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Information Visualisation in the User Interface for Augmentative and Alternative Communication

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Abstract: This study investigated the possibility of using Information Visualisation (IV) in the user interface of Augmentative and Alternative Communication (AAC) systems. AAC systems exist to assist people to overcome communication handicaps. Computer-based AAC systems can contain stored communication material for people with impaired communication to retrieve and use during interaction. As the size of the stored information corpus in an AAC system increases, the task of searching and retrieving items from that corpus will become more demanding, which will make it less easy for someone to successfully access and use such material. IV has therefore been investigated here as a way of accessing AAC content. A prototype visualisation interface was developed as a means of retrieving stored biographical text in an AAC context. Trial of this prototype showed that it was possible for people to successfully retrieve the stored information with the IV-based user interface, indicating that an IV-based interface could have potential within AAC. Further work could be pursued to investigate performance with larger corpora and alternative visualisation metaphors; alternative metaphors (using timelines, for example) may be preferred by different people who use AAC.

Keywords: Information Visualisation, User Interfaces, AAC, Augmentative and Alternative Communication, Assistive Technology, Human Computer Interaction.

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1. Communication and Disability

Inter-personal communication is straightforward and easy for most people who share a common language; they simply talk to one another. Interaction with others can be extremely difficult, however, for someone who is non-speaking. The field of Augmentative and Alternative Communication (AAC) has existed for many years with the aim of developing techniques, aids and systems to assist people with disabilities to communicate. Beukelman and Mirenda [7] give an extensive introduction to the field of AAC, including the ASHA (American Speech-Language-Hearing Association) definition [6] that AAC is "[the] area of clinical practice that attempts to compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders".

Computer systems can store large quantities of information, and it is now technically possible for a computer-based AAC system to contain a large amount of stored communication material for retrieval and use during conversation. As well as words, phrases, sentences and scripts, an AAC system can contain stories and biographical items about the person who uses the system, with the intention that they be available for use during conversation. Multimedia material may be included [28,29,30] in the information corpus. As the amount of stored AAC material increases, however, the task of searching for and retrieving individual items will become more demanding for the person using the system. (An important aspect of an AAC system is that it should not impose an excessive cognitive load on the person using it.) It also becomes more difficult to remember the items that are stored therein. This concern parallels a general problem in human-computer interaction (HCI) – that of finding and accessing items of information within large information repositories.

Information Visualisation techniques [9,56,58,64] have been developed and explored in HCI with the aim of assisting people to overview large information spaces in order to identify and locate individual items of information within such spaces. As AAC systems grow larger and contain more information, Information Visualisation may have a role to play in assisting non-speaking people to find and retrieve items (e.g. messages, stories, reminiscences, small-talk) within their AAC systems for use during conversations [60]. This paper describes an investigation into the potential of Information Visualisation in the AAC interface, including the development and trial of a prototype visualisation interface for AAC. The investigation was exploratory at this stage, with the aim of opening up the area to see what potential benefits might emerge. It was not clear if efficiency gains would accrue at this point, but basic possibilities for the concept could be explored. Any enhancement of the AAC user interface or the range of interface options is of interest and value to those who use AAC systems.

2. AAC Overview

2.1. Technology in AAC

Low-technology AAC methods, such as word charts/boards and sign, gesture and symbol languages, have existed for a long time, and they are very effective in situations where both parties in an interaction (e.g. a non-speaking person and a speaking partner) understand the method being used and have physical access to it. They are less useful when a non-speaking person needs to communicate with someone who does not understand the sign or symbol system being used, or a group of people needs to be addressed and the non-speaking person's word chart/board is too small for several people to observe simultaneously. Technological

AAC systems break down some of these barriers by extending the modes of interaction which may be used. A common example is the use of synthetic speech as an output mode so that conversation partners can hear what a non-speaking person has entered into their AAC system and thus engage in "spoken" interaction. The involvement of technology in AAC began largely with the introduction of electrical and electronic systems, for example to operate scanned row-column arrays as input systems for people with physical disabilities who could not type or encode information easily into a keyboard or communication system. The subsequent advent of low-cost and portable computing meant that many new technical approaches could be developed for use in AAC. As well as addressing user-interface (e.g. physical access and input methods) and language (e.g. word-prompting and spelling assistance) issues, many of these techniques were intended to help address the large difference in communication rates achieved by speaking and non-speaking people.

2.2. Rate of Communication

Conversation can proceed at rates ranging from 150 to 250 words/minute for people with no communication impairments, but those who need to use AAC can be very much slower (less than 8 words/minute in many cases) [7]. Physical disability often accompanies speech impairment and can make operation of an AAC system very slow indeed. Acceleration techniques have been developed to try to improve this situation. These usually invoke extra cognitive effort for the user in attempting to offset physical difficulties involved in entering or encoding information. There remains a large difference in the typical communication rates achieved by people who use AAC and people with no communication impairments.

Symbol and coding structures, abbreviation strategies [41], probability and prediction algorithms [35,44,59] and character and word disambiguation schemes [4,21,34] have been used to try to reduce physical workload and make input to AAC systems easier. Natural Language Processing (NLP) techniques have been exploited [14,33,38,43] to try to create more efficient language interfaces for AAC. Menus, on-screen keyboards and special interface layouts are often used to present selection options to the user. Some elements of conversation are relatively predictable and methods have been investigated to exploit concepts of conversational modelling and pragmatics in AAC [2,3,11,18,22,27,39,61,62,63, 65]. Topic-related phrases, sentences, paragraphs, scripts and frames may be stored for recall and use during conversation, as well as complete stories [72] and special-interest (e.g. hobby-related) texts. In a single-user case study [61], a non-speaking person attained a conversational rate of 64 words/minute, with well-rated quality of conversation, using a text-storage AAC system based on conversational pragmatics. Higher rates (around 80 words/minute) were seen when greater use was made of personal narrative. Although this performance was not within the range of natural speaking rates and was limited to a single-case study, it illustrates the possibility for significant improvement in rate that might be more generally attainable with AAC.

Most non-speaking people who use AAC do not attain this level of performance and more investigation of user interfaces is required to broaden the options available and seek out paths to better communication. The challenge is to develop user interfaces which allow rapid search and retrieval of AAC information while limiting the cognitive load for the person using the interface. The current investigation of Information Visualisation in AAC stems from this need.

3. A Potential Application for Information Visualisation

Computer-facilitated visualisation has been described as "the use of computer-supported, interactive, visual representations of data to amplify cognition" [10]. Visualisations attempt to assist the human vision system to detect the important features in a set of data or information [24]. Large amounts of data or information can be presented in a visual form that is intended to give a viewer an overview so they can rapidly perceive the main features or points of interest then focus in quickly on relevant detail, while having to perform less cognitive processing in making sense of that data or information. The aim is to take advantage of human perceptual abilities and transfer work to the perception system [13] in order to reduce cognitive load. Examples of previous work in the context of the visualisation of textual information include research on geographic metaphors [23,74], spatial mappings [50,51] and self-organising maps [12,36].

Rennison's "Galaxy of News" uses Associative Relation Networks (ARNs) to learn the relationships between news articles based on extracted features of the articles such as keywords [50]. News articles are clustered in a scene according to theme; zooming towards a particular theme reveals sub-topics and continued zooming eventually leads to an individual news article. The Galaxies visualisation tool (part of SPIRE (Spatial Paradigm for Information Retrieval and Exploration) [25,26,74]) produces a visualisation of a set of documents where each document is represented as a "docustar" within the "galaxy". Clusters represent similar documents and large gaps between clusters indicate unrelated documents. Such approaches allow overviews of large text corpora or document sets in order to make the detection of themes or clusters of similar documents easier. Many other visualisation techniques have been proposed for viewing different types of information, such as the Hyperbolic Browser [32], Cone Trees [52], SpaceTree [70], the Perspective Wall [37] and FilmFinder [1]. The Lifelines project [48] proposed a general technique for visualising personal histories for use with a person's medical or court records, for example, or other professional histories. These and other visualisation methods are described in the literature [20,31,56,58].

It is possible that a visual overview of information stored within an AAC system and the links and relationships between items within that body of information could help someone to locate and retrieve stored material for use in communication. Information visualisation techniques might therefore be able to make an important contribution in AAC, particularly as the quantity of stored information increases.

3.1. Spatialisation and Visualisation in AAC

Demasco et al. [15] discussed possibilities of applying spatialisation and spatial metaphor to AAC interfaces, and proposed the development of an interface using these principles. A specific interest lay in the type of user task described [1] as Visual Information Seeking (VIS). The interface would have a "virtual word board" (conceptually equivalent to the physical word boards and charts used in AAC) in the form of a large two-dimensional virtual surface populated with words, with a movable viewing window giving access to any part of the "board". Word association algorithms, three-dimensional presentation, sentences and narratives were all suggested as possible developments within the area, and although further development and evaluation were not conducted at that stage, it was evident that very interesting avenues were presenting themselves for research in AAC interfaces.

Information Visualisation techniques such as spatial mappings, timeline metaphors and abstract models have been further considered for use in the AAC context [5,60]. Items such as words, phrases or stories (or symbols representing them) could be displayed in a spatial scene, with relationships between items shown by linking or clustering them in the scene according to appropriate criteria, such as topic, keyword or type. The selection space might be a geographical scene, such as a forest or landscape, or it might be in abstract form, for example using nodes and interconnections to illustrate the contents of the system and how individual items inter-relate. A timeline metaphor (using roads or rivers, for example) may be useful for representing biographical information, with items ordered chronologically relating to particular periods in the life of the person using the system. Scenes could be two-dimensional or three-dimensional; three-dimensional portrayal might help to illustrate more complex relationships between items in the scene, particularly if it is possible to navigate through the scene and see different perspectives emerge as one does so. Animation might also be used to highlight particular aspects within scenes.

3.2. Visualisation of Conversation

Researchers have previously investigated how to present computer-based visualisations of the conversation process itself. On-line text-chatting [17,66] and audio-conferencing [53] have been examined in this manner, for example, and the analysis, visualisation or presentation of conversation and social interaction from text or computer-mediated environments have been researched [8,16,40,42,45,46,47,49,54,55,57,73]. While such research can give insight into how people interact, the work reported here has a different aim; it is concerned with assisting people to participate in live, real-time conversation through the more effective retrieval and use of stored content from an AAC system.

4. Prototype Visualisation System for AAC

A prototype interface incorporating visualisation was developed for an augmentative communication context in order to be trialled in a retrieval task on biographical information. Biographical information was seen as an example of the type of material which could grow to a significant size over the lifetime of a person using AAC, and was therefore suitable for investigation in this context. A biographical text was available which covered the life of a particular non-speaking person; this corpus had been created previously for experimentation on conversation in AAC, so it formed an appropriate corpus of information for this work.

The biographical text was segmented manually into topics and sub-topics, and entered into a database. Key topics were identified (Family; Education and Training; Holiday; Conference and Travelling; Games and Competition; Pet; Hobby) which were key aspects of the life of the non-speaking person, and the information was categorised accordingly. The stored texts after segmentation consisted typically of single sentences or short paragraphs that could be output as statements during an AAC interaction. There was also chronological information relating to many recorded events, and it was therefore also possible to associate much of the stored information with particular years in the life of the non-speaking person.

4.1. Prototype Interface

The prototype interface (Fig. 1) contained features which would be needed for the retrieval of texts from the database in an AAC application. This did not extend to a full range of facilities as might be found on a commercial AAC system, but was appropriate to give a framework for experimentation on visualisation and information retrieval within an AAC context. The interface had a window for a visualisation scene to appear in, two text areas (called “Life Story” and “Life Event”), and an area for a picture (e.g. clip-art) or symbol to appear in representing the item which has just been selected. The “Life Story” area displays text that has already been output by the system. (In a full AAC system, this would typically be output in synthetic speech form). When the person using the system selects an object from the visualisation scene, the text associated with that object is displayed in the "Life Event" area for preview; if they approve that text as suitable for output, the "Add" button is activated to add the new text to the "Life Story" area, representing output of the text item. Should they decide not to use the text, activation of a "Remove" button will delete the text from the "Life Event" box, and a different item can be selected instead from the visualisation scene. A "Clear" button enables them to completely clear the "Life Story" area, e.g. when a conversation has finished. The person using the system can therefore use the visualisation display to lead them towards items in the biographical database, items which they can then select and review for possible use in conversation.

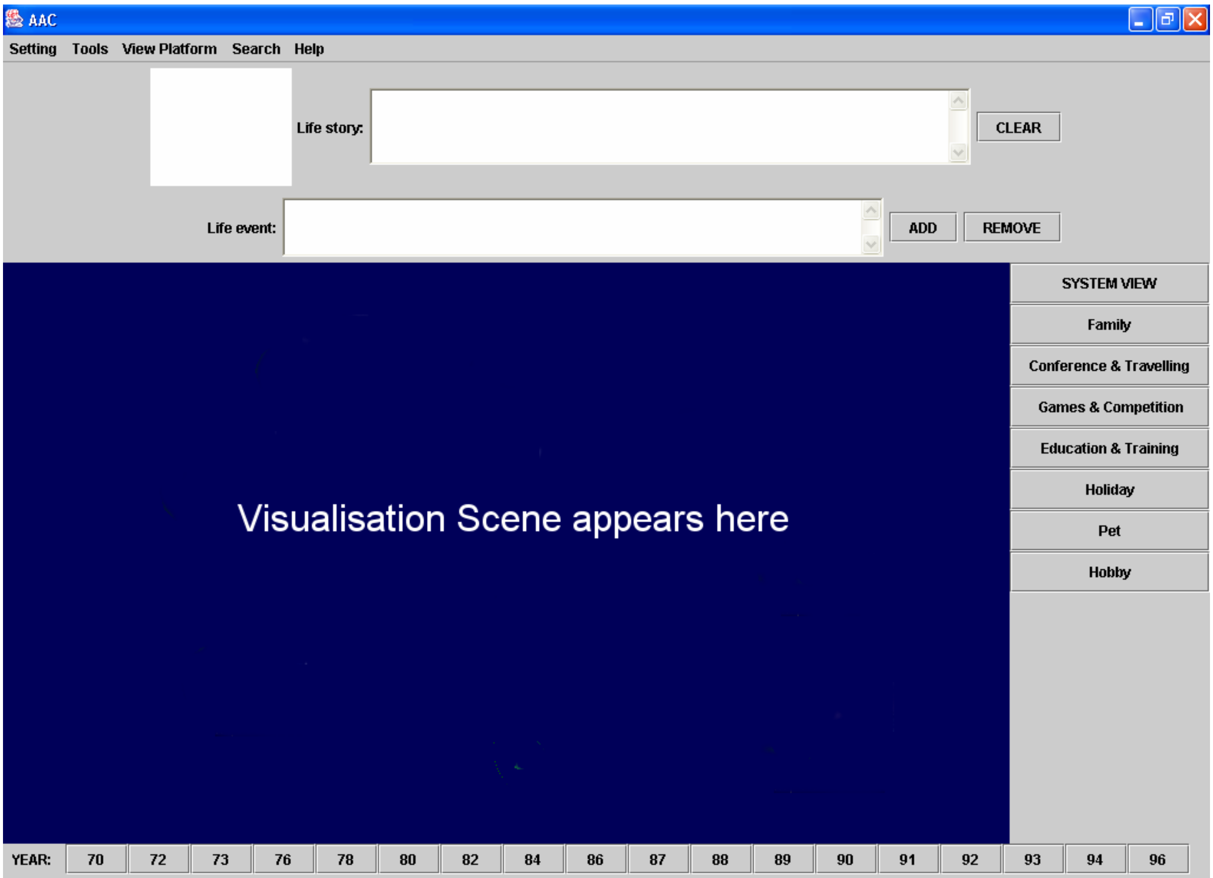

Figure 1: Prototype User Interface. *The prototype user interface showing area where the visualisation scene is displayed, text windows for Life Story and Life Event, and an area (top-left) for a picture (e.g. clip-art) or symbol to represent an item that has just been selected.*

4.2. Visualisation Metaphor

The visualisation metaphor developed for representation of the information space utilised concepts from previous research on information visualisation combined with knowledge of the type of AAC information to be represented. The biographical information was hierarchical in that it had been segmented manually into topics and sub-topics. Clusters of topic-related material were therefore already present within the information, and these clusters and the hierarchies within them could be presented visually. There was also the possibility of presenting a timeline of those recorded life events which related to particular years. Astronomical and geographical metaphors have been developed and reported elsewhere [23,25,26,50,51,74]; the "galaxy" concept [25,26,50,51,74] is a prominent example, one that can allow clustering of similar items (e.g. topic-related texts) as well as the depiction of hierarchies, and has been used before for the presentation of personal information [51]. An astronomical scene can give an overview of the information space, with detail appearing as the viewer zooms into the space and approaches individual clusters/bodies within the space. Astronomical space is also relatively empty and uncluttered compared to some other types of scene, and bodies such as suns, planets and moons can be used to represent items of interest within it. This was considered to be very suitable for this application. An additional desire, however, was for some form of "timeline" to give access to information on a chronological basis.

A hybrid visualisation metaphor was therefore developed that represented the information content as a galaxy of "solar systems", with a timeline included in the galaxy. A view of a scene of this type is seen in Fig. 2. Each solar system could consist of one sun with a number of planets around it and each planet could be surrounded by moons. Colour coding was applied to the suns (red), planets (green) and moons (blue) in order to help differentiate them. They were also differentiated by size, with suns being larger than planets and planets larger than moons. Each solar system represented a particular topic (e.g. Family, Holiday, Hobby) and each planet could represent a sub-topic within its topic. Each moon could represent a sub-sub-topic or sub-text within its planet's sub-topic; the number of planets and moons in each solar system depended on the number of sub-topics and sub-sub-topics within that solar system. All of the biographical information could be accessed via these solar systems and because the hierarchical nature of the stored information mapped directly to the hierarchy of sun-planet-moon, it was relatively straightforward for an astronomical model to be generated automatically from the database content by the system. (Much of the computation required during system operation related to the graphical representation of the astronomical model; the graphics facilities of the Java3D programming environment were very effective in this role.) The timeline concept was represented through the inclusion of a row of solar systems along the lower part of the scene, each of these representing one particular year. Information on life events that occurred within a particular year could therefore be accessed via its "year" solar system. Although a linear row of solar systems would be unlikely in a real galactic scene, it meant that a timeline could be represented in this case.

4.3. Navigation

Every solar system was labelled with either a text label (topic-clustered) or a year label (timeline). These labels became invisible if one zoomed away from the model (the only detail which could be seen from a distance was the planetary bodies themselves grouped in their galaxy). Zooming in towards the model revealed the topic or year labels on the suns of the solar systems, followed by clip-art images which symbolised the topic of each solar system. Further zooming caused text labels and clip-art images to appear on each planet, and then on each moon. (Fig. 3 shows the "Family" solar system at closer quarters, with clip-art images evident. The "clip-art" images shown here replace the original proprietary ones used on the prototype for reasons of copyright.) The level-of-detail therefore increased as the viewer zoomed in towards the scene and attention became focused on an ever-finer part of the scene. The level-of-detail at system start-up was such that solar system text labels were visible to the viewer, who could then commence to navigate around the model. A button was included on the interface to enable the viewer to return directly to this initial view from any point in the model, so that the viewer could re-locate to the known starting position easily and quickly. Fast-zoom buttons were also included on the interface (on the right-hand side and along the bottom) to auto-zoom the viewer to individual solar systems; these offered an alternative way for the viewer to rapidly approach individual topics or years.

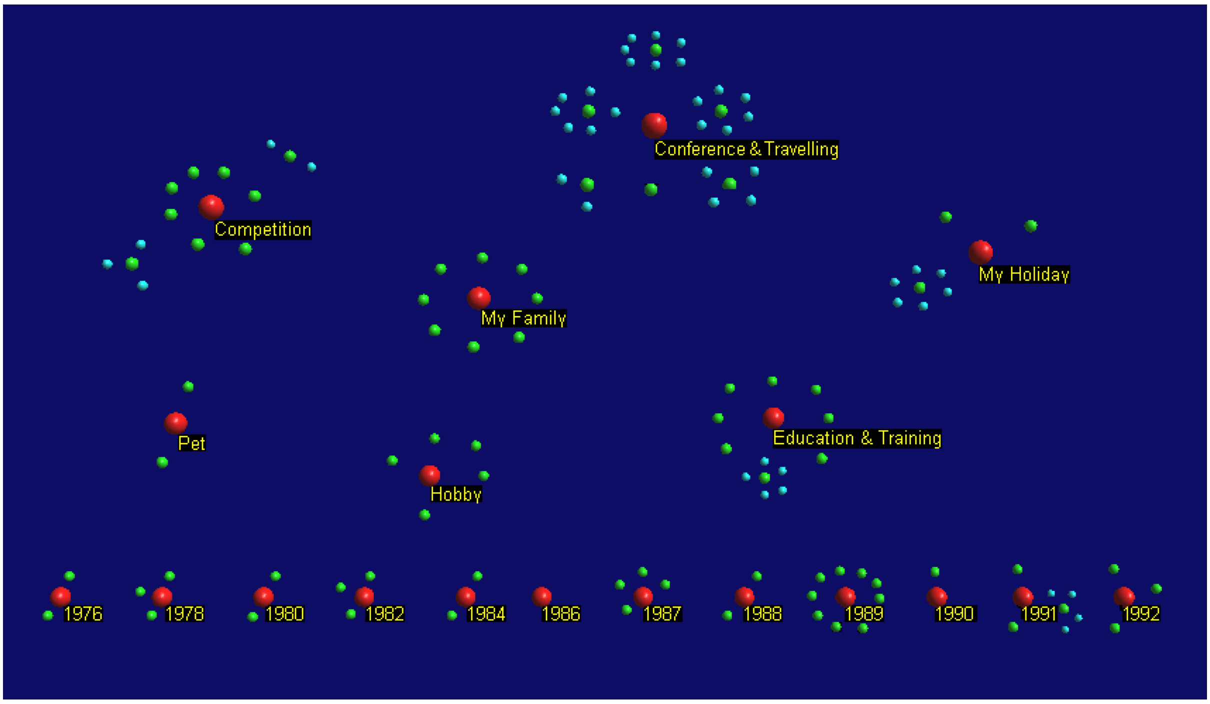

Figure 2: Visualisation Scene. *A visualisation scene showing solar systems representing topics and timeline. Text labels are visible on the suns indicating topic or year for each solar system.*

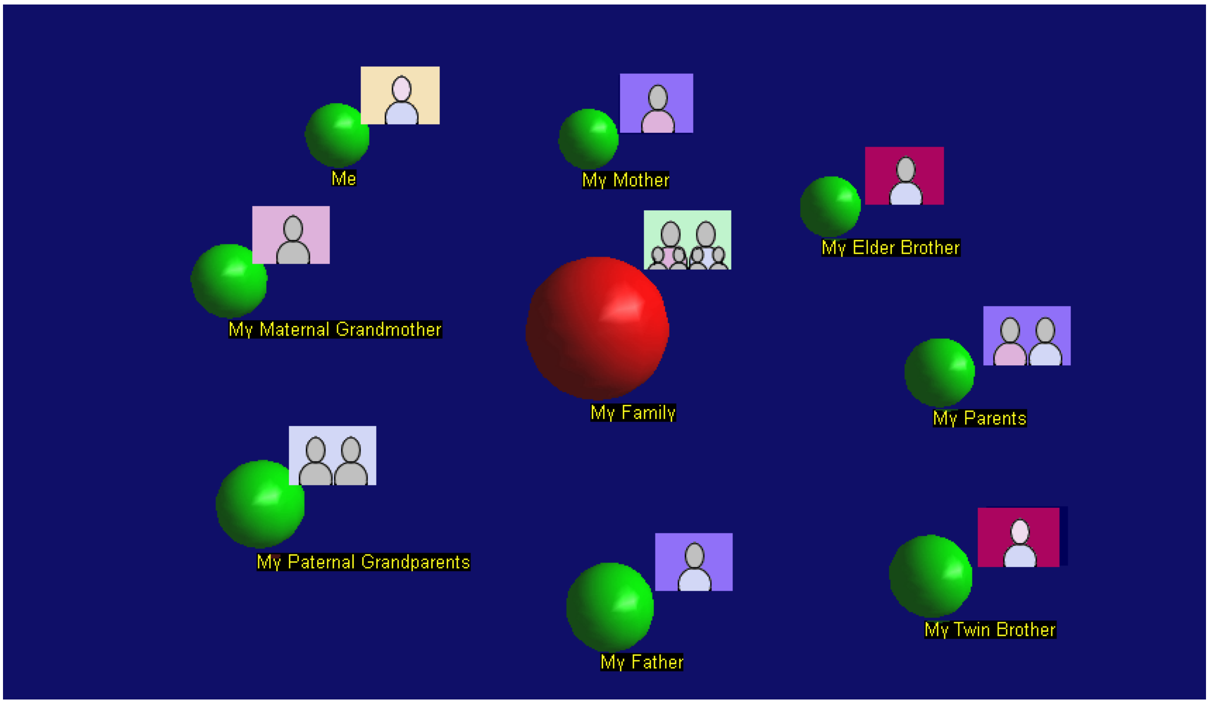

Figure 3: Solar System. *The "Family" solar system at closer quarters, showing text labels and clip-art labels* which emerge on zooming-in towards planets and suns. (*The original proprietary clip-art used in the prototype interface has been replaced in this figure for reasons of copyright. The labels shown here are of the same size as the original labels on the prototype.)*

Panning could be performed, and the whole model could also be rotated in three-dimensional space and viewed from any angle. Angle-of-view and panning could be controlled, like zooming, using mouse and/or keyboard control. In the initial prototype, the planets and moons gradually orbited their parent bodies. This brought each planet/moon to the foreground in turn so that, whatever the angle-of-view, planets and moons could not become permanently obscured by other bodies in their solar system. The viewer could navigate to any part of the displayed galaxy, approach any solar system, view the detail of items represented there, and select a planetary body. This would cause the piece of text represented by that body to be displayed in the preview ("Life Event") box on the interface. As described above, the viewer could then view the text and decide whether or not to use it. This prototype visualisation system thus enabled a viewer to search for and retrieve pieces of text from the biographical database, and so gave a basis for experimentation on visualisation in an AAC-type retrieval task.

5. Trial

The visualisation-based interface was trialled in a text-retrieval task along with a more conventional access method. There are two main types of system interface that are commonly used on AAC systems. One is a hierarchical tree structure (with text or picture elements) that allows someone to move between high-level topic areas and lower levels where a word or phrase can be retrieved; the other involves coding individual words with two-to-three multi-meaning icons [67]. Of these two methods, the first relates more closely to the visualisation interface, since it represents the same basic structure for storing the content, but without the visualisation aspect. It was therefore decided to compare the visualisation interface with a generic text-based one that gave access to the same content. The simplest possible instantiation of such a structure was a system of drop-down menus; this had the advantage of not duplicating any particular manufacturer's interface (which could have introduced bias into the trial) while ensuring familiarity for participants because of their common use in ubiquitous windows and internet applications. Using this familiar type of interface also ensured that there would be no need for exhaustive participant training in the use of a particular proprietary type of hierarchical interface. It allowed a comparison to be done between text-only and visualisation conditions without the confounding factor of an individual AAC system design.

The focus of the trial was the time required to find and retrieve texts from the biographical database. The menu-based interface (Fig. 4) used for the experiment contained life event and life story boxes for selected text items, just as the visualisation interface did, and these performed the same functions as their equivalents in the visualisation interface. Selection of items was done solely via drop-down menu, however, as shown in Fig. 5. There was no visualisation display in the menu-based interface. The biographical information in the database was identical to that for the visualisation interface.

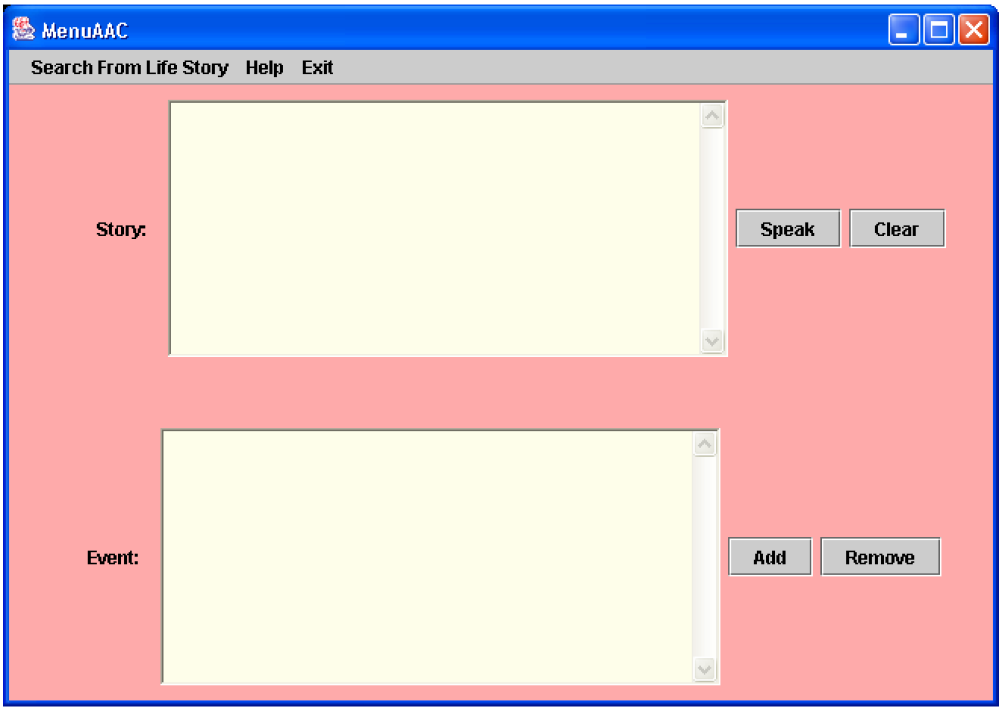

Figure 4: Menu-based Interface. *The menu-based interface for accessing the biographical text database.*

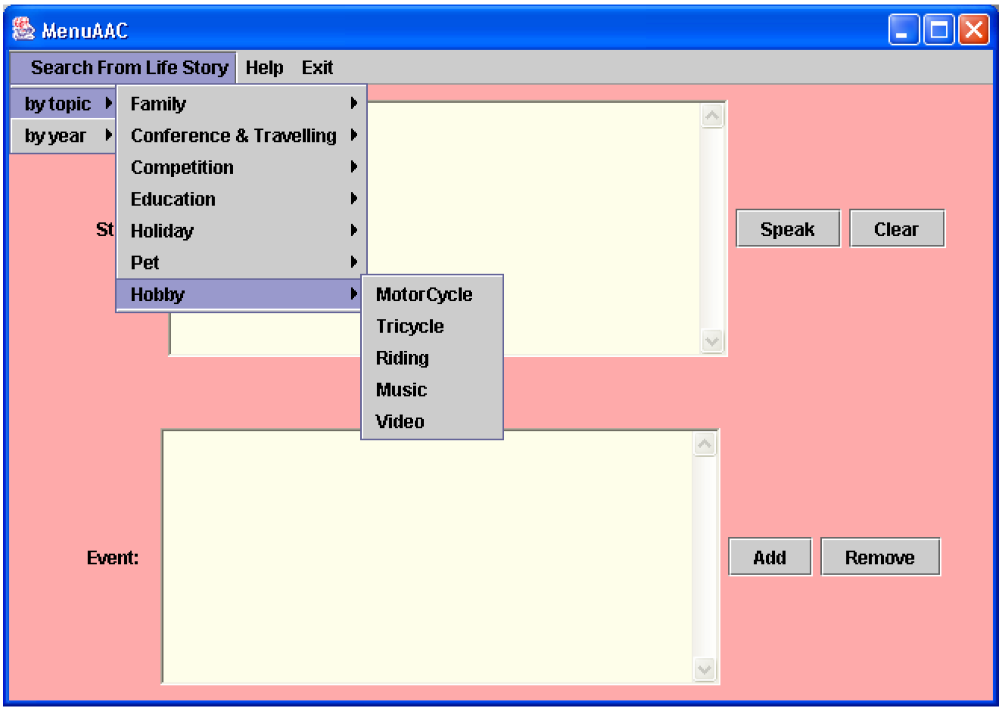

Figure 5: Drop-down Menus. *Menu-based interface showing drop-down menus for the "Hobby" topic.*

The prototype was trialled with a non-speaking person who was experienced in the use of AAC. This person had composed the auto-biographical material with which the system was populated and could therefore (a) relate directly to the stored information and (b) judge whether the visualisation-based interface would form a suitable means of retrieving the auto-biographical material in an AAC situation. This participant, who was very familiar with drop-down menus through the use of conventional software applications, tried both types of interface (visualisation- and menu-based) to ascertain if they were suitable for retrieval of the biographical material. Non-speaking people often have parallel physical and learning disabilities of a wide variability. There is no typical disabled person; even those with similar diagnoses experience different abilities and disabilities [71]. This makes it extremely difficult to design and implement experiments that require homogeneous groups of people with disabilities, and this has led to the common use in the field of a single-participant approach. This approach is also often used rather than syndrome grouping in modern neuro-psychology [68]. The single-participant approach was adopted here with the non-speaking participant.

The visualisation interface was also trialled with a group of able-bodied (speaking) participants who performed the same trial as the non-speaking person. This part of the exercise was seen as an extended exploration of the usability of the visualisation interface. While their user characteristics can obviously be very different from those of a non-speaking person, issues or problems emerging from a trial with able-bodied participants might shed light on general aspects of the interface that would also be relevant to non-speaking people trying to use it in an AAC situation. This was viewed as part of the investigation of the wider context of the visualisation technique and its potential in user interfaces of this kind.

5.1. Participants

The non-speaking participant was a young adult with cerebral palsy (CP) who was experienced in computer use and had the ability to manipulate a mouse, with, however, a degree of awkwardness due to physical disability. Reading and writing skills were limited, in common with many people who are born without the ability to speak. The mouse was this participant's usual method of cursor control and access to computer-based applications. Problems with literacy and lack of fine hand and arm control meant that text could not be written manually. The participant could, however, move the mouse sufficiently accurately to activate mouse buttons in order to select screen-based items in mainstream computer-based applications, and regularly did so in applications such as web browsers and music composition software.

The non-speaking participant generally used a portable word-chart, gesture and some vocal sounds for inter-personal communication, and had experience of using laptop- and PDA-based AAC systems. Usual access to synthetic speech output was via an Enkidu PDA-based system [19], though this was not used frequently. The participant was therefore familiar with low- and high-technology AAC methods, and could communicate effectively using them. The participant also had experience of general computer use including windows and menus, and used a laptop for work needs. Menu-based selection was therefore very familiar to the participant. Because of the linguistic limitations, it was felt that a visualisation-based AAC interface might be of benefit to this participant. Retrieval time measurements similar to those made with the able-bodied participants were conducted.

Eighteen able-bodied speaking participants were also recruited to take part in the study. These participants were adult university students with varying degrees of computing experience. All were familiar with windows and menu-based interfaces and searching for and retrieving items (e.g. files, texts) by menu selection.

6. Method

6.1. Non-speaking participant

The non-speaking participant was not familiar with the field of information visualisation before meeting this prototype, and spent a preliminary session familiarising with the new system. This was to introduce the participant to the concept of visualisation in the user interface and give some experience of navigating around the visualisation scene. The participant had physical access to the system by mouse which was, as described above, their usual method of access to computer-based applications. The participant was asked to first explore the visualisation scene by navigating around it and selecting items, then to seek and retrieve specific items as an introduction to system use.

After this familiarisation session, the prototype and its concept were discussed with the participant. The system was modified in the light of this discussion, in particular by stopping the orbiting action of planets and moons, in order to make the targeting of these easier. (The angle-of-view was positioned so that all bodies in the galactic scene were visible.) The non-speaking participant returned later to the laboratory for a second session with the system and, after an introduction to and familiarisation with the modified version of the system, performed the following sequence of retrieval tasks. The participant was asked to find and retrieve ten pieces of text from the database, once using the visualisation-based interface and once using the menu-based one. The ten pieces of text were selected from different parts of the life story and placed in a random order before the evaluation began.

The pieces were identified by titles like “Motor Cycle”, “Seoul Olympics” and “Twin Brother”. The participant was given the name of the piece of text to find, and was then timed in finding and retrieving that text. Successful retrieval was concluded when the paragraph appeared in the text display area on the system interface. This resulted in the measurement of ten retrieval times for each access method (the visualisation interface and the menu interface) from which mean retrieval times were calculated for each method. The participant was also invited to comment on the visualisation access method.

6.2. Able-bodied (speaking) participants

Each able-bodied (speaking) participant was introduced to the system and its two interfaces (menu and visualisation). After a period of familiarisation with the system, as done by the non-speaking participant, the participant was asked to perform the same sequence of retrieval tasks that the non-speaking participant had performed and they were timed in the same manner. In order to control for possible learning effects, half of the participants used the visualisation-based interface first, followed by the menu-based system, while the other half used the menu-based interface first, followed by the visualisation-based interface. This resulted in the measurement of ten retrieval times for each access method for each participant. Each participant was also invited to comment individually on the visualisation access method, as the non-speaking participant was.

7. Results

7.1. Non-speaking Participant

The non-speaking participant was able to retrieve items using both interfaces, achieving mean retrieval times for the ten pieces of text of 11.3 seconds on the visualisation-based interface and 12.9 seconds on the menu-based interface. This participant had little familiarity with

Information Visualisation techniques prior to this trial, so the performance recorded here indicates an ability to adapt to the new method rapidly and successfully. While there were aspects of the visualisation interface that did not suit this particular participant (as discussed in section 7.1.1 below), these were specific to the participant and the particular visualisation metaphor in use rather than being general concerns. The outcome suggests that visualisation techniques may have potential in the AAC domain.

7.1.1. Qualitative Data: Views of the Non-speaking Participant

Using familiar communication methods such as word-chart, gesture and PDA-based AAC system, the participant discussed the visualisation interface with the researchers. The participant considered it to be very different from other known AAC interfaces and interesting as a research concept; the idea of navigating/flying through the selection space appeared novel compared to other AAC interfaces. The timeline (chronological ordering) aspect was particularly liked, as it made it easy for the participant to locate and identify many key moments in the auto-biographical sequence. The linear display of solar systems along the lower edge of the visualisation scene, where topic areas were ordered according to year of occurrence, was therefore a favourite part of the interface, and many texts were retrieved through that part of it. The metaphor of the planets was otherwise considered to be rather difficult, however, and one that might take the participant some time to come to terms with. The gradual movement of planets (slow orbiting action of the planets around their suns) had not been helpful, as it made targeting the individual planets with the mouse less easy; the removal of that feature after the initial familiarisation session was therefore viewed as welcome. Zooming with the mouse (pushing the mouse forward caused the viewer of the scene to zoom-in towards the scene, while pulling the mouse back towards the viewer caused them to zoom back out from the scene) was also found to be rather awkward, although the clip-art pictures which appeared on zoom-in were helpful. The level-of-detail feature therefore assisted the participant, but a different physical method of zoom control would be preferred; alternative physical interface devices and/or methods could be sought out for zoom control.

The chronological ordering was helpful possibly because many key life moments related to major sporting events (a keen personal interest of the participant) and these events were strongly associated in the participant's mind with particular year dates. The value of this was such that the participant expressed a desire to have a similar timeline on the interface of their PDA-based AAC system. The participant also suggested extending chronological ordering to certain individual topics (e.g. sport), so that someone could select a topic area and then see events and aspects relating to that topic in chronological sequence. Other topics (e.g. some family matters) were not so clearly time-related, however, so would not necessarily benefit from being displayed in chronological order. User involvement in the categorisation of topics, and their structuring for selection, was seen as an important aspect in helping to make the information space navigable.

The participant indicated that the conventional menu-based interface was satisfactory, although a little difficulty was experienced in getting started at the top of the menu tree. The menu concept appeared to cause no problems and the participant suggested that pictures (as on the visualisation interface) would be very helpful on the menu to complement the text labels. The "year" menu was also considered to be good for locating texts about events (as the chronological ordering of solar systems had been on the visualisation interface) and would similarly be a very useful feature on their PDA-based AAC system.

7.2. Able-bodied Participants

The mean retrieval times measured for the eighteen able-bodied participants were 4.51 seconds for visualisation-based retrieval and 4.86 seconds for menu-based retrieval. A small number of out-lying data were removed before these means were calculated. The results showed that there was no significant difference between the times taken to retrieve items from the database using the two methods. (A two-tail t-test for repeated measures showed no significant difference between the means for menu- and visualisation-based techniques ($t(17)=1.52$; ns)). The able-bodied participants were able to use both types of interface to find and retrieve items. As the participants were much less familiar with visualisation-based interfaces (a relatively novel concept) than with menu-based ones, it was notable that the visualisation interface should be used successfully by all of the participants. It clearly presented an access method that the participants could familiarise with quickly and use as an alternative to menus.

7.2.1. Qualitative Data: Views of the Able-bodied (Speaking) Participants

The able-bodied participants were also generally positive in the views that they expressed about the visualisation-based interface. They all reported that the new interface was in general easy to use, easy to relocate when lost and that the clustering of information by topic similarity was a good approach. Two of these participants felt that the astronomy metaphor was not particularly helpful, however, and two others registered their preference for the traditional menu-based system. All but one participant felt that using the mouse or keyboard to navigate the interface posed few problems. Other general feedback from these participants included the observation that for non-literate people who use AAC the visualisation model may have a lot to offer, and the timeline was also commended as being particularly useful as a location guide. One participant felt that they had particular difficulties relating the timeline objects with the group objects. These are aspects that could be addressed in any further development of the system. One area for investigation, for example, following the comment above about non-literate people, might be the particular cognitive skills required by such people in using a visualisation-based interface.

8. Discussion

The visualisation-based interface was found to give an effective means of retrieving the biographical information of a non-speaking person in an AAC-type application. This was true for the non-speaking participant as well as for the able-bodied speaking participants. It would therefore be possible for a visualisation scene to be included in the user interface of an AAC system, possibly as part of a suite of interface options from which someone could choose. There are issues to be investigated further, notably the suitability of different visualisation metaphors for the role, but the work reported here indicates that Information Visualisation has a potential role to play within AAC.

Other forms of AAC content could be represented using visualisation, for example stories, narratives and humorous anecdotes [28,71,72] could be clustered in topic groups and arranged in hierarchies in a very similar manner to biographical material. Stories relating to the same people or places could be clustered together and arranged in hierarchical fashion, for example. Multimedia material such as personal videos and photographs are also valuable in the context of AAC interaction [29,30] and could be similarly categorised, clustered and represented on a visualisation interface. In future it may be that content management systems, as used to manage content for web-sites, would be used to manage stored information for visualisation-based AAC systems.

8.1. Visual Metaphors

While the astronomy metaphor was effective for the majority of the able-bodied participants, who found it easy to use, it was not favoured by the non-speaking participant. There are many possible visualisation metaphors which might be tried, however, and others may well be suitable for this participant, such as those involving timelines. The non-speaking participant placed strong importance on the chronological ordering feature, so the concept of using road or river metaphors for this was discussed; the participant indicated that that could be a very powerful approach and worth pursuing in future research. (The idea of auto-scanning, or auto-navigating, a visualisation scene in an equivalent manner to auto-scanning in other AAC interfaces was also seen as worth investigating.) Time-related visualisations [69,23] have been investigated elsewhere, and the concept could be developed further for AAC. Part of future work should therefore involve investigating different metaphors for the role; a suite of visualisation metaphors could be developed for evaluation and use in AAC. Familiarity of the viewer with the metaphor is a factor to consider; abstract metaphors, for example, may be difficult for some people to embrace because of their unfamiliarity and more concrete or life-like ones may be more easily accepted in some cases. A suite of visualisation metaphors developed for experimentation should therefore contain a wide range of different types and styles of metaphor, including some that relate very directly to daily life and physical reality. Spatialisation and spatial metaphor have been considered before for use in AAC interfaces [15] and spatial metaphors such as landscapes with natural features representing information or information clusters have been proposed [60]. Alternative ways of displaying hierarchies have also been developed (e.g. Cone Trees [52], SpaceTrees [70]) and these might be investigated if a hierarchical approach is to be developed further. Ultimately metaphors such as these would have to be investigated individually to ascertain their suitability for a role in AAC; the development of a visualisation suite for AAC would facilitate research of this nature. Individual non-speaking people are likely to have individual needs and preferences, and ways of personalising visualisation interfaces will be needed to give the flexibility required to meet individual needs.

8.2. Clustering

Clustering of information was performed manually for this exercise during development of the system. Information was clustered by topic, which the able-bodied participants generally found to be a good approach. Automatic clustering methods could be investigated to establish if AAC information can be categorised automatically prior to display in a visualisation-based interface. Automatic clustering would mean that the system could absorb new information about a non-speaking person, entered either by the non-speaking person or by a carer, and place it appropriately in a visualisation scene, close to related items. The carer or non-speaking person would then not need to be concerned with the clustering process. It might also be possible for whole new visualisation scenes to be constructed *ab initio* by the system for other non-speaking people from their own biographical texts, with clustering performed by the system. The biographical information would generally need to be composed beforehand by non-speaking people and/or their carers.

8.3. Input Devices

The input devices used in this investigation were mouse and keyboard. Development of the physical interfacing could make navigation around the model easier for individual people with disabilities. A wide range of special switch and sensor technology exists for interfacing people with disabilities to their equipment, hence a range of devices and techniques could be incorporated to assist interaction with a visualisation interface. The option of two-dimensional representation could also be incorporated to bring greater flexibility to the interface and possibly make operation easier for some people.

8.4. Further Evaluation

Further evaluation of the concept using larger and longer trials would be appropriate to give more comprehensive insight into its efficacy. The investigation reported here was exploratory in nature, designed to open up the research area and investigate basic possibilities for visualisation in AAC; it would be appropriate for a fuller investigation to be performed to give a wider view of potential benefits. It would also be valuable to evaluate the concept in conversational situations. The visualisation interface would need to be embedded in a complete AAC system with speech output facilities (e.g. synthetic speech) and assistive input and interface features typically found in AAC systems. Conversations between people who use AAC and conversation partners could be evaluated to investigate how the visualisation might contribute to the quality of the interactions. Larger AAC databases could also be built and evaluated to investigate how the size of the stored information corpus might influence relative performance.

9. Conclusion

The visualisation-based interface was found to work as a means of retrieving information from a biographical AAC database. Retrieval times were similar in this instance to those attained using a conventional menu-based interface. Further development and fuller evaluation of the concept could be pursued to investigate how different visualisation metaphors might contribute and whether improved performance can be achieved with other visualisation techniques or with other (including larger) information corpora stored in the system. The exploratory work reported here has highlighted a valuable area for user interface research and represents a step towards developing new and different interfaces which could extend the choice available to people who use AAC.

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