SIACG 2002 - 1st Ibero-American Symposium on Computer Graphics
1-5 July 2002, Guimarães - Portugal

# INTERCOMUNICANDO
## Computer Assisted Communication for Severely Handicapped Persons

João Brisson Lopes
Dep. Engª. Informática, IST
Av. Rovisco Pais, 1049-001 Lisboa
brisson@ist.utl.pt

Ricardo Amaro
LEIC, IST
Av. Rovisco Pais, 1049-001 Lisboa
rjmpa@mega.ist.utl.pt

António Pereira
LEIC, IST
Av. Rovisco Pais, 1049-001, Lisboa
ajpereira@tmn.pt

**Abstract**

*This paper presents project INTERCOMUNICANDO whose aim is to provide computer assisted pictogram based communication as a rehabilitation tool for severely handicapped persons. The project developed a suite of integrated applications that use autonomous agents with speech and animation to provide on-line help, feedback and motivation to users. The paper addresses user interface design. It also addresses the user requirements and the development methodology used to provide users with all services, including input, that smoothly adapt to the kind and degree of disability of each user. The current state of the project is described along with results. Conclusions and recommendations for the following project (RECRIA) are presented.*

**Keywords**

*Handicapped users, user modelling, interaction, interaction devices, agents, games, therapy.*

### 1. INTRODUCTION

The communication ability of severely handicapped persons is usually extremely impaired because, although such persons can understand speech, think and express feelings, they lack the minimal skills required to use voice to communicate with other persons. This inability to communicate leads to frustration and isolation and severely hinders all efforts by therapists, relatives, educators and friends to relate to such persons.

Of the many therapeutic approaches in existence, the use of pictographic languages based on printed symbols of persons, nouns, verbs, adjectives, etc., has been established as one of the most successful. Handicapped persons use these languages to communicate by pointing in sequence to printed symbols to compose sentences. To answer back or elicit reactions, relatives and educators point to symbols and speak the words associated with them, or even gesture, to enhance meaning and provide strong feedback.

The need for strong feedback and encouragement is the reason why computer assisted communication has had limited success. There are many applications targeted at such users, but these have only showed success with moderately handicapped persons. Furthermore, most products, like Writing with Symbols 2000 [Johnson00] and BoardMaker [Johnson01], are self-contained and do not provide the means to promote language learning and the use of computers, nor any means to assist therapists' activities or to create tailored language sets. Although it is well known that (handicapped or not) persons communicating through computers tend to discard all their inhibitions, this aspect has been little used to advantage because of the need for strong feedback and motivation build-up in the case of severely handicapped persons. As a consequence, the opportunities offered by computer-assisted communication have been seldom explored.

One reason for this is the high variability of disabilities shown by severely handicapped persons. Such disabilities affect the ability to move, sight, etc, to different degrees. This extremely complicates the user model and the support that applications must provide. Furthermore, many applications overlook the fact that handicapped persons need to be trained on the use of computers and must learn a pictographic language before using it.

This paper presents the INTERCOMUNICANDO project that attempts to provide computer-assisted communication for severely disabled persons to allow them to communicate with relatives, educators and therapists and between themselves.

INTERCOMUNICANDO developed the AEIOU system (Portuguese acronym for Learning and User Integration and Assessment Application) that brings together the facilities for user adaptation, computer use and language learning, and communication for severely handicapped persons.

AEIOU uses agents to provide strong feedback and reinforcement mechanisms and promote communication. This allows the immediate absence of a therapist or an educa-

tor and removes the constraining source of disappointment (inability to communicate properly) that their presence embodies, and makes the user freer to experiment.

AEIOU also provides support for the tasks of therapists and educators, especially those related to recording and assessing user progress.

INTERCOMUNICANDO was supported by a grant from the Portuguese National Board for the Rehabilitation and Integration of the Handicapped Person (SNRIPD) under its CITE 2000 research programme and was carried to by Instituto Superior Técnico, AFID (National Association of Families for the Integration of Handicapped Persons) and ISPA (Institute for Applied Psychology).

## 2. USER REQUIREMENTS

The use of computers by persons with disabilities demands that special requirements be met, particularly at the level of human-computer interaction. The widely varying degree of disabilities and number of user model parameters that must be supported requires specific solutions for each case because "each case is a case" that is different from all other cases [Eduards99].

Therefore, user-computer interaction must adapt to each and every user to support specific input and output devices. Also, dialogues and dialogue layout must be carefully designed and the applications must support the means to induce and motivate users to communicate. This calls for user models that exhibit a very high level of configurability.

Some severely handicapped persons are able to use input devices like trackballs and even mice and joysticks. But these cases are more the exception than the rule.

In general, input must be based on sweeping techniques where a cursor sequentially hovers over icons on the screen and users make selections by pressing a switch (see Figure 1). Switches used in conjunction with sweeping are slow input devices but, nevertheless, allow a high interaction degree such as text input and document editing if they are used along with on-screen virtual keyboards. Typing speed can be further increased if word-suggesting software is used.

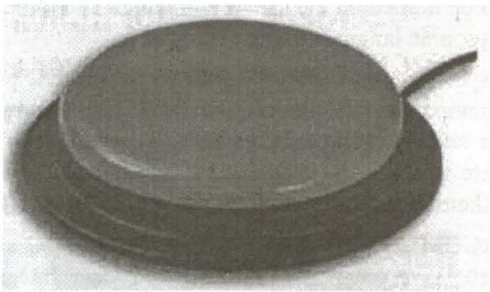

**Figure 1 – A hand-operated switch.**

Other important factors in user interface design for persons without disabilities must be kept in mind too. These factors are easy and immediate perception of the state of an application and feedback effectiveness. The user must effortlessly be aware of the state of the application, what commands are available and the purpose they serve [Nielsen94]. The interface must be such that users can immediately recognize changes to the interface brought about by the execution of user commands [Nielsen98].

These requirements turn out to be critical in user interfaces designed for handicapped persons. Interfaces must be able to supply the stimuli that in every day's life are provided by therapists, educators and family relatives and, like them, pay attention, promote communication and reward results, even when communication fails.

All this means that the design of user interfaces for handicapped persons must support:

- User variability. Interfaces must provide the means for user adaptation (size, color and number of icons and objects on the screen, etc.).
- Input from a wide range of input devices and related supporting software.
- A wide range of output modes that combine graphics and sound, including synthetic speech output, which adapt to the user profile.
- Minimal user interface design and other interface design good practices [Nielsen98] that do not leave out that some users need richer interfaces.
- Means to promote user interaction (communication), retain user attention and keep them motivated to communicate.
- Strong feedback mechanisms that stress results and changes to the user interface, and provide rewarding schemes.

This meant that INTERCOMUNICANDO had to produce a suite of highly configurable applications and tools that could run on off-the-shelve hardware with the necessary peripheral devices upgrade to meet user psycho-motive impairments. These tools should enable educators and therapists to record and assess user progress and help them on such tasks.

Last, but not the least, there was the play or game factor. Previous experience pointed out that users would be more prone to engage in communication if the communication environment was presented as a playing environment rather than a formal communication environment.

## 3. PICTOGRAPHIC LANGUAGES

The main objective of INTERCOMUNICANDO was to provide computer-assisted communication between severely handicapped persons and relatives and therapists using pictographic languages. Among the early requirements that were identified was the need to support more than one language since field experiment subjects had a background on several different pictographic languages.

Therefore, INTERCOMUNICANDO needed to support languages such as PIC (Pictogram Ideogram Communication, [Maharaj]), PCS (Pictographic Communication System, [Johnson97]) and Makaton [Makaton]. These languages are based on vocabulary sets where words and

concepts are translated into symbols (pictograms) printed on tables or communication books.

The PIC language uses close to 2100 terms and 900 pictograms. However, most have not yet been translated into Portuguese. Therefore, the Portuguese PIC version is reduced to approximately 400 pictograms. PIC is the language of choice of speech therapists, but does not specify any method on how to teach the language. Therapists and educators are free to devise teaching strategies for different persons.

The PCS language contains some 3200 symbols. As with PIC, it does not suggest any language learning method.

The Makaton pictographic language has a Core Vocabulary that specifies 8 learning levels and provides a common background that fits most user needs. Supplementary words can be selected from Resource Vocabulary sets to suit particular needs. In all, there are more than 16,000 terms in the complete Makaton set of symbols, but current language releases are limited to approximately 4000 terms. Unlike PIC and PCS, Makaton defines a method for learning based on the 8 levels of the Core Vocabulary that take learners through stages of increasing semantic complexity and number of words.

AEIOU supports these languages in a transparent way through XML descriptions of the languages' sets of symbols. Upgrades and corrections, as well as new pictographic languages are smoothly integrated with the system by adding or replacing the XML files describing the languages. An editor allows therapists to create and edit reduced language versions to suit particular user needs.

Figure 2 shows one sentence expressed in the three pictographic languages currently supported by AEIOU.

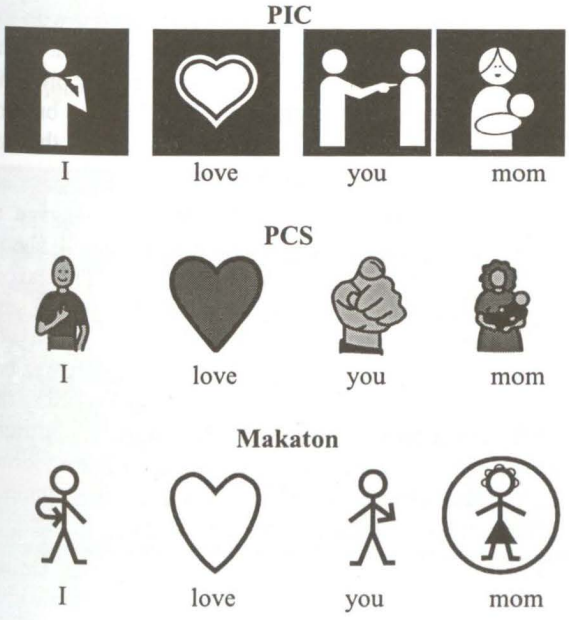


**Figure 2 – A sentence in the PIC (above), PCS (middle) and Makaton (below) languages.**

## 4. GAMES AND AGENTS

Most of the target users of the INTERCOMUNICANDO project were severely handicapped persons with cerebral palsy. This means that their ability to talk and move is very limited. Such persons require constant support from therapists, educators and relatives whose task is twofold. First, they must keep the persons in their care interested and motivated in the tasks to perform. Second, they must teach how to perform these tasks.

One strategy often used by educators and therapists is to carry out all tasks as if they were games. This is a very successful strategy, especially if games are simple. For this reason, INTERCOMUNICANDO decided to transpose this successful strategy to all its applications.

Application support of the role of therapists and educators can be implemented in many ways. One way is to implement such support as part of each and every application. However, this complicates the design of all applications and prevents them from being modular.

An alternative is to use autonomous agents acting as tutors that are able to show body expressions through animation and can produce spoken output either from text or from sound files. Autonomous agents [Bradshaw97] can be programmed to acquire changes (or absence of changes) in the environment, update their internal emotional state, make decisions according to rules and display external reactions. This way, agents expressing themselves externally by acting characters can be used to retain users attention, keep users motivated to perform tasks and reward user actions.

Programming an autonomous agent can be done regardless of the applications it will be used with. An agent can retain the same external appearance when used with a suite of tools and applications and thus "keep company" with the user.

INTERCOMUNICANDO selected to use autonomous agents whose external expression uses Microsoft Agent [Microsoft98a, b, c] because it allows:

- A large number of different characters
- A wide variety of body expressions
- Text-to-speech engines supporting national languages

However, MS Agent shows some limitations to its degree of animation expressiveness and quality of speech output, particularly in the case of the text-to-speech engine for the Portuguese language, which has a strong Brazilian accent. Nevertheless, as trials showed, users relate easily to the agent characters, keep on being interested at all times, and show progress in the tasks they were asked to perform as long as the agent's character is on the screen.

## 5. TYPES OF APPLICATIONS

Given the user requirements, INTERCOMUNICANDO could not restrict itself to develop and deploy communication applications alone.

In fact, users must learn the PIC, PCS or Makaton pictographic languages, and how to use computers and their input and output devices. Moreover, educators and therapists need tools that enable them to configure and update the user environment (user profile) of a given user and monitor his/her progress. They need also to produce individually tailored sets of symbols.

Therefore, INTERCOMUNICANDO developed a suite of integrated applications as follows:

- **Communication application (Comunicando)**. This is the core application that enables users to compose sentences on the screen and talk to each other.
- **Learning the Language application (Game of Words)**. This application lets users get familiar with language symbols, spoken words and text, matching text, sounds and symbols. This application has been designed as a game.
- **Training on computer usage (TIC-TAC-TOE Game)**. This application was designed to let users get acquainted with the use of computers and interfacing devices. The application implements a simple game (Tic-tac-toe) that makes users familiar with the interaction schemes that will be used by all other applications.
- **Table editor**. This tool was designed to let therapists and educators design sets of pictograms for a user in particular and add new symbols (e.g., subject's or parent's photographs) to the set.
- **Administrative tools**. These tools provide user profile management and adaptation to the user (e.g., input device configuration, presentation layout, language level choice) as well as user session recording, and user progress assessment.

## 6. METHODOLOGY

Given the fact that normal conversation could not be carried out with the end users, the usually accepted methodology for the development of an application could not be followed, especially in what regards requirements collection and identification. Some requirements might be (and in fact were) identified at the start of the project through interviews with therapists. But since the therapists involved were not conversant with information technology, these were of limited help.

INTERCOMUNICANDO had to gather user requirements incrementally by applying a methodology based on incremental prototypes to circumvent these limitations.

First, some rough prototypes for the communication tool, the game of matching words and the Tic-tac-toe game were developed and tested. Two alternatives were considered for each of them. These prototypes were mainly implemented in HTML to make it possible to quickly change them even during field trials.

With the knowledge gathered from early prototype trials, it was possible to advance to a second series of prototypes. These were much more elaborate prototypes that already looked close to the final solution. However, the rationale behind the early prototypes was kept: implement prototypes in a way that they could be easily changed as field trials continued.

During this second phase, the prototype of the Tic-tac-toes game was extensively used to determine the user model parameters and was the subject of many incremental versions as new parameters were identified and brought into the model. The other prototypes (communication tool and table editor) followed these developments.

Final implementation began with the design and implementation of INTERCOMUNICANDO tools as components of an integrated solution. This shared among components such characteristics (and code) as configuration and interaction strategies (e.g., sweeping mechanism).

## 7. PROTOTYPES

### 7.1 Early Prototypes

Two prototypes for the communication tool were developed. Prototype A allowed users to compose sentences with PIC symbols in two operating modes: standalone or two-way communication. In standalone mode (Figure 3) users compose sentences by picking symbols from a scrollable list of symbols at the center of the screen. Six large buttons above the list select which of six color-coded lists of symbols is shown on the interface. These color codes are the ones used by therapists to denote persons, verbs, nouns and social terms.

Symbols are added to the sentence bar at the top of the screen as the user picks them from the active list. The bar at the bottom of the screen offers suggestions for the next symbol to pick. Users are free to select symbols from the suggestion bar or pick them from the active symbol list.

Symbols are shown in reverse video mode when the cursor hovers above them and the words associated with the symbol can be heard when sound output is enabled. Users can also hear the sentence on the sentence bar by pressing the speaker button on the right of the bar. The two buttons on the left of the sentence bar allow deletion of the last symbol in the sentence or of the whole sentence.

In two-way communication mode, two users engage in conversation by exchanging sentences. Figure 4 shows the interface layout seen by the two users. The layout differs from the standalone layout in that the symbol suggestion bar was moved to the left hand side of the screen and that the lower part of the screen shows a sentence bar with the last sentence sent by the other user. Pressing the speaker button on the right of this bar starts sound transcription of the sentence. The button with a letter icon at the top right corner sends the sentence on the sentence composition bar (on the top) to the other user.

Figure 5 shows the user interface of prototype B. Unlike prototype A, prototype B lacks two-way communication capabilities but provides more sentence editing capabilities than prototype A. With prototype B, users can insert and remove symbols from the sentence bar at the bottom of the screen. Default symbol insertion at the end of the

current sentence can be overridden if symbol selection is preceded by the selection of a bar separating two symbols on a sentence. Symbol removal applies the wastepaper basket metaphor.

Prototypes C and D were built to test two solutions for the user interface of the Learning the Language tool. Figure 6 shows the user interface of prototype C. Users pick a word from the list of words on the right of the screen and then try to match it with a symbol from the symbol list show on the left. The sound of the word is output when the cursor hovers above a written word or a pictographic symbol.

Prototype C was highly configurable since not only the number of words and symbols presented at any one time on the screen can be separately set, but also the size of symbols and written words can be set according to each user's profile. If the number of words or symbols is larger than the number that can be simultaneously presented on the screen, the lists of words and symbols scroll automatically after a time interval defined by the user profile.

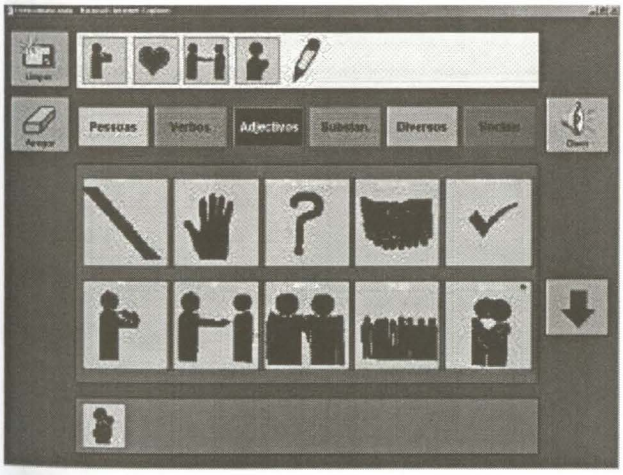


**Figure 3 – User interface of prototype A for communication in standalone mode.**

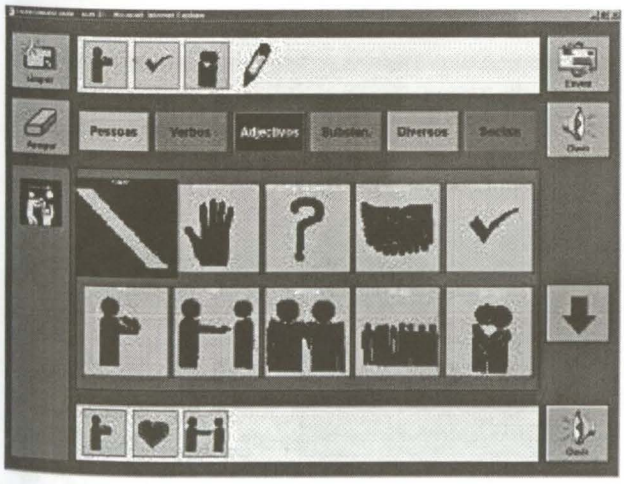


**Figure 4 – User interface of prototype A in two-way communication mode.**

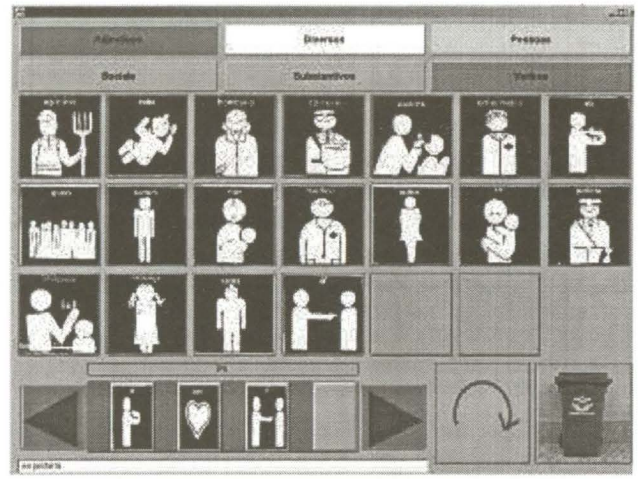

**Figure 5 – User interface of prototype B for communication**

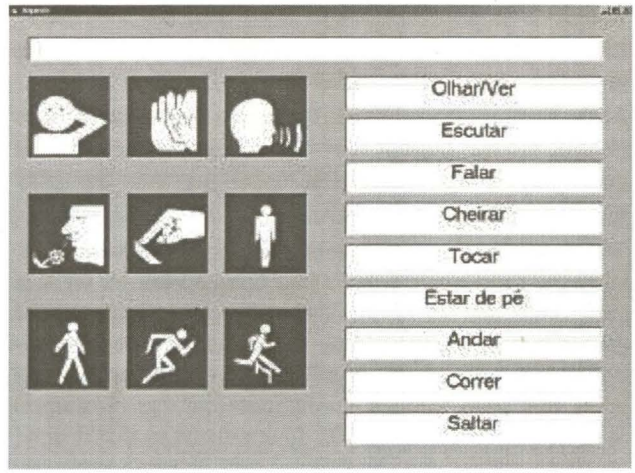


**Figure 6 – User interface to prototype C implementing a matching words game.**

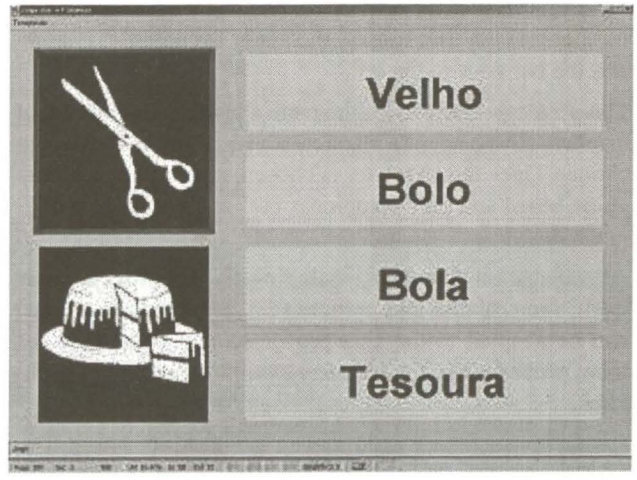


**Figure 7 –User interface of prototype D for the matching words game.**

The user profile can be modified at any one time through a dialogue box that is hidden from the user for security reasons.

Prototype D was built along guidelines that were similar to those used to build prototype C, but its main intent was to test the dialogues leading to the start of the game and all security implications involved, rather than the game itself. Figure 7 shows the user interface of prototype D.

### 7.2 Agent Prototype

The agent prototype was designed and tested to assess the effectiveness of autonomous agents as (partial) substitutes of educators [Bradshaw97] and as a test bed for user input solutions, the agent itself and the tic-tac-toe game through which users get acquainted with the use of computers. The test had to be simple so that results could easily stand out and that the prototype could be modified on location [Pereira01]. This prototype was also used in the second series of prototypes, the difference being the number of parameters of the user model. The prototype was developed in HTML and JavaScript and runs under Internet Explorer. This way, the prototype could be easily upgraded, even during field tests.

At the core of the prototype is an agent that knows how to play tic-tac-toe, but not too well. A random factor in the game-playing agent makes it make mistakes and play wrong moves.

The tutoring agent monitors the sequence of moves, knows a good move from a bad one and knows when a game ends and its result. It also keeps statistics on the games played so that it may define and update its emotional state. The agent uses MS Agent to externally express this state through animations and speech output. Speech output is divided into four categories that depend on game status: win, loss, draw and game in progress. Each category is in turn divided into 3 sections. Each section of a category represents a value of the agent's emotional state. A "Happiness bar" expresses the agent's emotions. In a series of tic-tac-toes games, the agent becomes happier if the user wins, and the bar progresses to the right. If the user looses, the agent becomes less happy and the bar goes to the left.

The prototype starts with the page shown on Figure 8 that displays all the agent's characters available for the user to choose. Once the character is chosen, a new page with the game board and the "Happiness bar" is displayed, as Figure 9 shows.

All objects on this page, including the agent's character itself, are scalable and colours (e.g., background colour) can be adapted to the user profile so that users may see them properly since most users exhibit visual acuity problems.

Earlier experiments used screen pointers to assess user preferences for object sizes. The tests showed that large screen pointers are necessary and, that, contrarily to common belief, screen pointer animations may ease the user task.

As Figure 9 shows, almost all window tools were removed from the window where the game is played. This maximizes the area available for the game, prevents the user from being distracted and avoids any inadvertent resizing or destruction of the window.

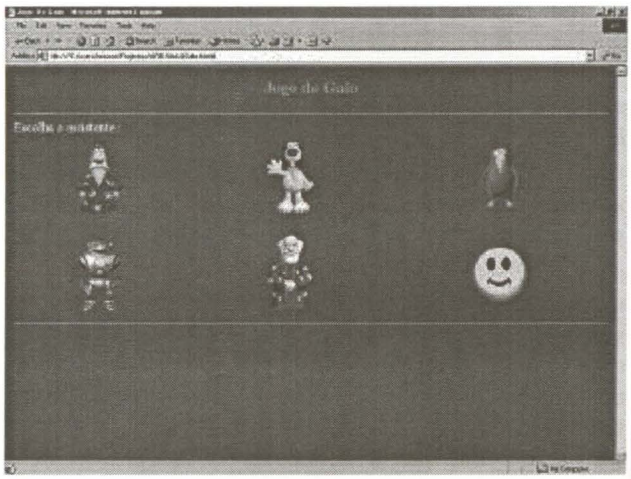

**Figure 8 – Start page of the agent prototype.**

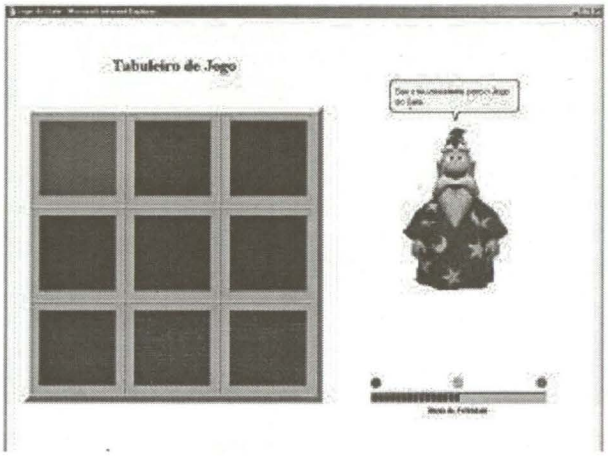


**Figure 9 – User interface of the agent prototype to play tic-tac-toe.**

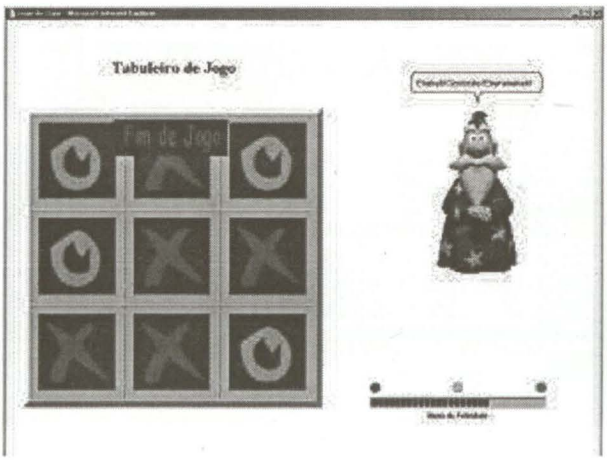


**Figure 10 – The agent congratulating the user after the user wins a game.**

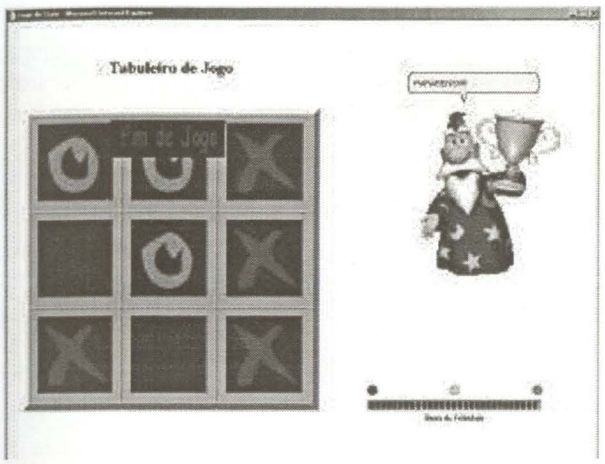


**Figure 11 – The agent congratulating the user after the user wins a series of games.**

At the beginning of the game, the tutoring agent shows up on the screen, explains the game and draws the user attention to the "Happiness bar" and that the user can increase the agent's happiness by winning several games in a row.

Afterwards, the tutoring agent comments every move on the game. Comments include sentences to keep the user focused on the game. The agent waits when the user stops playing and, after a time, starts prompting the user to continue playing.

If the user wins a game, the agent becomes happier and congratulates the user effusively (see Figure 10). The agent expression goes overboard with congratulations after the user wins a series of games that make the agent's "Happiness bar" reach its maximum. Depending on the agent character chosen, the agent may even present the user with the winner's cup, as Figure 11 shows.

The agent also comments when the user loses or draws but keeps on trying to motivate the user to keep playing and win.

## 8. INTERMEDIATE RESULTS

The early and second phase prototypes were field tested [Brisson01] to:

- Determine user requirements and problems of the user interface to enable better design of all applications and tools of the AEIOU system.
- Assess user acceptance of the agent and its effectiveness in providing adequate feedback and user motivation.

Field tests were carried out with a heterogeneous sample of users that showed a split into two groups: users that understood the goals and required almost no help, and users who required help.

Users who did not require any help showed great motivation to play and paid attention to the games and the tutoring agent. These users understood the meaning of the icons on the screen and played the games easily. The ease of use demonstrated by these users showed also that both the games and the agent might have been more elaborated for these users.

The users who required help had the common characteristic of carrying very deep disabilities, especially in terms of mobility and control of the hand and head. Although these users showed great willingness to play, they lacked concentration and showed little understanding and mastering of the tasks to perform to play the game. The main constraints to their performance were the inability to use the input devices available and lack of coordination between on-screen pointer displacement and input device manipulation.

The results obtained with the second group of users in the field tests of the agent's prototype provided invaluable data on user requirements and many suggestions for future improvements.

The first conclusion was that all applications had to provide a range of levels of difficulty and alternative ways to perform user input and user tasks.

The second point was that applications should be highly configurable and adaptable to each user. Input tasks should be made simpler for users with greater handicaps. Applications should support a wide spectrum of input devices, ranging from mice and joysticks to the use of sweep techniques under switch control.

Another point was the need to make the tutoring agent even more active to stress out moves or actions of the user or the computer. Depending on the particular user, the agent should even be able to make suggestions. This was particularly true in the case of the communication tools (see above) when mechanisms for word suggestion (as in prototype A) were used.

One other point was the need to filter input device generated events. The tests showed that users may inadvertently press buttons or switches twice in a row instead of just once or keep the same buttons and switches pressed for a long time, thus generating an unwanted sequence of events when there should have been only one event.

The main result arising from field tests was that all applications and tools had to support a wide range of configuration parameters in order to be able to support the wide range of user variability. This support required the development of additional tools to manage user profiles.

Another important result was the need for more functionality from the tutoring agent. This can be achieved with the adoption an agent framework like the APE framework for autonomous agents [Cabral01] that was developed to introduce complex behavior and expressiveness to pedagogical agents.

## 9. THE AEIOU SYSTEM

With the knowledge gathered from the field tests with the prototypes, it was then possible to advance to the design and implementation of the AEIOU system and its components. The system is divided into two groups of components: the components for the system's end users (handi-

capped persons) and the components for therapists and system administrators.

The early components, available in end user mode, provide the means to let end users into the system, identify them and make them choose the agent that will keep them company while they play or communicate. These components of the system include the Comunicando tool for pictogram-based communication, the Game of Words to learn pictographic languages and the Tic-tac-toe game to enable end users to get acquainted to the use of computers.

The later components, available in restricted mode, are meant for therapists and system administrators and provide tools to register users into the system, configure end user profiles, inspect end user activities results and edit symbol tables matched to specific end users.

### 9.1 End User mode

In end user mode, AEIOU makes available to end-users its communication and game playing components, and registers user actions. Therapists can later assess such records in restricted mode.

The first thing that is shown to a new user is the panel depicted on Figure 12 where the user has to select the external representation of the agent that will be present in all his/her activities. After this selection, the user will be asked to identify him/herself in the dialogue shown on Figure 13. The agent will always prompt and stimulate the user to make a choice and will guide him/her through these operations. Sweeping is the default interaction mode, but mouse operation is also available.

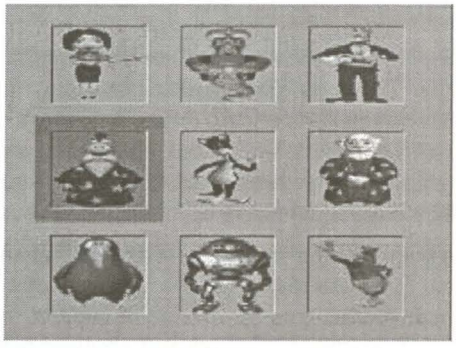

**Figure 12 –Dialogue panel to chose the agent**

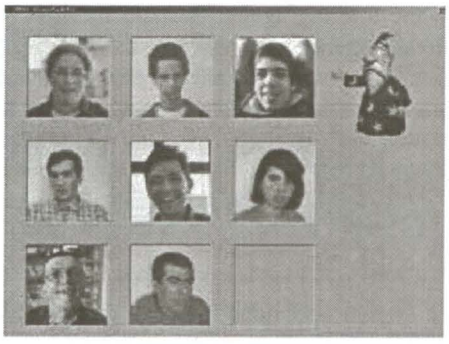

**Figure 13 – User login panel (end user mode)**

Once the user has been identified, the user profile is loaded into the system setting the sizes, colours, timings, identifiers and interaction strategies of the user. The user can then pick the application to be run from a panel (see Figure 14) showing the applications that are available. Figures 15 through 18 show the new layouts that were implemented.

The Tic-tac-toe game (see Figure 15) does not show many differences from its prototypes since it was one of the most elaborate of them during the early development stages. The main differences are the full use of the screen, a higher number of configuration parameters and significant changes that were introduced to the visual and audio feedback.

There were a lot of significant modifications that were introduced to the Game of Words (see Figure 16), which shows a new layout where the most significant differences are the space that was created for the agent, and the presence of the emotional state of the agent and the "Happiness bar". The game itself now allows 6 levels of increasing difficulty that starts at the lowest level with one pictogram and two words and increases them up to six pictograms and four words. Audio feedback that echoes words when a word is highlighted is now provided.

It is now possible to change the user profile at any one time during the play of the above two games. Figure 17 shows the dialogues to make such changes. These dialogues are hidden from end users and can only be accessed by a therapist knowing the right key combination to make the dialogues show up on the screen.

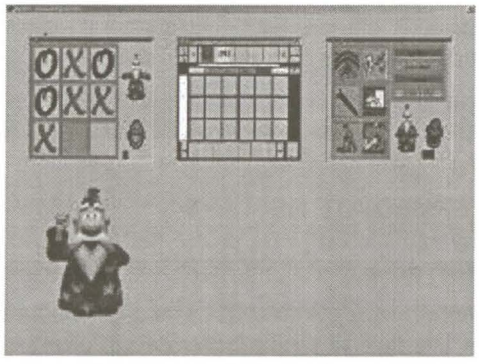

**Figure 14 – End user mode dialogue to select a component**

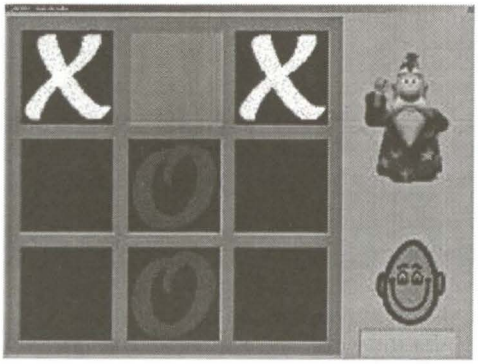

**Figure 15 – AEIOU TIC-TAC-TOE game layout**

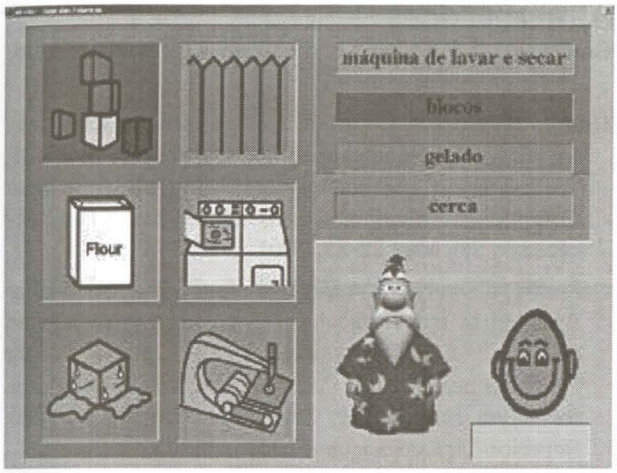


**Figure 16 – AEIOU Game of Words layout**

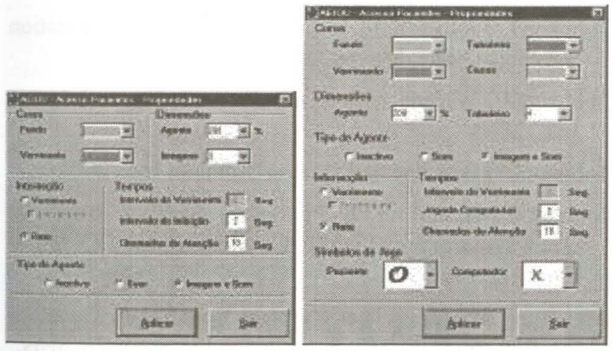

**Figure 17 Dialogues for runtime configuration of Game of Words (left) and TIC-TAC-TOE (right)**

**Figure 18 – AEIOU Comunicando tool layout**


**Figure 19 – Restricted mode toolbar makes its components easily available for selection**

The new layout of the communication tool (see Figure 18) resulted the experience gained with prototypes A and B and brings together most of their best characteristics.

### 9.2 Restricted Mode

Restricted mode is reserved for therapists and AEIOU system Administrators that must identify themselves to the system. After a successful login, a tool bar is shown on the screen (see Figure 19). The toolbar allows users to start the Table Editor, administer user profiles and users, browse the contextual help subsystem and exit restricted mode.

The Table Editor (see Figure 20) allows therapists to compose customized tables that are adapted to the proficiency and learning capabilities of each end user.

User registration and maintenance creates complete user data sets that are more than user registers in the way that they include the user's clinical records. It is also possible to access and modify user profiles and configurations as well as the statistical data gathered during end uses sessions (see Figure 21). This constitutes an invaluable tool for therapists that can assess end user performance and progress, as well as other clinical data.

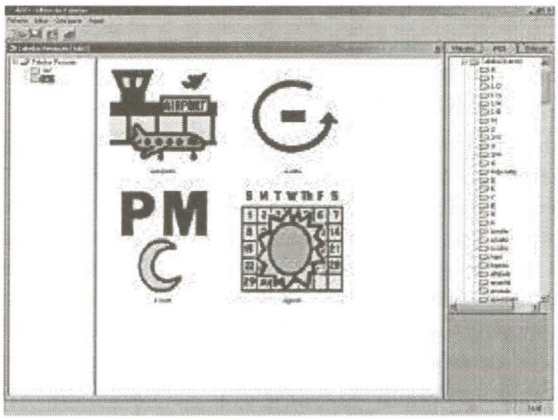


**Figure 20 – The table Editor layout showing a table in composition (center)**

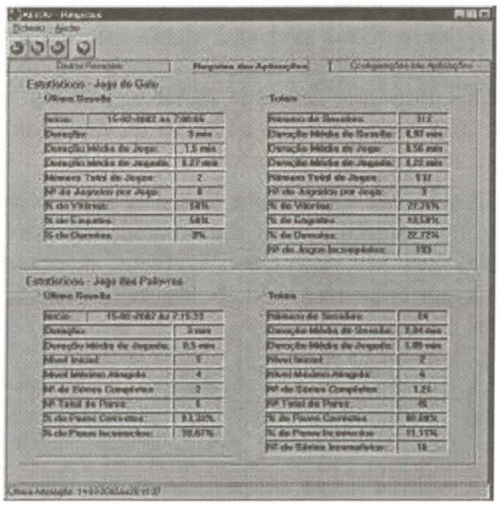

**Figure 21 – User statistics record**

## 10. CONCLUDING REMARKS

INTERCOMUICANDO has successfully developed and tested the AEIOU system for computer-assisted communication between severely handicapped persons and therapists and relatives using pictographic languages. The system transparently supports three pictographic languages and can be extended to support yet some more. AEIOU provides tools for end users to learn how to interact with computers and to learn those languages by means of games. Agents that fulfil therapists and educators' tasks in providing feedback and motivation to end-users support all AEIOU applications.

AEIOU provides tools for user registration and recording of end-user activities that can later be analysed by therapists. These have also means to examine user records and clinical data.

During the project, a large number of the parameters of the extended user model were identified through extensive experimentation with prototypes. Such identification was carried out this way because it is not possible to carry normal requirement discourses with the end users given the high level of disability exhibited by most of them. The user model was therefore heuristically built and it now remains to turn the data gathered into a comprehensive user model of severely disabled persons. This will be carried out by RECRIA, the project that will follow INTERCOMUNICANDO.

At the same time, experimentation with AEIOU will continue to collect yet more data on user characteristics and ranges of values for the user model parameters already identified and as well as new ones. AEIOU needs such data to evolve and be able to provide tools to help therapists and educators in assessing user progress and customising user profiles. The data collected will also help in identifying pictogram sequences used in sentences to build next-symbol suggestion algorithms that will enable users in speeding up communication.

RECRIA will also take AEIOU beyond its current restriction to LAN operation. As AEIOU evolves, it is envisaged to operate it on a wider scale to let resident users communicate with relatives and friends that are at home or other users at other institutions, including day-care users. This poses new demands, including security, which will be addressed with the adoption of emerging technologies, like the .NET framework.

RECRIA will also experiment with new agent technologies to free AEIOU from the limited expressiveness available from MS Agent and synthetic speech output which is currently restricted to language accents, e.g., Brazilian accent.

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