services are ***AlchemyAPI [6], Speech to text service [7]*** and ***Visual Recognition service [8].*** They are described as following:

> ***AlchemyAPI*** offers a set of services that enable businesses and developers to build applications that understand the content and context of text in webpages, news articles, and blogs. For instance, using AlchemyAPI, developers can perform tasks such as extracting the people, places, companies, and other entities mentioned in any publicly-accessible webpage, posted HTML/text document, or a predefined corpus of news articles.
>
> ***Speech to text service*** - The Speech to Text service converts human voice into written word. It can be used anywhere there is a need to bridge the gap between the spoken word and their written form.
>
> ***Visual Recognition service*** - Finding meaning in visual content, analyzing images for scenes, objects, faces, and other content. Finding similar images within a collection.

The ***AlchemyAPI*** could be useful to understand the web application used during the study. It could pre-organize the participant data and associate it to another predefined corpus of knowledge (other design references for "happiness"). This cognitive feature is related to potential points for cognitive computing PP1 and PP2. The ***Speech to text service*** could help with audio transcription and the output text could be structured, searched, organized using other features, assisting the researcher to find data relations. This cognitive feature is related to potential points for cognitive computing PP1, PP2 and PP3. The ***Visual Recognition service*** could augment the researcher capability by identifying images similar to those indicated by participants during the study. Considering other scenarios when participants indicated any image they like, this service could help identifying similar images, relating the participants who indicated the images. This cognitive feature is related to the potential point for cognitive computing PP1.

IV. FINAL REMARKS

In this paper, we presented a case discussing some challenges related to HCI qualitative research. Using the QDA tool Atlas.ti 7, we conducted coding and quotation activities. We discussed key QDA features that support qualitative research and how they could be improved considering a cognitive approach. We also discussed APIs and services available through a cloud platform that could improve those key features.

We identified three potential points (PP#) in that case for cognitive computing potentially augmenting the researcher capacity and understanding in decision-making processes of coding and quotation of the data, during a qualitative analysis. Considering those potential points, we discussed key QDA features that support qualitative research and how they could be improved considering a cognitive approach.

The relation between people and data (e.g. person said a phrase, person draw a sketch, etc.) are central for HCI research. However, most of this association is done during analysis and carried manually, i.e. it is very dependent of researcher's expertise in the analysis. Commonly, during data collection, little is done in order to organize, tag or identify the data. More than relate people to data, the researcher needs to relate people to knowledge while collecting data (e.g., people cite a book, reference someone else). Modeling how knowledge, data and people can be related seems to be a good way to design the research space and process. In this sense, as a next step we plan to explore the NCM (Nested Context Modeling) [12][13][14], which offers a modeling notation that could be used for that purpose. Data collection structuring and knowledge intensive analyses, such as HCI qualitative studies, are scenarios where we intend to explore this model in the future.

Cognitive-intensive practices, like qualitative research, can be explored within Human-Centered Computing (HCC) studies, which articulate technical, personal, social and cultural factors, addressing the use of technology, its design and development. Particularly, the Signify Suite [5] stimulates this discussion. It does not consider augmenting human capabilities through cognitive computing, but is a path we intend to explore in our research agenda.

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