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ABSTRACT
This position paper describes ongoing work with auditory direct manipulation for blind computer users. The major issues of auditory direct manipulation and the long term goals and benefits will also be discussed.

INTRODUCTION
The term "universal design" is often used and defined as being "the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities" [6]. According to this definition, the work outlined in this paper could hardly be called a case of universal design, we are not thinking about anyone else but people who are blind. But if we instead look at it as a way to make a well established, non-universal, design principle more accessible by allowing people who are blind to use it too, then the intent is universal and this work is a part of a process of universal design [6]. This latter way of understanding universal design is more preferable, since it encourages research and development that is not trying to cover all aspects of different disabilities but rather tries to understand the needs and wishes of one user group at the time.

DIRECT MANIPULATION
Direct manipulation is a fundamental concept within HCI (human-computer interaction) and is based on that the interface has the properties *continuous presentation*, *physical actions* and *rapid incremental reversible operations with immediate feedback* [5]. This means that you for example move a file by simply pointing the mouse at the file you want to move, grab it by pressing down the mouse button, drag it to the place you want it to be and drop it by releasing the button. This very direct and in many ways intuitive way of interaction has been very influential in today's graphical user interfaces and will influence the way we interact with computer for a long time.

The only drawback is that this kind of interaction is not accessible at all for blind computer users and screen readers doesn't support direct manipulation at all. This means that even though blind people are using the same software as their sighted coworkers, they are practically using a different software with a completely different look and feel. Another problematic area is instructions, blind people is sometimes left out when a new software is introduced on the workplace since they don't understand the instructions for the new software since it is based on the direct manipulation features of the graphical user interface [8].

The two general research question that we want to address in this project are:

- Is auditory direct manipulation possible?
- Is auditory direct manipulation interesting or do we have to seek other paradigms for interaction with an auditory interface?

AUDITORY DIRECT MANIPULATION
Auditory direct manipulation is a rather uncharted territory both in research and development, given that we talk about real direct manipulation and not just interacting directly or almost directly with interface objects. In the GUIB project for example [2] the work has been concerned with giving the blind computer user a more direct way of interacting with interface objects, but it has not dealt with direct manipulation itself. Other work has been done on complex auditory interfaces (see for example [1]), but most of these has been monitoring tasks were the focus has been on the display of information rather than the interaction with auditory objects [4].

The first property, *continuous presentation*, is probably the most difficult one to solve when using audio. Since audio has a strong ambient quality and is not bound by line of sight, you can't look away or focus in a effective way like you can when looking, it could be hard when the number of objects is large. The questions are rather what is continuous enough and how do we deal with the ambient quality of sound without losing the overview and the feeling of the objects being there all the time.

The second property, *physical actions*, could be seen as articulatory or mimetic directness [3]. This means that the action should mimic the desired change on the interface object. One interesting question is whether you could use a relative pointing device like the mouse or if you have to use absolute pointing device like a graphics tablet.

The final property, *rapid incremental reversible operations with immediate feedback*, requires that all operations could be reversed, for example moving a file back to it's original position, and that the new location and the new status of the auditory space is immediately audible for the user.

AUDITORY TOWERS OF HANOI

In order to answer the above questions, we have designed and implemented an auditory version of the Towers of Hanoi [7,8]. In this game, the user interacts using a regular mouse and a pair of headphones, with no screen at all. The first study we did on this game was an experimental study where we investigated continuous presentation and what this could mean in an auditory interface [7,8]. We compared three different levels of continuous presentation where the main difference was the interval length and type when repeating the sounds. The second study was a qualitative case study were we wanted to explore the qualitative aspects of auditory direct manipulation and the subjective experience from playing the game [8].

The results from these studies showed that with a limited set of auditory objects (5 objects in three by five different locations), the presentation mode (level of continuous presentation) gave no significant differences [7]. What was more important was that there need to be a way to focus in the auditory space, in the same way that you focus when looking at a specific part of a computer screen. This focus function was the feature of the auditory game that the subjects liked the best [8].

DISCUSSION

Many questions remain to be answered, for example if these principles really are the best way for interaction with an auditory interface. These studies shows that it could be a good way, but what happens when the complexity increases? So far the only application tested is a game, but how scalable is this to a real context for example?

I believe that auditory direct manipulation will make the well established design principle of direct manipulation truly universal, since the only people today who cannot interact in a physical and direct way are people who are blind.

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