Overcoming Communications Difficulties
Platform of Alternative Communication

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Abstract
We present in this paper an alternative communication system for disabled persons. Alternative communication primarily relies on an alternative access to the computer and has to take into account the communication situation together with the user's characteristics. The PCA system (where PCA stands for Alternative Communication Platform) proposes various techniques and accessibility methods to assist the user in verbal and non-verbal communication. The homogeneity of the system allows a comfortable switch between the different communication techniques, both in terms of accessibility and message style. PCA makes use of generic resources: a French lexicon of more than 300 000 forms with intrinsic frequency of occurrences and morphosyntactic information and a pictograms base of 750 icons, allowing an efficient basic communication. The PCA system is moreover evolutive. Thanks to its training module, the system builds a user's model by learning personal habits during each use of the system. PCA also includes a tool allowing the customization of the organisation of the pictogram base and the addition of new icons to the user's personal lexical material. The evolutivity of the system also suggests that PCA can be used as a re-educational tool. The platform has been developed by a consortium of laboratories and French associations for disabled persons. Keywords : augmented communication, handicap, software.

Résumé
L'aide à la communication pour personnes handicapées doit prendre en compte les besoins des utilisateurs en général, mais également pouvoir s'adapter aux diverses situations de communication rencontrées au quotidien par l'utilisateur et à l'évolution (positive ou négative) de ses capacités. Le système PCA (Plateforme de Communication Alternative) est un logiciel d'aide à la communication verbale et non verbale caractérisé par l'homogénéité de son utilisation quel que soit le moyen d'expression choisi. Le système est paramétrable en fonction des modalités de contrôle maîtrisées par l'utilisateur et permet l'utilisation simultanée de plusieurs de ces modalités. Le principe d'homogénéité de la PCA permet de plus un passage aisé d'un contrôle à un autre. Les ressources utilisées sont génériques : un lexique du français très couvrant donnant les fréquences et les caractéristiques morphosyntaxiques de chaque forme, mais également une base de pictogrammes permettant une communication élémentaire très efficace. La PCA est un système évolutif qui, grâce à son module d'apprentissage, construit au fur et à mesure de l'utilisation un modèle utilisateur. De plus, l'utilisation des pictogrammes est contrôlée à l'aide d'un éditeur permettant de personnaliser l'organisation de la base de pictogrammes ainsi que d'ajouter du matériel lexical propre à l'utilisateur. L'évolutivité de ce système lui confère un caractère réversible : il est en effet possible de concevoir son utilisation en termes d'aide à la rééducation.

Mots-clés : communication assistée, handicap, logiciel.

1. Introduction

By alternative communication we mean a series of tools designed to help disabled people with motor and speech disabilities caused by paralysing neuro-degenerative disease or vascular brain accident. These patients can only control a few muscles (such as an eye-lid) and can no longer speak.

For other pathologies, such as some types of aphasia, linguistic and cognitive capabilities are affected and alternative strategies such as non-verbal communication using icons must be used. The aim of this type of system is to allow the user to improve or even to re-establish communication with his entourage enabling him to write messages, to control a system of word synthesis or to point out objects or actions.

The effective needs of the users in an actual situation of communication must be taken into account, and multiple modalities of interaction must be integrated into the aid to communication and environment control (see Vaillant 1997 and Brangier & al. 2000)

Communication aid for the disabled is a major problem, but one which can benefit from the technological maturity of work carried out in the fields of linguistics, ergonomics and cognitive psychology. The solutions found up to now are not entirely satisfactory, especially as far as interaction between the disabled user and his human or electronic environment is concerned. (See Maurel & al. 2000)

A few systems of communication aids in French are now available on the market. For verbal communication we can take as examples the WiViK, a virtual keyboard with word prediction and optional scrolling system which also allows the control of the operating system; Eurovox Suite, virtual keyboards and word prediction based on a dictionary containing 35,000 forms.

For non-verbal communication there is Clicker 4, a non-verbal system of communication based on icons which integrates a rudimentary reformulation, Axelia, designed for young children with cerebral motor diseases and aphasia, and which is accessible via a graphical developed user interface, which bases its reformulation on the applicative and cognitive grammar model (see Abraham 2000 and Abraham 2006).

Finally there are a certain number of experimental applications which have been developed in the academic environment: for example Vitipi (Boissière & al. 2000), HandiAS (Le Pévédic 1997) or Kombe (Pasero & al. 1995), but these systems have not really been made available to the general public. Let us give a special mention however to the Sibylle system (Schadle 2003, Wandmacher 2007), a spelling keyboard with a specially designed scrolling facility and equipped with a very efficient word prediction engine, which will be freely available very soon.

The alternative communication platform (ACP) has been developed in the “Word and Language Laboratory” by a multidisciplinary team comprised of computer and linguistic researchers, as well as cognitive psychologists, ergonomists, electronics engineers, doctors and physiotherapists and with the cooperation of health centres and associations for disabled people. Available since early 2004 the ACP is characterized by its homogeneity, its genericity and its evolutivity, three key points in any assisted communication system (Copestake 1997). The ACP software allows the assisted composition of messages according to two principal modes: the verbal mode and the non-verbal mode (Blache & al. 2003, Bellengier & al. 2004). These two types of composition are accessible via either the keyboard, the mouse or a procedure of scrolling controlled by a binary sensor according to the degree of motricity of the users (Blache & al. 2004). (a demonstration version of the ACP is available on http://www.aegys.fr/)

In verbal mode, composition is carried out using a virtual static spelling keyboard complemented by a dynamic keyboard of word proposal. The prediction engine built into APC uses an extensive French word lexicon and proposes a contextual prediction which includes information on morphosyntactic traits associated with what is in the lexicon as well as a user's model which takes into account the language habits of the user as it goes along.

In non-verbal mode, composition takes place with the help of a keyboard consisting of icons. The general icon base shared by all users, consists of around 750 pictograms which have been designed from a graphic semantic chart developed by the Word and Language Laboratory. It covers varied communicational needs. The base has around 200 verbs (the most common verbs and also specialized verbs such as those used in the medical field), around 200 common nouns (that designate objects, places, people, etc.), and around 50 adjectives, pronouns, adverbs, determinative words, the most common prepositions, and numbers. The base also consists of icons representing letters and phonemes which allow the creation of alphabetical or phonetic keyboards. Each user will then be able to create and add, via an easily accessible interface, his own icons (from digital photos for example). The system incorporates a module of iconic reformulation which generates, from the sequence of composed icons, a sentence in natural language which is syntactically and semantically correct (Blache & al. 2007).

In this article we propose to describe the properties of the ACP communication system. In section 2, we will present the different modalities of accessibility which allow the disabled user to interact with the system. In section 3, we will describe how the spelling ACP works. The iconic ACP, whose interface is devoted to non-verbal communication, is presented in section 5.

2. Modalities of accessibility and interaction with the system

2.1. The accessibility modalities

The underlying problematic to the control of the computer environment by persons with motor deficiencies is this: how can persons who are physically incapable of manipulating the keyboard or the mouse of the computer, access the different services and applications distributed by the software publishers? The solution that we have developed puts into perspective in a coherent way the control devices developed with the different accessibility modalities.

In the fields of software ergonomics, the keyboard device and the mouse device play distinct roles.

- The keyboard device is needed each time the user wants to bring out a text or a sequence of characters (for example, entering the address of a web site into the navigation window on the Internet, or get out the name of a file, etc.) Most of the applications distributed on the open market necessitate the use of the keyboard (except perhaps for software videogames). Some applications, through keyboard short cuts, give access to operations commands (for example selecting a command in a drop down menu).
- The mouse device plays a double role. On the one hand it allows the positioning of the mouse cursor on the screen (pointing mode) and on the other hand the carrying out of operations on the

object pointed at by activating the buttons of the mouse (by clicking on the mouse). The actions initiated by the mouse are multiple: the opening of an application, the selection of a command on a drop-down menu, the release of an action by clicking on a button, the selection of a fraction of a text or part of the screen, etc. Given that the software publishers have given their preference to software control via graphic interfaces, one can rarely find today any application that does not necessitate the use of the mouse device.

Three modalities of accessibility are available to control ACP software according to each user's degree of motricity. Whatever the means of accessibility used to compose e message, the general usage principles of ACP and of its graphic interface remain unchanged. Thus, a user who needs to change the modality of accessibility as his pathology changes will not have to re-learn how the software works (this is the case, for instance, of those users who have a neurodegenerative disease or of those who are in a phase of remediation). The three modalities of accessibility installed in ACP are as follows:

- The "keyboard": The user interacts with the computer by using the physical keyboard of the computer, that is to say by pressing on the letters and the function keys of the keyboard (this movement can be slow), to select the key (a pointer may be used to reduce uncontrolled trembling) and to press on the key. The user can then carry out all word processing types of operation. The operations normally activated by the mouse device (pointing and mouse clicks) have to be carried out in an alternative way. In order to do this, a virtual mouse, that is to say an application controlled by the aid of the keyboard keys which allows the movement and positioning of the mouse cursor on the screen, must be used.
- The "mouse": The user can control the movement of the cursor of the mouse on the screen, by using the standard computer mouse, a trackball or a joystick. This modality can be proposed to a user who still possesses motricity of the wrist (even if this is very little). Alternative solutions, as for example, associating the movement of the mouse pointer to the head movement of the user filmed by a webcam, can be retained as a means of pointing. The activation of mouse clicks is carried out by means of a virtual keyboard whose keys are selected by a binary interaction activated by a captor or a contractor. In this case, the user can control an intentional movement (pressure of a finger, a breath, blinking of an eye etc.) detected by the captor. A mode to automatically select, after a certain lapse of time, a virtual key, can be installed. In the same way, word processing operations will necessitate the use of a virtual keyboard allowing the selection of alphanumeric characters.
- "Scrolling": The user can control an intentional movement, which is transformed into a binary interaction. The computer environment is then controlled by virtual keyboards which are displayed on the screen. A cursor moves along the keys of the virtual keyboard. Whenever the cursor passes over the desired key, the user selects the virtual key by activation of the captor. This modality of accessibility necessitates the development of a virtual mouse and of a keyboard comprised of virtual letters which function according to the principle of scrolling.

In this way, our multimodal control platform of the computer environment (ACP Pilot) integrates, whatever the modality of accessibility used, virtual keyboards playing the role of the computer's keyboard and mouse devices.

- A virtual keyboard of letters functioning in scrolling mode or in mouse mode.
- A virtual mouse functioning in scrolling mode controlled by meta-events of binary interaction type.

These tools are completed by adequate material devices in terms of captors and are compatible for multimodal functioning. A more detailed presentation of the ACP Pilot is made in Ader & al. 2007.

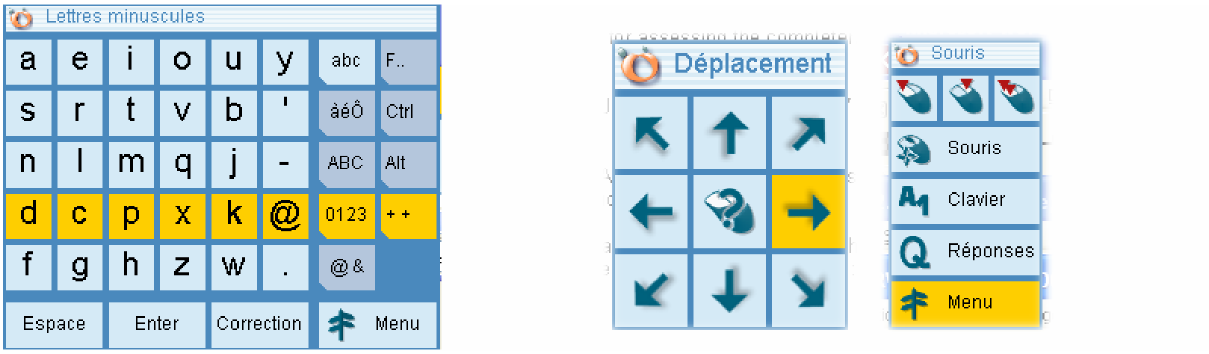

Figure 1: An example of virtual keyboards which constitute the ACP Pilot module of control of the computer environment. On the left is the virtual letter keyboard, in the centre, the keyboard allowing the movement of the mouse, and on the right, the virtual keyboard allowing the emulation of mouse clicks.

2.2. Interaction, with the system: the captors

In this section we shall overview various solutions available at the present time. We shall first present the movement captors which allow persons with reduced motricity to interact with the outside environment. Then we shall resume the software solutions proposed to serve as a substitute for the use of binary interaction devices.

2.2.1. Devices of binary interaction type

A certain number of electronic devices have been elaborated in order to detect the intentional movement that the disabled user can control.

- Contactor: the impulsion is created by leaning on this device (type "mushroom"). A very limited motricity is sufficient, but the user must be able on the one hand to control the movement (of his arm, foot etc.) and on the other hand to exert a pressure on the device. This type of contactor can be set and used in different ways: placed on a table, attached to a belt, fixed to the wheelchair (for example in a chin strap), etc.
- Captor of small movements: this is a device that is activated by a very small pressure. It is usually used to detect very weak finger movement. The device can be mechanical (a switch) or electronic (touchpad type).
- Captor of movement: these captors allow the detection of a tilting movement and can also be activated by acceleration. They are therefore useful in detecting head movement whether they be slow or fast, vertical or horizontal.
- Captor of vibrations: these piezoelectric captors detect vibrations of the surface on which they are applied. Applied on fixed zones of the skin, they can thereby be used to detect the contraction of certain muscles.
- Blinking captors: an infrared ray emitted by an optical fiber reflects on the eyeball and is in turn captured by the fiber. When the eyelid is down, the reflection of the ray is interrupted. And this activates a signal. This procedure has been developed and recently marketed by the company Tash Inc. (USA) and is called SCATIR.

- Blowing captor: the impulsion is activated here by breathing in or breathing out of a tube. The moment of activation can be regulated. This type of device is suitable for persons whose limbs are totally paralyzed, and with little motricity of the head. Most of the captors still need labial and tongue muscle control however.

All these captors are simple switches allowing the interruption or the flow of the electric current. The signal produced needs therefore to be transformed so as to redirect it to one of the classic devices of the computer. For this, specific boxes, with an adapted connection, are used. It is often difficult or even impossible, to connect several of these captors simultaneously.

2.2.2. Procedures necessitating software

A new generation of movement captors has recently been developed. These are procedures which use computer equipment in general use (joystick, microphone, webcam etc.) whose signals are captured via the non standard devices of the computer (game stick input, microphone input, webcam input) the signal is then processed by a software layer to produce meta events of the binary interaction type or movements in the plane (i.e. the events which serve to direct the pointer of the mouse on the screen).

- Generic microphone captor: this is a generic procedure developed by the Aegys company (France) which allows interactions such as sound or breathing as well as contact with the captor (a slight pressure will activate the interaction), eye blinking (detection of vibrations caused by the contraction of the orbicular muscle of the eye) to be picked up. As we have here a software solution, the parameters such as the threshold of detection, the sensibility etc. can be regulated. The basic signal is transformed by algorithms, which process the audio signal into meta events of the binary interaction type.
- Pointing procedure using video tracking: the principle here is to associate the movement of the mouse pointer to the movement of part of the body (usually the head and for some procedures, eye movement) placed in the field of a video camera. Several companies distribute this type of procedure (Tracker 2000 by Madentec Limited, USA; QualiEye by QualiLife SA, Switzerland; Visioboard by Metrovision, France; Quick Glance by EyeTech Digital Systems, USA, etc.), whose efficiency varies according to the quality of the image processing algorithms applied to transform the input video sequence into meta-events of the movement in the plane type.
- Movement captor using video tracking: the principle here is to associate to a specific movement (eye blink, hand movement etc.) the processing of an event of the binary interaction type. The company QualiLife SA (Switzerland) has developed such a procedure (QualiEye). The working of the device is however strongly interfered with by uncontrolled movements of great amplitude (for example by movements of the head in the case of eye-blinking).

3. Presentation of the spelling ACP

The spelling version of the ACP is principally destined for persons possessing a good mastery of the written word, but who suffer from severe motor disorders that prevent them from writing naturally. The problem first of all is to propose a solution that is adapted to each disabled user to enable him to direct the communication aid software. An evaluation of the user’s level of motricity is therefore fundamental and the choice of the right captors must take into account factors such as the failure rate, the level of cognitive load, the comfort, the speed and the fatigability of the user.

Figure 2: Interface of the spelling ACP

Besides this, the problem rests with the slowness with which written messages are processed (on average 1 to 5 words a minute on a normal keyboard (Wandmacher & al. 2006). The communication aid software must therefore propose to the user procedures which allow the acceleration of the writing process. In the following section, we shall describe the improved letter keyboard conceived to accelerate the processing of messages, and the strategy needed to be followed in order to write messages with the spelling ACP.

3.1. The letter Keyboard

The virtual letter keyboard is shown in figure 2. It is a static keyboard where the placing of the characters is optimised for the modality of scrolling accessibility. In this case, the keys are selected according to a line-column scrolling. Thus two interactions with the captor are needed to process a character, one to select the line where the key is situated, and another to select the key on that line. The access time is proportional to the sum of the position of the line and the column of the key in the keyboard (see for example Copestake 1997). The letters are arranged diagonally according to their frequency of use (for French), from the most frequently used at the top on the left to the least frequently used at the bottom on the right (i.e. two scrolling times are needed to access the letter a, three for the e and s, four for l, r and n…, nine for k and z). We have decided to change this organization slightly according to the frequency in order to be able to regroup the vowels on the first line of the keyboard.

The key called “end” is used to indicate the end of the processing of a word when a new word is added to the personal lexicon of the user. A system of tabs (the blue-grey keys at the bottom of the keyboard) allows the user to access other sets of characters. Thus he can access the keyboard of capital letters, that of the figures, of brackets and of mathematical symbols, that of accented characters and special characters.

So as not to have to change tab with each typing of accented or capital letter, the keys of this keyboard actually represent several characters. Key “e” for example allows the processing of the letter “e” or of its diacritics *è, é, ê, ë* or the character *E.* The difference between the different characters is detected automatically when the user selects the chosen word from the list of words proposed by the prediction engine. This mechanism limits the use of accented or capital letter keyboards when the user wishes to add new words to his personal lexicon. Moreover it enables the user who encounters problems of accentuation as he goes on to access the correct spelling of the word.

3.2. Writing messages

The dynamic word prediction keyboard is all important in the message writing process. On the one hand it represents fewer interactions and considerable gain of time, and on the other, considering the good coverage of the lexicon, consultation of the word list proposed, gives the user a procedure for verifying the spelling of the word he is writing.
The writing of a sentence is carried out word by word by using the propositions of the system. When writing a sentence, the following cycle of operations should be respected:

- Reading of the list of words proposed by the prediction engine;
- Selection of the word if it is on the list, the word is added to the sentence being written, and the writing of the following word begins; the addition of spaces between words and of capital letters at the beginning of sentences is carried out automatically.
- The word is not present in the list, addition of a letter to the word while it is being written; the operation must be repeated until the desired word appears in the list of proposals.
- At the end of a sentence, addition of a punctuation mark.

At any time, a correction key allows the user to cancel the operation or operations he has just carried out.
Once the message has been written, the ACP offers the possibility of reading the text aloud by voice synthesis, of memorizing the text in a file, of sending the message by e-mail or of carrying out editing operations on a part of the message.

3.3. Description of the word prediction engine

The word prediction system installed in the ACP uses a general French lexicon containing 320 000 spelling forms whose frequency of usage and associated morphosyntactic traits are supplied. A personal lexicon allows the user to add to the general lexicon by memorizing the unknown words that he writes. A “learning” module stores the sentences produced during the course of message writing and calculates the individual user’s frequency of usage. A module of morphosyntactic prediction then modifies these lexical frequencies according to the syntactic context of the word being written.

The system offers the user N proposals displayed in a dynamic keyboard (the number of proposals displayed can be modified, from 1 to 9). The list of words proposed changes each time the user selects a punctuation mark or a word in the proposal keyboard or adds a letter to the word being written.
When a new word or punctuation mark is selected, it is added to the context of the sentence being written (In the case of the beginning of a sentence, this context is reinitialized). The frequencies from the lexicon are initialized. The morphosyntactic prediction module modifies the frequency of each lexical addition according to the morphosyntactic traits that are associated to it, and taking into account the syntactic context of the sentence. The module that enables the user's already written sentences to be given more weight is then applied. Finally, in cases of elision, the frequencies of the written forms to be rejected are put on zero.
When a new letter is added during writing, two operations are carried out. The first is to put on zero the frequencies of the element corresponding to the previously shown proposal (and therefore not selected by the user) the second consists in applying a filter which eliminates all the elements which do not begin with the letters already printed.
For both types of events, the most frequent N words are then taken out on the base of recalculated frequencies and finally sorted in alphabetical order to be displayed in the proposal keyboard.

3.4. The general lexicon

The lexicon used by the ACP word prediction engine is taken from the DicoLPL (VanRullen & al. 2005). It is a very extensive French lexicon containing 440 000 different spelling forms. For each entry, DicoLPL supplies the spelling form, the phonetised form, the morphosyntactic category, the lemma and the frequency of usage. The frequencies of usage have been calculated on a corpus of around 143 million words taken from the Monde newspaper (VanRullen & al. 2005).

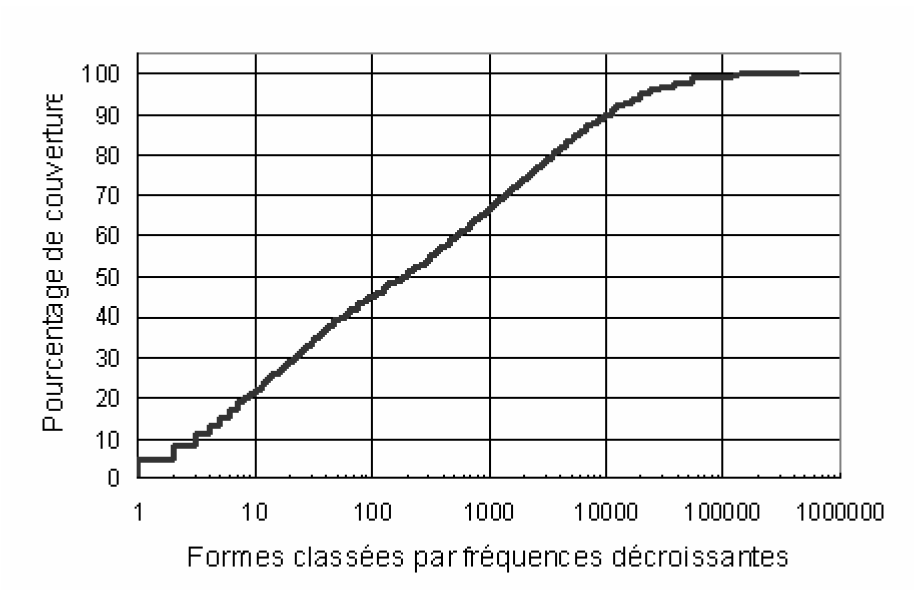

Figure 3: The covering level of the dicoLPL lexicon according to the N-first forms classified by decreasing frequencies

Figure 3 illustrates the covering properties associated to the DicoLPL lexicon. On the X axis, the forms have been classified by decreasing frequencies of occurrence. Form 1 therefore corresponds to the preposition “de”, this form appearing the most often in French , followed by the second most frequent form “et”, etc. On the Y axis the covering rate of n-first forms is noted. Thus the 10 most frequent forms constitute on average 21% of the terms in French, the 10 000 most frequent forms constitute on average 90% of the terms, etc. A lexicon limited to the 10 000 most frequent forms would cover on average 90% of French, or, in other words for statements of 100 words, 10 words on average would be absent from this 10 000 form lexicon. It is interesting to note that the 54 000 most frequent forms cover 99% of French ant that only 181 000 of the 444 000 forms that constitute our lexicon have been observed in the corpus of 143 million words analysed. The little used forms, which number 263 000, that is to say around 60% of the lexicon, are for the most part composed of verbs (80%), common nouns (15%) and adjectives (5%)

Each entry of the general ACP lexicon corresponds to an orthographical form to which is associated its general frequency and the list of morphosyntactic categories categorising the word. Thus this list possesses several elements in case of any syntactic ambiguity (for example the entry “montre” proposes (noun, verb) as morphosyntactic categories)

3.5. The personal lexicon and user’s own frequencies

When the user writes an unknown word, that is to say one which is not in the general lexicon, this word is memorized, following a request for confirmation, into the personal lexicon of the user. By default, the added unknown words are classified as proper nouns (this is often relevant in practice considering the good cover of the general lexicon). The entries of the general lexicon and the personal lexicon are put together to form the word list of the global lexicon.

3.6. The module of morphosyntactic prediction

The prediction engine integrates a morphosyntactic module which modifies the frequency of each entry of the lexicon according to the list of morphosyntactic categories associated to the entry and according to the syntactic context in the sentence being written. The model of language adopted here is a stochastic model with no notion of constituents nor overlapping structures. Probabilistic grammar is learnt on a corpus of phrases annotated morphosyntactically. We have used the corpus of the CLIF project (extracts taken from the newspaper Le Monde containing around 370 000 words (Abeillé & al. 2001). The syntactic information is represented as 24 morphosyntactic categories for which the elements of gender, number and person are available when relevant.

We use the model of patterns (Blache & al. 2006) to calculate the probability of each entry in the global lexicon considering the syntactic context constituted by the sequence of orthographic forms already noted in the phrase. The pattern model, a sub-class of the hidden Markov models, presents advantages with respect to the N-grammes models. The learning phase of the probabilistic grammar on the CLIF corpus supplies 224 patterns of various sizes which allow the calculation of the probability in context to give to each entries of the lexicon.

3.7. The evaluation of the prediction system

The ecological evaluation of a system of aid to communication for the disabled is a complex problem which involves subjects as varied as psychology, ergonomics, psycholinguistics and linguistics.

The first problem that one meets is that of the interaction device to link the user and the support machine of the system. A certain number of technical solutions (contactors, movement captors, breath captors …) are available today but it is difficult to evaluate their efficiency in rate of failure, fatigability and comfort. The evaluation and diagnosis of the device best adapted to the motricity of the user are however fundamental, on them depends in practice the use or not of the aid to communication system.
The evaluation of the ergonomics of the software interface is another problem. The different tasks carried out by the user during message writing must here be quantified in terms of duration and number of interactions. The cost associated with the task of searching for a word in a list, or a character in a dynamic letter keyboard or the cost of cancellation when a processing error occurs, must be calculated. Numerous evaluation metrics have been proposed in the literature (see Vigouroux & al. 2004) but they only cover a part of the totality of the cognitive process.
Finally, the evaluation procedure must take into account the linguistic competence and the communication strategy of each user. Wandmacher & al. 2006 show that the performances of word prediction aids vary greatly according to the type of language register considered. So, how does one modelise the language register produced by the whole group of users of a communication aid system? In the same way, what weight must one give to the linguistic errors produced by the user during the process of evaluation? (See Boissière & al. 2007)

We have adopted the method used by Boissiere & al 2006 which consists in only evaluating a sub-part of the system, that is to say the impact of the word prediction engine on the performances of the user. The metric used to evaluate the language model of the system on a corpus is the rate of economy of processing defined by the equation:

Keystrokes saving rate = 1 – (number of characters struck – number of validations / total number of characters.

The number of characters processed does not take into account the procedure used to select the characters on a virtual letter keyboard. We are therefore not evaluating here the contribution of the letter keyboard. The number of validations corresponds to the number of word selections in the given list of words. The model does not take into account the cognitive cost associated with the finding of the word in the list of propositions and the possible spelling weaknesses of the user.

Figure 4 shows the variation of the economy rate of words according to the size of the list of propositions. The results are obtained from a group of 500 words and when 8 000 words have been learnt by the user model. The dark grey bars represent the result for the whole engine. The economy rate of processed words rises, as would be expected, with the number of propositions, but a leveling off can be observed from 5 propositions (rise of 4% between 3 and 5, 2.5% between 5 and 7, and 1.5% between 7 and 9 propositions). It does not therefore appear necessary to augment the number of propositions, the gain in performance being counterbalanced by the cognitive cost associated with the task of searching for the given word in the list of propositions.

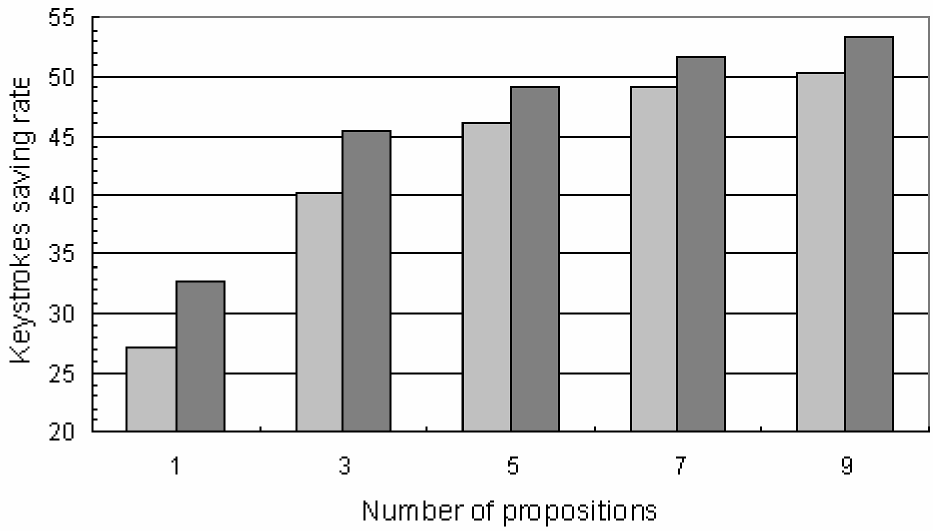

Figure 4: The economy rate of words according to the size of the list of propositions (1, 3, 5, 7, or 9 words proposed). In light grey, the values for a prediction based only on the frequencies of the general lexicon. In dark grey, the economy made for the whole engine (frequencies + learning + morphosyntactic module)

The performance of the APC Orthographic word prediction engine is good and can be favourably compared with the results obtained by the Sibylle system (Wandmacher & al. 2007). For a list of 5 propositions, the economy rate is around 50% which is the same rate as that measured for Sibylle on the corpus of the newspaper type and without integrating the module based on latent semantic analysis.

We have tried to analyse the contribution of the different components of our word prediction engine. The light grey bars in Figure 4 represent the economy rate of processing for our prediction engine amputated from its morphosyntactic prediction module, taking into account personal frequencies of the user and the sentence tree (for technical reasons, the personal lexicon has been kept). The prediction engine then establishes the list of words proposed on the base of frequencies in the general lexicon, with no notion of context. We can observe that this is the dominating factor of the model (for 5 propositions, the economy rate of processed words is over 45%). For the cases of 5, 7 or 9 propositions, the integration of the other modules in the engine raises the economy level by around 3%. We have also tested the engine without the morphosyntactic module and with learning (gain of 2%) and with the morphosyntactic prediction and without learning (gain of 2%)

4. Presentation of the Iconic APC

Composition in non-verbal mode is carried out with the help of an icon keyboard (see figure 5). The general icon base shared by all users contains around 750 pictograms which have been designed from a graphic semantic chart developed by the Word and Language Laboratory, and tested by numerous users. It covers varied communicational needs. The base comprises around 200 verbs (the most common verbs and also specialised verbs used for example in the medical field, around 200 common nouns (designating objects, places, people etc.), around 50 adjectives, the most common pronouns, adverbs, articles and prepositions, and numbers. The base also contains icons representing the letters and phonemes which allow the creation of alphabetical or phonetic keyboards. Each user will then be able to create and add via an easily accessible interface, his own icons (from digital photographs for instance)

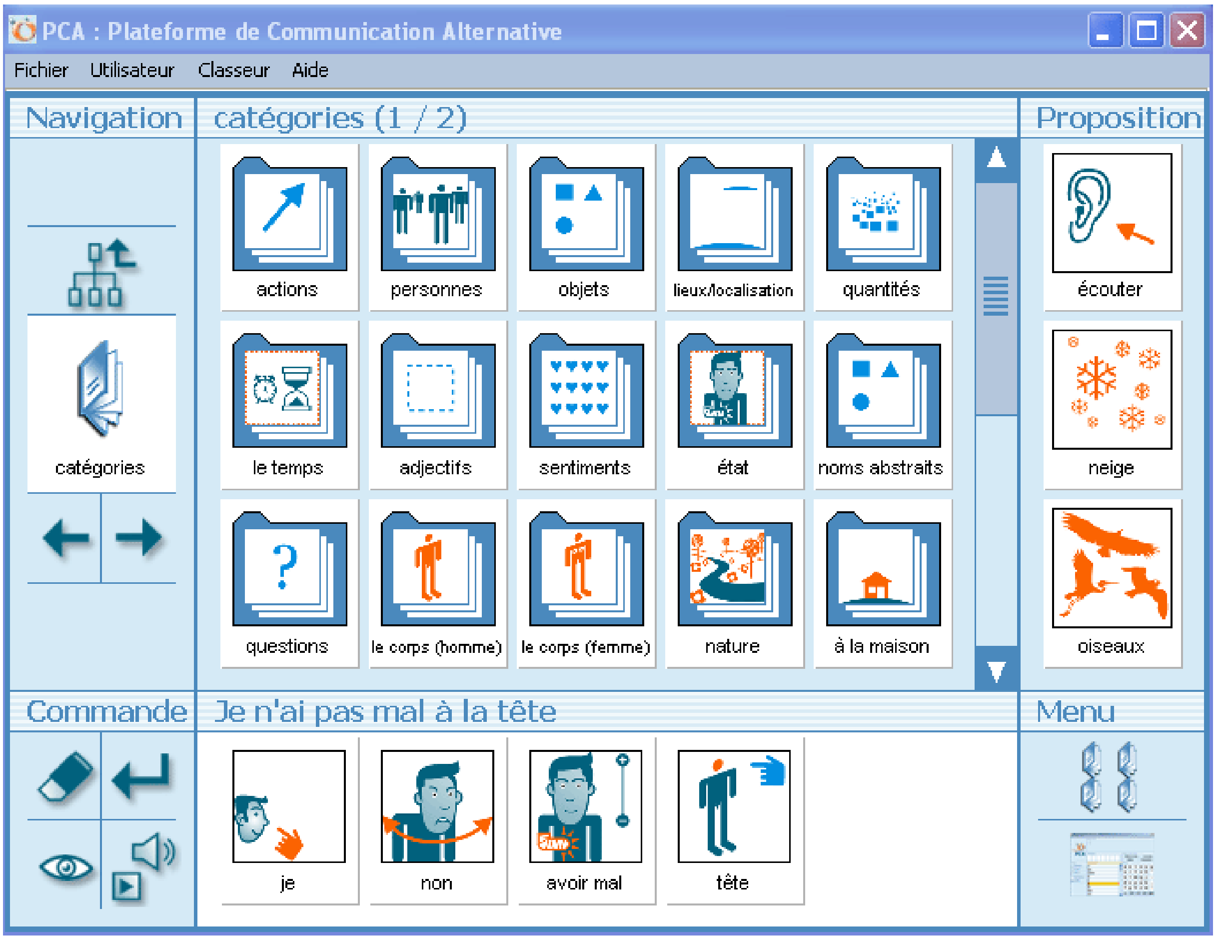

Figure 5: Graphic interface of the Iconic APC

4.1. The iconic reformulation module built into APC

Many authors (see for example Abraham 2000, Abraham 2006) have addressed the problem of the reformulation into natural language of a message composed of a sequence of icons.
Two problems must be considered. First, what syntactic and semantic information must be associated to each icon, or in other words, what information necessary to the engendering must be put on the lexicon? Then how does one manage syntactic constraints and semantic constraints simultaneously when an entry turns out to be incomplete, since some information is absent from the sequence in question?

4.1.1. The linguistic information necessary to the engendering

It is subtlety of the linguistic information associated to the item of language that conditions the performances of the reformulation module. In the case of a closed system for instance, that is to say a system that does not allow the adding of any new lexical material, it is desirable to have as finely tuned a description of the syntactic and semantic properties of each item as possible. In the case of the non-verbal communication aid developed by APC, we have opted for another choice. We believe that it is indispensable for the user to enrich his lexical material by additions or modifications of the icon base supplied by default. The opening of the system severely conditions the implementation choices of the reformulation rules.

The user or the person helping him will therefore have to give the necessary information, for each new item created, to the natural language reformulation module. The formulation of linguistic information must therefore be simple enough to be accessible to all (that is to say to people who do not have any special expertise in the field of linguistics).

Nom	Les noms propres et les noms communs
Verbe	Les verbes
Locution verbale	Les verbes suivis d'une locution, ex. "prendre garde"
Adjectif	Les adjectifs qualificatifs
Préposition	Les prépositions, ex. "à", "de", "avec", etc.
Adverbe	Les adverbes, ex. "souvent", "très", "facilement"
Déterminant	Les articles définis, indéfinis, démonstratifs, possessifs
Pronom	Les pronoms personnels et démonstratifs
Et/ou	Les conjonctions de coordination "et" et "ou"
Négation	La négation "ne...pas"
Question	Les unités interrogatives du type "Quand", "Comment", "Qui", etc.
Nombre	Les chiffres et les nombres
Lettre	Les lettres ou groupes de lettres
Phrase	Les phrases ou parties de phrases qui ne sont pas reformulées

Figure 6: The list of syntactic categories of the ACP reformulation module

The reformulation module built into ACP is thus based on a lexicon containing minimal linguistic information. To each icon is associated one of the syntactic categories listed in figure 6. The semantic information associated to each entry in the lexicon is very limited. One mainly has to specify the nature of the common nouns (person, object, place, or transport) and the prepositions associated to the verbs.

4.1.2. The rules of reformulation

The rules of reformulation built in ACP come from a compromise between the desire to interpret a maximum of iconic messages composed while asking for a minimum of information necessary to characterize the syntactic and semantic properties of icons. Moreover, we have had to make certain choices of interpretation for the situations presenting semantic ambiguity. We have chosen the reformulation rules described in figure 7.

Ajout d'une unité lexicale

- Le déterminant devant un nom commun : *"père"* + *"et"* + *"mère"* → *"le père et la mère"*
- Le pronom sujet : *"vouloir"* + *"dormir"* → *"je veux dormir"*
- Une préposition entre le verbe et le complément : *"il"* + *"entrer"* + *"chambre"* → *"il entre dans la chambre"*
- La préposition *"de"* entre deux noms : *"clé"* + *"voiture"* → *"la clé de la voiture"*

- La préposition *"de"* entre le nom suivi d'un pronom : *"lit"* + *"je"* → *"mon lit"* (littéralement *"le lit de moi"*)

Gestion des accords

- Accord déterminant-nom : *"fruits"* → *"les fruits"*
- Accord nom-adjectif : *"beau"* + *"fille"* → *"la belle fille"*
- Accord sujet-adjectif : *"elles'* + *"être"* + *"gentil"* → *"elles sont gentilles"*
- Accord sujet-verbe : *"vous'* + *"vouloir"* + *"journal"* → *"vous voulez le journal"*
- Mise au pluriel : *"les"* + *"enfant"* → *"les enfants"*

Formation de la négation

- Positionnement de la négation : *"Pierre"* + *"non"* + *"venir"* → *"Pierre ne vient pas"*

Déclinaison des pronoms

- Nominatif (pronom sujet) : *"ils"* + *"mange"* → *"ils mangent"*
- Accusatif (pronom COD) : *"je"* + *"voir"* + *"elle"* → *"je la vois"*
- Datif (pronom introduit par la préposition *à*) : *"je"* + *"parler"* + *"à"* + *"il"* → *"je lui parle"*
- Oblique (pronom introduit par une autre préposition que *à*) : *"je"* + *"aller"* + *"chez"* + *"tu"* → *"je vais chez toi"*

Gestion des phénomènes linguistiques particuliers

- Elision : *"le"* + *"enfant"* → *"l'enfant"*
- Contraction : *"je"* + *"aller"* + *"à"* + *"le"* + *"cinéma"* → *"je vais au cinéma"*

Concaténation des chiffres en nombre

- Concaténation et transformation en déterminant : *"je"* + *"avoir"* + *"1"* + *"5"* + *"an"* → *"j'ai 15 ans"*

Concaténation des lettres ou groupe de lettres

- Si le message est exclusivement composé de lettres : *"b"* + *"on"* + *"j"* + *"ou"* + *"r"* → *"bonjour"*

Figure 7: The reformulation rules built into APC

Figure 8: An example of a reformulated message

An illustration of a reformulated message is shown in figure 8.
These rules have been isolated in resource files external to the programme. In this way, this architecture gives us a certain leeway to allow the characterisation and the extent of cover of all the interpretable messages to develop.

5. Conclusion and perspectives

In this article, we have presented the main principles governing the Alternative Communication Platform. The prediction engine of the ACP, in its orthographic version, uses a general extensive

French lexicon with 320 000 spelling forms for which the frequencies of usage and the associated morphosyntactic traits are known. A personal lexicon allows us to complete the general lexicon by memorizing the unknown words written by the user. The prediction engine possesses a user's model which calculates the frequencies of usage of each individual user and memorizes the sentences produced during repeated uses of the system. The engine also integrates a morphosyntactic prediction module which balances the frequencies of the predicted words according to the syntactic context of the sentence being written.

We have conducted the evaluation of the system, or, to be more precise, the evaluation of the language model of the word prediction engine, by measuring the economy rate of data entries on a test corpus. The results are satisfactory; the economy rate of data entries is around 55% for a list of 9 propositions. The APC in its orthographic version is mainly destined to people having a good mastery of the written word, but who suffer from severe motor disorders that prevent them from putting it into practice naturally. The users of the orthographic ACP (around 50 up to now) are generally very satisfied with the functionalities offered by the system. The main problem met with, is in fact the search for a captor that is best adapted to the motricity level of the user.

As for the Iconic ACP, around 50 ACP systems equipped with the reformulation module have so far been distributed, equipping private persons, professional and special needs centres (a demonstration version is available on the site http://www.aegys.fr/). It is still too early to have a reliable evaluation of the contribution of the reformulation module to the communication needs of the users. Nevertheless, the feed-back we have received concerning the use of the modules has been encouraging. It seems that the oralisation of the reformulated message by the voice synthesizer gives the user a natural control of his production. This phenomenon is observed not only in the use of the ACP as a communication tool, but also in its use within a re-educational protocol.

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