Chapter 11 Conclusions

> "To my knowledge, on the whole planet right now, there are perhaps only a dozen people who have undertaken a serious enough study […] to become craftspeople. We need to go through a Renaissance before we can have a modern art movement with this stuff. Virtual Reality is genuinely new and different. One of the overwhelming problems right now when you look at Virtual Reality in the art world is that it tends to look ugly. And it's not an intentional ugliness; it's the kind of ugliness that results from the lack of any tradition of craft."
>
> Jaron Lanier, in: Powell (1996)

Chapter 11: Conclusions

This chapter reviews and compares the results to the original research aims as formulated at the outset of this research, to the findings and makes recommendations for future research.

11.1 Introduction

This chapter concludes this work by comparing all findings to the original research aims and objectives formulated in Chapter 1, and looks into the effectiveness of the research approach that was used. Furthermore, it discusses the methodology used for the research presented in this thesis. This approach has been adopted in order to clearly identify the areas for improvement of the CVE development process. Next, it discusses the four main evaluation techniques developed for CVE usability testing, during the writing of this thesis. Finally, it discusses the possible further avenues of investigation and development for usability evaluation and design of CVEs.

The next section describes the pertinent results from the research presented in this thesis and it discusses how well the aims and objectives of the research presented in this thesis have been met (11.2). Section 11.3 makes recommendations for future research and development in this area.

11.2 Looking Back

The main findings derived from the experimental results and analyses in this thesis can be summarized as follows:

- The perceptual affordances of CVE design are insufficiently exploited, leaving users confused.
- The sequential affordances of CVE design are insufficiently exploited, leaving users confused.
- The narrative affordances of CVE designs are insufficiently exploited, leaving users confused.
- The collaboration process is insufficiently supported in the CVE used for the experiments, creating problems for the users when trying to build up and maintain an understanding of who does what, when, aimed at whom, with what results on what and for whom.
- Many CVE user activities can be partly or fully automated, which is hypothesized to lower the cognitive overhead of controlling the virtual embodiment, so that users can get on with their collaborative task more effectively.
- The success of CVE design tasks is dependent on thorough requirements analyses via interdisciplinary teamwork.

This thesis has presented three methods to improve and further the design and evaluation process of CVE technology:

- Observation method, which is generally applicable to CVE user observation and analysis of collaborative behaviours, however the categories used for the analysis can be adjusted to refocus the topics under observation. It was shown how to develop and apply the method.

- Design method, which is generally applicable to CVE design; to be used during the specification of the actual look and feel of the CVE spaces, CVE objects, and CVE interactions.
- Inspection method, which is generally applicable to CVE evaluation, to be used during all design stages, assessing the usability of the design for each interactive element in the total task of a CVE user.

The observation method has provided a rich view of the actual behaviour of CVE users during focused and unfocused collaboration. Their behaviour was analysed for areas of usability problems, and detailed advice was given on how to improve them, showing how usability problems can be redefined in terms of usability recommendations. The design method and the inspection method complement each other, making use of the same interaction cycles to design and evaluate the CVE user task.

11.2.1 Definition of the Problem Revisited

This thesis has provided an exploration of the usability problems introduced by CVE technology, in an attempt to address the lack of CVE specific usability design tools and comprehensive guidelines for the design and evaluation. Investigating the human behavioural aspects that affect performance and satisfaction in CVEs, proved to be a rich source of information for the task of developing tools for CVE usability-design and evaluation. By embedding the focused exploratory study into the unique aspects and phenomena of CVEs, in a general framework of scientific inquiry, the results have been made more reusable and more easy to turn into guidelines.

11.2.2 Research Aims and Objectives Revisited

Several analyses of aspects impacting usability design for CVEs have been performed throughout this thesis. To be precise:

1) The capabilities and limitations of current CVE systems, in terms of their impact on usability, have been critically reviewed.
2) Existing theories and methodologies for designing and evaluating artifacts (hardware and software) have been analysed for their bearing on design and evaluation of CVE applications.
3) Human collaboration activities in real and virtual environments have been identified and described.
4) Experiments using representative CVE user task scenarios, and analyses of observations of collaborating users have been performed.
5) A structured framework was used to propose and support CVE usability requirements analysis.
6) Recommendations for the future of CVE design and evaluation have been provided.

The focus of this thesis is on the investigation of the central claim of CVE technology: the facilitation and support of collaboration, rather than the broader aspects of usability for CVE technology, however broader usability aspects of CVEs also emerged through the analysis of the collaboration process in CVEs.

11.2.3 Research Methodology Revisited

This thesis aimed to make explicit the consequences of the CVE design for the CVE user, given an understanding of what tasks the user tends to perform through the application of empirical research techniques. The psychological claims of usability and design have been critically analysed in order to clarify how CVEs will better suit the task of collaboration. The results from this study are derived from empirical observation of how people perform their work, presented through informal language and a more formal task analysis. A greater understanding of the task of collaboration in CVEs and its associated problems, has been generated. New task definitions were created to serve as the foundation for the formulation of new validation criteria and as requirements for future CVEs.

This thesis used a variety of methods to research and present the data collected about collaboration in CVEs to come to usability evaluation and design guidelines for CVEs. Specifically: interviews, task analysis, observation, inspection reports, usability reports, questionnaires, and design reflection reports.

11.2.4 The COVEN Project Revisited

The COVEN project was unique in terms of the high number of partners involved, the long duration of the project, the network connectivity, the three iterations of design, and of course in terms of its topic. Nevertheless, the project suffered from similar problems to any other large-scale software development effort (Viller et al, 1999). Typical problems, common to requirements engineering in general were:

- Performance of the design groups. Low status employees of each partner performed the actual work, but did not always get a chance to decide about the work, or to be present at meetings. Some design meetings did not have members possessing the right expertise. Some design ‘meetings’ were only conducted via electronic document exchange.
- Contributions of individuals. Often it was left to the individuals concerned to decide on their task and approach. This caused confusion about what was important and caused considerable overhead in coordinating the individual efforts.
- Organisational failures. The use of standard engineering practises was not sufficiently enforced throughout the project, resulting in limited and biased ‘requirements specifications’ and design choices at the beginning of the project, which propagated through the project, making the different components of work difficult to benefit from each other through timely integrations.

Although the management of the project encouraged equal group-participation, made great allowances for minority views to be heard and taken on board if this seemed to benefit the project, and controlled the work delivery process tightly, the problems listed above were not avoided. Among the reasons for this are that the partners were distributed across Europe, came from a wide variety of backgrounds, and had a relatively high turn-over of individuals responsible for the work due to the long duration of the project. Additionally, the main communication channel between collaborating individuals was a number of electronic mailing lists dedicated to the

different strands of the project, which did not contribute to easy collaboration on and coordination of the work.

The main aim of the COVEN project, to demonstrate a future collaborative (tele)work and communication system for professional and home users, has been reached in a successful manner. By the end of the project a large number of scientific publications had been published and the COVEN platform was going to be made commercially available.

11.3 Recommendations for Future Research and Development

This study has argued for CVEs to be developed in a systematic and structured fashion. It describes several frameworks which structure the design of CVE evaluation studies, the scientific inquiry into the nature of CVEs and CVE usage, and the development process. It points out that CVE usability will be most effectively assessed and enhanced through team work and the selection of appropriately balanced design specifications, on the basis of user and task analysis, user observation and inspection of the interface.

The question of whether CVE technology will ultimately be able to support serious, high standard meetings, is important. There is little that is known about the capabilities of CVE systems in terms of support for collaboration, but the nature of collaboration and the type of problems that CVE design need to address are better known, and not likely to change. It would therefore seem possible and necessary to develop guidelines for the evaluation and the design of CVEs. The author has made an attempt at clarifying these issues. A thorough understanding of the capacity of

CVEs to support high quality collaboration, will be essential when considering the applicability of CVEs for telecommunication. If CVEs can provide a unique solution to a particular problem, then design and evaluation techniques will be needed to provide evidence of this. This would therefore seem to be an area that is highly important to address.

11.3.1 Heuristic Evaluation

There is currently no standard heuristic evaluation technique specifying CVE usability, apart from the one presented in Chapter 9, section 9.3.2.1.1. The development of heuristics involves a complete understanding of all types of usability problems that are common to CVEs. Nielsen developed his heuristics based on 249 usability problem observations. CVE design is still in the early stages, so it is to be expected that the type of usability problems that occur will change over time. A meta-analysis of all types of usability problems found with CVEs to date, would provide a good start for the development of CVE design heuristics.

11.3.2 Inspection

There is currently no standard CVE inspection method, apart from the one presented by the author and developed during the COVEN project, and a single user VE inspection method developed by Kaur and Sutcliffe (1998). However, neither of these methods are in popular use yet, and will need thorough testing and refining. Both inspection methods try to address the freedom of interaction typical to a VE by using interaction cycles to define the task domain. Further work is required to assess whether the six interacting cycles which have been proposed, are exhaustive for the inspection of the complete repertoire of interactions available in CVEs. Inspections

tend to provide a rich source of usability observations, in a relatively short time, and can be applied before the application is ready to be used by end-users. This allows for a quick and relatively cheap way of detecting and avoiding usability problems early on in the development process. As such it would seem to be important to develop this method for CVE evaluation.

11.3.3 Observation Method

With regards to observation of CVE users and CVE usage, this is the area that has the most interest, but observational results have only just started to appear. One of the reasons has been the immaturity of the technology. This has meant that there were few CVEs available where users could be observed during regular use, across affordable network connections, with a sufficiently distributed number of regular business or consumer type users involved in collaboration activities. However, with observation studies, more can be understood about the capacity of CVEs to support collaboration, which is likely to help decide on directions for further development. What is required in this area is as follows:

- A project with a quick turn-around of the design and evaluation cycle.
- A requirements specification that describes all elements necessary for effective collaboration, in sufficient detail for direct implementation.
- A refinement of the understanding of the type of behaviours that are essential to collaboration support in CVEs.
- An educational process for CVE users, in which they learn what to expect from CVEs, in terms of its function as a telecommunication device, and in terms of the expressive limitations of CVEs as a medium.

11.3.4 CVE Usability Design

Usability design choices are currently mostly made by the programmers of the application. A systematic design process may seem to involve a great number of meetings between a great number of developers; however, if the user requirements are not assessed properly, there is no guarantee that the design choices satisfy user requirements as well as satisfy the technical requirements analyses. There are a great number of techniques available to perform user requirements, however they are not usually performed. One of the reasons for this may be that the activities involved in the user requirement analysis are not as strictly pursued as those for the system requirements. These issues are old problems, known to HCI practitioners, and they invariably need to be addressed at management level, so that what could be easily regarded as 'extra work' will not be avoided (Viller et al, 1999).

11.3.5 CVE Design Guidelines

There are currently no standard design guidelines for CVEs. There are no standardised ways of specifying a design for CVEs. Standard engineering methods are applicable, but it is by no means clear how much they will support the designer's needs for guidance with CVE usability design. The author has suggested an initial set of CVE guidelines and a CVE design method, adapted from standard engineering methods, but these new approaches need to be tested and further developed. Guidelines will greatly improve the usability of CVEs, reduce development time, and reduce costly errors, and all other problems exacerbated by uninformed decision making.