

Virtual reality as a communication aid for persons with aphasia

Elisabeth Ahlsén and Vladimir Geroimenko

Department of Linguistics and SSKKII Center for Cognitive Science
Göteborg University, Box 200, SE-40530 Göteborg, SWEDEN

eliza@ling.gu.se, vladimir@ling.gu.se

ABSTRACT

The paper presents a prototype using virtual reality as the basis for a picture communication aid for persons with aphasia (acquired language disorder after a focal brain injury). Many persons with aphasia have severe word finding problems and can produce no speech or very little speech. This problem is often connected to problems of abstraction, which makes it problematic to use picture communication based on classifying pictures by semantically superordinate categories and searching for them via these superordinate categories. The use of virtual reality makes it possible to use purely visuo-spatial orientation as a search strategy in a picture database. In the Virtual Communicator for Aphasics, we are exploring these possibilities. By "moving around" in a virtual environment, based on video-filmed panoramas, the user can search for pictures essentially in the same way as he/she would search for objects in the real world and communicate by pointing to the pictures. Pointing for communication can be used directly in the panoramas, in overview pictures accessed by hot-spots, and in arrays of pictures of objects also accessed by pointing to hotspots in panoramas or overview pictures. Speech output is possible. Some of the potential advantages and limitations of using virtual reality based on photorealistic panoramas and pictures in this type of application are discussed.

1. AIM

The main aim is to develop a prototype for a communication aid which uses virtual reality and a spatial orientation strategy for picture communication. Persons with aphasia will try the prototype for evaluation and further development. The study is part of the project Intermodal translation (supported by KFB), which investigates the conditions for using information in different modalities for communication and for the transfer of communication between modalities in relation to disabilities which prevent the use of one modality.

2. GENERAL BACKGROUND

Within the project Intermodal translation, different sub-projects are exploring the conditions for transferring communication between different modalities or different manners of communication. One of the challenging areas are persons who have disabilities preventing them from communicating by using spoken or written language. How much communication can be achieved by using pictures and how can this type of communication be made reasonably fast, efficient and easy to use? How can the different needs of different disabled groups be met by the use of emerging technology? One of the target groups are persons with aphasia and severe language output problems.

Persons with aphasia generally suffer from anomia, i.e., they have more or less severe word finding problems. This pervasive feature of aphasia is believed to be related to a difficulty in using abstraction or decontextualization, affecting the ability to categorize. For example, many persons with aphasia have considerable problems filling in the last word of sentences like "Dachshund and poodle are both types of _____." or "Volvo and Fiat are both types of _____." etc.

A number of aphasic persons have severe problems of linguistic expression, i.e., they might not be able to speak at all or only be able to say a few stereotypic utterances and perhaps yes and no. These persons are badly in need of a means of expression and many efforts are being made to provide aids using communication technology. Some of these aphasics can have relatively well preserved language

comprehension, whereas others have more global problems. All of the, however, need to be able to communicate.

Since written communication is most often not available to the severely aphasic persons, most attempts to develop communication aids for them are based mainly on using pictures that are linked to synthetic or digitized speech. (Cf., however, Todman et al, 1995, Todman and Grant 1995, Dennis et al 1995, for approaches using written text and speech.)

It is well known that picture communication involves some problems. It is not always readily used by aphasic persons for expressing needs and wishes, even when it would be possible. Perhaps this depends on the somewhat indirect and unusual or artificial nature of picture communication, as opposed to speech and gesture. The area of picture communication in general and the specific conditions for picture communication in relation to aphasia is still in need of a great deal of basic as well as applied research, involving a number of disciplines, such as psychology, linguistics, cognitive science, semiotics, sociology and neuroscience.

3. SEARCH STRATEGIES AND PICTURE COMMUNICATION

Since low-tech communication boards, picture books and card stacks have been replaced by computers allowing the use of dynamic displays and the storage of large picture databases, the problems of organizing search strategies in such databases have come into focus. Given that the user has a large number of pictures stored in his/her computer but only the screen size for interface, how does he/she find the pictures needed for communication in a specific situation in a reasonably fast and efficient way?

There are two main search strategies used in this context:

- 1) Search based on semantic categories
- 2) Search based on visuo-spatial orientation

(A third possibility is the use of associations of mixed types, i.e. visual, semantic., phonological etc., used in Minspeak applications, cf. Baker 1987, which will not be treated here, but can perhaps be seen as an expansion of the first search alternative above.)

Let us look a little closer at the conditions of the two search strategies.

Search by semantic categories is, by far, the most common way of organizing picture communication aids. This means having an overview screen with pictures representing superordinate categories, e.g. persons, clothes, actions, furniture, vehicles, food etc. Sometimes the subordinate-superordinate relation of pictures to categories is supplemented with part-whole or location relations, such as a kitchen for kitchen related objects or a town for shops.

The challenging tasks in this enterprise are to find a intuitive, transparent and consistent taxonomy of categories and, not least, to find pictures to represent these superordinate categories. The latter can be done by, for example:

- 1) choosing a typical (or prototypical) object from the category to represent the whole category, (e.g. a hammer for tools, an apple for fruits)
- 2) having a more abstract representation that is supposed to give associations to the category (e.g. a pictogram, a simplified line drawing or a sign like lightning for actions, i.e. signs resembling traffic signs)
- 3) trying to give a more complex concrete picture, including several objects from the category (e.g. a small drawing of a kitchen for kitchen related objects or a set of clothes (sock, trousers, shirt) for clothes. (These pictures usually become quite hard to decipher, since they include many details on a minute surface.)

Some examples of communication aids using this type of search strategy are C-VIC/Lingraphica (Steele et al 1989, 1992) and PicBox (Johnsen and Linell, 1995).

The search strategy based on semantic categories presumably works fine for a person (aphasic or not) who can figure out, learn and remember the system for categorizing and the pictures for the superordinate categories, thus knowing in what category to look for what more specific pictures. It is, however, not possible to use for persons with severe problems in using abstraction.

Already in the systems based on semantic categories, we could see that locations or situations, like a kitchen or a garden, could sometimes be used as a complement.

The alternative way of orienting in a picture database is to build as much as possible on visuo-spatial orientation, which is assumed to be preserved in most of the persons with problems of categorization/abstraction.

The idea behind visuo-spatial navigation for communication is to avoid the categorization/abstraction problem as much as possible, by using a map-like orientation based on locations and giving the user the feeling or illusion of walking around in the world, communication by looking for things in places where they are usually found and pointing to them.

This idea has been exploited by the Danish communication aid Genlyd (Rygaard, 1990). In Genlyd, the user finds himself in a miniature town with a main street including many shops and offices etc. There is also a house which can then be used as the home interface and in the different rooms different objects of everyday life can be found. Genlyd uses simple line drawings. The main overview pictures are the town, the house and the rooms of the house.

4. VIRTUAL REALITY AND VISUO-SPATIAL ORIENTATION

The example programs mentioned above were designed a few years ago. Today, more general picture databases, where pictures can be selected and included in individually adapted, multi-layer communication windows using dynamic displays, e.g. for activity based charts or semantic category charts, provide a great potential for experimenting with picture communication.

The basic principle of spatial orientation has, however, not been fully explored and exploited. Virtual reality provides a new and exciting means for making the illusion of truly spatial search in a real-world like environment more realistic and potentially more useful to a group of persons with no other possibility for expression. An interface where the user moves around in a photorealistic or artificial virtual environment is quite different from the so far used map-like overviews which give more of a bird's eye perspective.

5. THE VIRTUAL COMMUNICATOR FOR APHASICS (VCA) PROTOTYPE

5.1 Content and function

The VCA prototype utilizes digitized videorecorded panoramas as the basic overview interfaces on the screen. The user can move around in the panorama using the mouse and move further into new panoramas using relevantly located hot spots.

The presently available panoramas are:

- The town with two streets surrounding the house
- The shopping street
- The office street
- The interior of the house with the different rooms seen from the entrance hall
- The interior of each room

From the panoramas, it is possible to move to more detailed overview pictures, such as the interior of a cupboard and from those pictures to individual pictures, e.g. of objects usually found in such a cupboard.

An example of how the present structure can be used is presented in the example shown in Fig. 1.

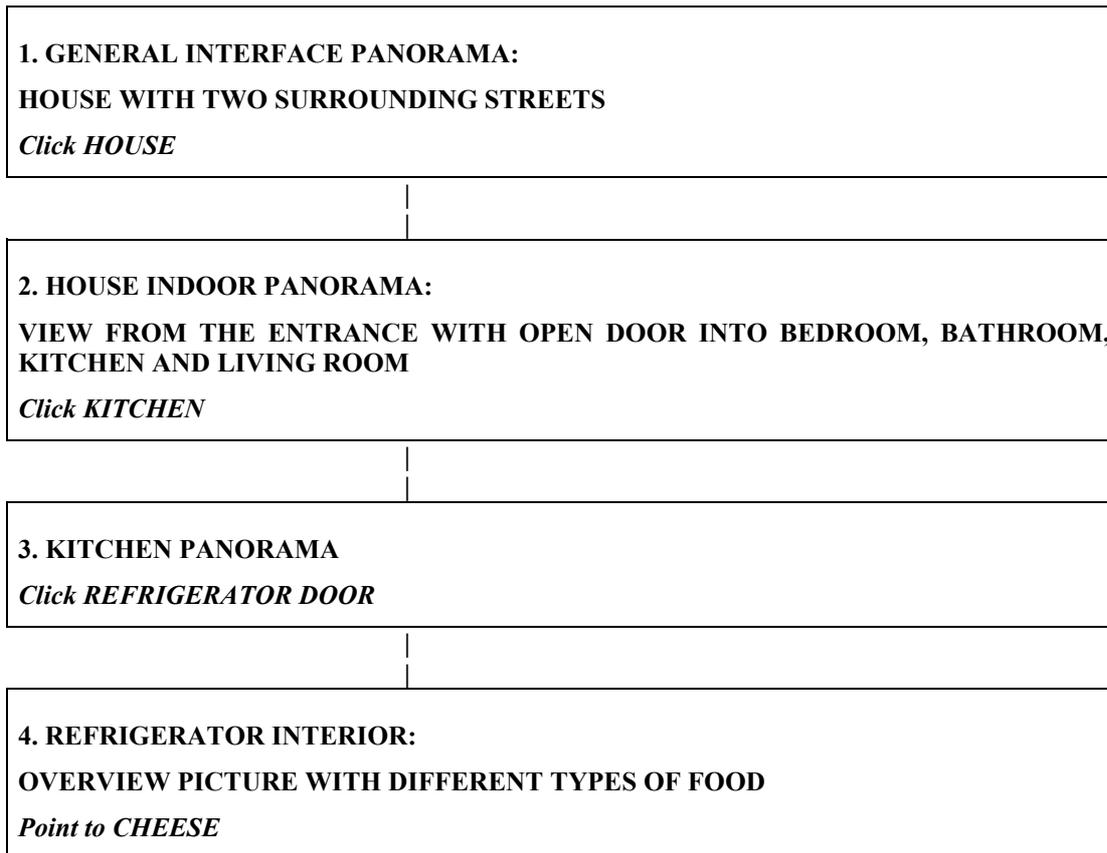


Fig. 1. Example of the spatial search structure in the prototype for virtual communication: search for the word *cheese*

An alternative addition to the search route in Figure 1 would be to click the *overview picture* in order to get a set of *pictures of different types of foods* to and then click *cheese* in the separate picture of cheese, but this would probably not be necessary if a cheese is clearly visible in the overview picture. An addition of this type would, however, be a way to find more clearly visible pictures of different objects from an overview picture or even objects that can not be seen in the picture but could be expected in it, since an overview picture of, for example, a refrigerator, can not contain all the items that could possibly be kept in a refrigerator.

The panoramas can be used in full-screen format or leaving the leftmost part of the screen open for arrays of more specific pictures, such as pictures of different kinds of food in response to clicking on the overview interior of the refrigerator, in its turn reached by clicking on the door of the refrigerator, in our example.

By clicking at objects in the pictures the user can get recorded speech output from the computer. It is, thus, possible to, for example, create a shopping list for a relative over the phone. (This is a function also included in some of the existing communication aids.)

The panoramas can, of course, be extended to interiors of shops and offices, to outdoor scenarios etc.

The VCA prototype, thus, exploits the same kind of content as Genlyd, the crucial differences being

- 1) the use of photorealistic pictures and especially panoramas, intended to give the feeling of moving in a virtual scenery
- 2) the speech output
- 3) the potential future use of actual photos and panoramas from the user's own home etc.

5.2 Technology

Our prototype is based on one of the most interesting and powerful VR technologies available at this time - Real VR from Live Picture Corp. The basic elements of this technology are 360 degree panoramic images of real places in JPEG file format. The high level of compression enables us to create full-screen high-

resolution panoramic views with the file sizes under 70K. This means that our prototype is fully Internet-based and can be downloaded easily in real time even via a 28.8 kbps modem.

The panoramic virtual environments based on the Real VR technology are VRML 2.0 compatible and can include all types of multimedia objects with complex interactivity and behavior. First at all, users are able to navigate through VR panoramas using the mouse or keyboard: look around, up and down, zoom in and out. Then they can interact with any active parts of a panorama (called hotspots) or interactive objects inside a panorama. The Real VR technology has unlimited possibilities of integrating VR with multimedia elements. In principle, all existing types of multimedia can be integrated into this kind of VR, for example: 3D VRML objects and environments, 2D image-based on-screen and world objects, 3D image-based on-screen and world objects, 2D (GIFs) and 3D animation, audio and streaming audio (incl. 3D spatial sound), video and streaming video, multimedia databases, hotspots, links, FlashPix images, etc.

Although we are using only some of the above multimedia elements in our current prototype, the Real VR technology gives us great opportunities to use any multimedia that may be necessary for achieving our present aim as well as for the further development of the prototype.

At this time, we are developing the following two version of the VCA prototype:

- 1) The plug-in version that includes all available elements and functions. The only drawback of the version is that users have to download a plug-in (Live Picture Viewer) in order to experience the prototype. Concerning platforms and browsers, the plug-in is available for both PC and Macintosh and for Netscape Navigator as well as Internet Explorer.
- 2) The Java version that does not require any plug-in and works on the principle "just click and see" on any computer. Unfortunately, at this time the Java version is not able to provide us with all the objects and functions that can be implemented in the plug-in version.

6. VCA AND APHASIA – POSSIBILITIES AND PROBLEMS

6.1 Possibilities

Some of the possibilities of using a VR tool, like the VCA prototype, are:

The spatial search strategy: Preserved ways of orientation can be used for communication, thus avoiding dependence on categorization and abstraction skills.

The photorealistic panoramas and pictures: The user does not have to deal with visual abstraction to line drawings or simplified/stylized picture representations.

The natural/intuitive search way: The aid should be easy to use, by just pretending to walk around looking for things in the 'world' on the screen.

The vocal output: Turntaking/attention getting is facilitated, and phone messages are possible.

The possibility of individual adaptations: It is not impossible for an individual user to have more or less of his/her own environment and own objects inserted.

The possibility to add any information that can be spatially represented: What is needed can, in principle, be put in.

The virtual access to different locations: Not all users can move around in their real life environment and use pointing. Many potential users are hemiplegic and some of them use wheelchairs. They can, by using VCA, at least refer to the places in the interface and objects in those places.

6.2 Limitations

The VCA is a first attempt to make use of at least some of the possibilities listed above. There are, however, also many potential limitations and problems motivating further research.

The spatial strategy – the search vs. size problem revisited: How much picture information is it possible to place in natural locations that are easily found by search in a virtual environment? As picture based communication systems grow larger, search problems will appear, regardless of which main search strategy is employed.

Non-picturable and non-localizable information: What about information that is not easily picturable or located in a specific type of place? This problem is partly shared with category based strategies, when it comes to picturability and natural place in the search procedure. A major problem is that only part of the

information that a person needs in order to communicate is easily picturable at all, mainly objects, persons, places and to some extent actions, events and properties and mainly concrete instances of these categories.

Photorealism and abstraction: Can photorealistic pictures be a problem? This has to be investigated by letting potential users try the aid. Although search in a photorealistic VR world seems very intuitive and straightforward, it might be a problem to even recognize a panorama representation of one's own home. Maybe this also requires some kind of abstraction, And what about photographic picture representations of objects as communication tools? It may be problematic to use a photo, which is a highly concrete and specified representation, to represent an object which with respect to some of the specific features is not exactly like the one in the photo. Persons with aphasia have, for example, been known to reject colored drawing of a yellow sock when searching in a picture database in order to say that they want their own gray socks. This is one of the reasons for sometimes choosing more simple rudimentary line drawings or pictograms that are not so highly specified for details in picture communication systems. Far too little is known, at this point in time, to make any hasty predictions about how individual persons with aphasia will react to the photos and panoramas. One question here, is, of course, whether an artificial VR environment would be more suitable for some aphasics and whether a mixture of video-panoramas, photos and simple drawings should in some cases be used. The photorealistic VR environment (like most category based picture communication systems) is also, by necessity, very culture specific.

Individual adaptation: A related question to the above is how much individual adaptation would be needed and how much would be realistic for most users.

Other limitations: Like other communication systems, there could also be problems for the user related to visual half field defects, apraxia and more general problems in managing the computer as well as problems related to the portability of the communication aid (Ahlsén, 1996).

7. WHAT'S NEXT FOR VCA?

The VCA prototype will be a rudimentary picture communication aid which can demonstrate the possibilities of a VR communication aid and to some extent be evaluated. Persons with aphasia will be able to try the prototype. Interviews with aphasic persons and with experienced speech-language pathologists will also be used for evaluation and further planning.

A related case study of the ordinary daily communication of a couple of non-aphasic elderly persons (many aphasics are elderly persons) will be carried out. The purpose of this study is to obtain more information about what types of more specific information could and would need to be included in VCA to make it a useful tool for communication in every day communication.

8. FURTHER POTENTIAL DEVELOPMENTS

The next step would be to make a highly individualized VR application for a single person in cooperation with that person and to evaluate it in real-life use. At the same time, a standard version which is more rich in information and, thus, has a more advanced system for spatial search should be developed.

There is also a need for experimental studies evaluating the features and usefulness of different types of picture representations for persons with aphasia (as well as other persons).

9. OTHER POSSIBLE APPLICATIONS OF VCA

The VCA prototype is designed specifically for persons with aphasia, since their need for spatial navigation seems to be great. This group might, however, not be the only one that could profit from the use of spatially based picture communication. Other potential users could be persons with Alzheimer's disease or other forms of dementia and persons with mental retardation. If and how these persons could use VCA is an open question, having to do with how easy and intuitive the search strategy will turn out to be.

Extending the scope of VCA would also make it a possible tool for language learning that could be used both for first and second language education in training basic vocabulary for objects etc. in various environments.

10. REFERENCES

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