Evaluation of the acceptability and usability of augmentative and alternative communication (AAC) tools: the example of pictogram grid communication systems with voice output

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The multiplication of communication software based on pictogram grids with voice output has led to the democratisation of this type of tool. To date, however, there is no standard, nor systematic evaluation that makes it possible to objectively measure the suitability of these tools for a given language. There are also no methods for designers to improve the organisation of words into grids to optimise sentence production. This paper is a first step in this direction. We represented the Proloquo2Go Crescendo vocabulary for a given grid size as a graph and computed the production cost of frequent sentences in French. This cost depends on the physical distance between the pictograms on a given page and navigation between pages. We discuss the interest of this approach for the evaluation as well as the conception of communicative pictogram grids.

Additional Key Words and Phrases: Augmentative and Alternative Communication, pictograms, evaluation

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1 INTRODUCTION

Pictogram grid communication systems with voice output (PGCS) provide an interesting support for the communication of speakers with speech and language impairment. First available only on dedicated devices, they are now available on computers, tablet computers as well as smart phones for free or at a reasonable cost. In most of the cases, the software include a "vocabulary" i.e. a set of words associated with pictograms for a given language. Pictograms are then organised into pages of two dimensional tables. This organisation depends on the designers' view of language organisation and can favour lexical, pragmatic or syntactic constraints. The software then provide various functionalities of use or adaptation of the vocabulary. In use, speakers build their messages by sequentially pointing to the pictograms, which is significantly much slower than natural speaking. Moreover, most of the vocabularies and organisations were conceived for a given language and later on translated into another language, which questions the optimisation of the vocabulary. Our

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aim is to objectively quantify the temporal efficiency of this type of Augmentative and Alternative Communication tool for a given language by estimating the temporal cost of the production of frequent sentences.

This article will begin by putting AAC in perspective through a table of pictograms and its limitations, then we will explain the method we have adopted and finally we will end with an example of applications of our tool.

2 PICTOGRAMS GRID COMMUNICATION SYSTEMS

Augmentative and Alternative Communication (AAC) is defined by the National Joint Committee of the American Speech-Language-Hearing Association as: “multiple ways to communicate that can supplement or compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders”. As put forward by Beukelman and Mirenda (2017): "The ultimate goal of AAC...[is] to enable individuals to engage efficiently and effectively in a variety of interactions and to participate in the activities of their choice." [2].

There are a lot of different types of AAC tools among which pictogram grids. The latter are based on grids consisting of various numbers of pictograms representing words, which the person can point at to form utterances. In most cases, the software includes a "vocabulary"; consisting of a set of words associated with pictograms for a given language. Pictograms are then organized into pages of two-dimensional tables. This organization differs between tools focusing either on lexical, pragmatic or syntactic constraints. Users build their messages by sequentially pointing to the pictograms. One can easily understand that this results in much slower productions than in natural speaking. In this study, our aim was to design a system able to objectively quantify the production cost of basic utterances using an AAC pictogram grid based tool. Such a system could then be used to compare production costs from one system to another.

Today, a lot of pictogram-based AAC tools are available but very few tools are developed in French or for French (our target language). They are mainly based on the syntax of the language in which they are developed and then simply translated into French. This questions the optimization of the tools for French. Between Makaton, PECS, PODD, Coghamo, Proloquo2Go, SnapCore First, etc. families and healthcare professionals can have a hard time finding what they need. No scientific studies on their usability and efficiency have been conducted. This is partly why we wanted to provide a way to objectively compare the tools from a production cost point of view.

3 MOTOR PRODUCTION COST AND METHODOLOGY

In order to have a first glimpse of what the evaluation of an AAC tool can be, we have chosen to materialise the motor production cost. We define the motor production cost by the minimal number of actions needed by someone to compose a message with a Pictogram Grid Communication System. To be able to automatically compute it whatever the message (phrase, sentence, text, corpus,…), we need a mathematical representation, the straightforward one is a directed weighted graph. (or arcs)

3.1 PGCS representation and interaction

PGCS are represented as a group of various grids. In each of these grids we can find pictograms expressing ideas, concept, words or phrases which we can be used form sentences or texts. In addition to these pictograms, some buttons, defining categories or actions, are used to navigate between the grids. For the represention of these grid-to-grid links, and for the rest of the PGCS architecture, we designed an open format (the *interaaction group open format*) allowing us to precisely describe each of the grids of the PGCS, and each of the items composing the grids. This format is used in an open PGCS software developed in the team but outside of the scope of this article[1].

Interactions with PGCS are heterogeneous, they can occur through touch, gaze tracking, buttons, etc. All interactions don't have the same cost for selection or displacements. For instance touch can be short or long, gaze tracking often uses dwell interaction[3, 8] so that a pictogram is selected when gaze stays on it during a certain time, . . . for selection while displacement cost is low for gaze and quite long for button interaction. Hence while we can consider for instance that the cost of a simple touch is one, the cost of gaze interaction will be based on dwell time. These costs depend on user abilities, for instance with strong cognitive difficulties (apraxia for instance).

We note n as the cost of the interaction for selection, m the cost of interaction for displacement.

3.2 Graph representation

Mathematically, a graph is a pair G = (N, E), where N is a set whose elements are called nodes, and E is a set of edges (or arcs) which link nodes together. In a directed graph, edges have a one-way direction. When the graph is weighted, edges have a weight. Directed weighted graphs are commonly used to represent distances between towns for instance and here we use them in order to represent cost between two pictograms or pages in a pictogram grid communication system.

3.2.1 Nodes. To form the nodes, we manually created a list of the tool's pictograms. We assigned a unique identifier to all the pages and all the pictograms. It is composed of three parts: The word associated to the pictogram, an @ and the name of the page containing the pictogram. So if we want to give an identifier to the "I" pictogram on the "home" page to create a node, we use: **"I@home"**.

3.2.2 Edges and weight. Besides, we created the edges of the graph. To go from one page to another, on all PGCS we study, only one action is needed, in this case, the corresponding cost is n $(1 \times n)$ where n is the cost of the interaction to select (see section 3.1).

For the cost between pictograms on the same page, it depends on distance between the pictograms. Hence, the cost between pictogram P_1 and pictogram P_2 is $D(P_1, P_2)m$ where $D(P\_1, P\_2)$ is the distance between P_1 and P_2 where m is the cost of interaction for displacement. On the figure 1, the cost to go from A to D is $3m$, while it is $4m$ between A and B and $2.24m$ between A and C.

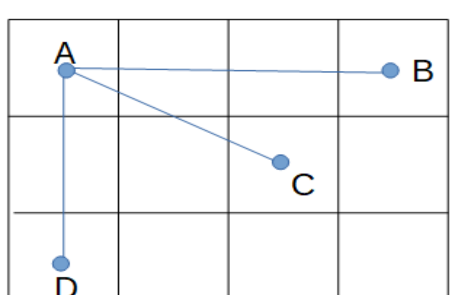

Fig. 1. Diagram of the arcs and their distances

3.3 Extraction of the shortest path

Revoir si le temps

[1]AugCom github website https://github.com/GazePlay/AugCom

In this part the system takes as input a written text read line by line. For each line, it scans the path and draws up a list of potential "candidate path" per word pair. For example, if we take the sentence "I want to play", the system will list all the possible arcs to go from the word "I" of any page to the word "want" of the same page or any other page. We will then have a list of arcs of the type (I@pageA,want@pageB) with a given weight. These arcs will be kept in memory in a list and we will continue with the pair of words "play" and "to", so on until the end of the sentence. At the end a new graph can be created with this list, containing only the words of the sentence, a Dikjstra algorithm can then be applied in order to find the shortest path.

3.4 Corpus

A corpus is a collection of documents used for a specific research purpose. We choose to use the corpus ESLO 2 (Sociolinguistic Survey in Orleans) [**?**]. This one includes about 400 hours of oral speech in different socials situation. These transcribed speech hours will therefore be used as reference sentences to compare the different production cost between the PGCS. Using this corpus allows us to have a wide choice in our sentence selections. Indeed, we are not reduced to conversations between adults we can also select sentences from parents to children. The use of this child's speech is a definite advantage for testing the PGCSs that are directly addressed to them.

4 APPLICATIONS

To illustrate our method we use here the sentence : *I want to go to the park* or more precisely *I want go park* which is not grammatically correct but closer of what is often done with PGCS. Indeed, user often wants to create a sentence quickly which does not necessarily make grammatically correct sentences. The shortest path given by the system for this sentence is the following one: **['home', 'I@home', 'want@home', 'go@home', 'places_r@home', 'places', 'park@places']**

Following the method the cost is $3m + 3n$ where n is the cost of the interaction for selection and m is the cost of interaction for displacement.

For a user with no particular problem and using touch (m = 1 and n = 1), the cost for the composition of this message is 6 while it is 18 for a user with no particular problem using eye-tracking with a little dwell interaction (m = 0, n = 6) and 75 for a user with dispraxia and a higher dwell interaction time (m = 5, n = 20).

All code is open source and permits to compute this code for any PGCS in the Interaaction Group Open format and is available on GitHub[2]. We intend to continue to develop this project and to introduce new metrics and corpus.

5 CONCLUSION & PERSPECTIVES

The lack of standards, and methods to evaluate the layout of PGCS makes the design of AAC tools hard to improve and hard to correctly suit to the targeted population.

Our system offers a possible opening on the evaluation of PGCS. Indeed, our system is able to calculate the cost of a message from a correctly described tool. It also makes it possible to find the shortest path to reach a pictogram.

We hope that our evaluation system will initially allow us to optimise sentence production and the usability of the tools in context. In addition, we want parents, speech and language therapists and users to have a real means of comparing the effectiveness of the tools whatever the reason for their use.

[2] https://github.com/GazePlay/Pictogram-Grid-Communication-Systems-Evaluator

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