The Creation and Facilitation of Speech and Language Therapy Sessions for Individuals with Aphasia

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ABSTRACT

Aphasia is the degradation of one's ability to comprehend or convey language, usually due to brain damage caused by strokes or some external force. Sufferers can regain some or all of their prior abilities, but only with significant speech and language therapy (SLT) sessions. SLT sessions are resourceintensive, as they often require skilled therapists to adapt the therapy for the individual patients.

We present Ogma, a novel approach to the automatic creation of SLT sessions. Ogma is comprised of a proprietary mobile front-end application that the patients interact with, and an offline GA that designs patient-specific sessions based on a patient's progress. Key to this is the ability to accurately capture the difficulty of the generated sessions; this paper presents the results of experiments where SLT practitioners perform beta testing on Ogma, to ascertain its ability to consistently produce useful sessions of appropriate difficulty.

Categories and Subject Descriptors

H.4.m [Information Systems Applications]: Miscellaneous; I.2.1 [Computing Methodologies]: Artificial Intelligence—*Applications and Expert Systems*; I.2.6 [Computing Methodologies]: Artificial Intelligence—*Learning*

General Terms

Human Factors, Algorithms, Performance, Reliability

Keywords

Genetic Algorithm, Evolutionary Computation, Aphasia, Speech and Language Therapy

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1. INTRODUCTION

Aphasia can be defined as the loss or degradation of one's ability to comprehend or convey language in a coherent manner. While Aphasia is commonly associated with cerebrovascular accidents (also known as 'strokes'), it can be caused by any significant injury, which leads to damage to the brain. The effects of Aphasia are manifold, and can impact an individual in terms of their reading and writing comprehension, as well as their ability to effectively communicate with others. Aphasic individuals often present with concomitant ailments including Dysgraphia, a condition, which leads to difficulties in writing. Dysgraphia largely results in an impedance of the individual's motor skills when writing, leading to both functional and stylistic inconsistencies. Though traditional forms of therapy exist [3, 1], which purport to rehabilitate individuals, they are often resource intensive and can demand a significant time commitment from all participants, as well as indirectly involved parties, i.e. carers and or family members. An individual's engagement in a given therapy program may be determined by their location and the availability of those, on whom the individual is dependent as well as the therapy's facilitator.

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A genetic algorithm (GA) has been developed, which is capable of prescribing speech and language therapy sessions for aphasic individuals. The GA is responsible for the creation of therapy sessions, which are tailored to the capabilities and interests of each individual. Generated sessions are presented on the developed application via an image identification and word recollection task. Sessions consist of an arbitrary number of words, each of which is represented by an image. The user is then tasked with identifying and spelling the target word. The application elicits responses from the user via a series of interactive cues. The results of each session are interpreted and inform the GA's future session generation.

2. RELATED WORK

The role of computer technology in Aphasia rehabilitation was reported on at length by van de Sandt-Koenderman (2011) [5], including the benefits and complexities associated with its inclusion. Mortley et al. (2004) [4] presented a computer mediated form of word retrieval therapy, with a remote monitoring facility and minimal therapist input and

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intervention. Fink et al. (2002)[2] discussed the benefits of a computer mediated cued naming form of therapy. Ogma's front-end mobile application features a prompting framework, influenced by both Anagram and Copy Treatment (ACT) and Copy and Recall Treatment (CART) - methods which have been explored thoroughly [1].

3. ANALYSIS

A study was conducted to examine the ability of the GA's fitness function in determining the perceived difficulty of sessions and their individual terms. The GA's ability to interpret perceived difficulty was appraised and compared to the expectations of trained speech and language therapists. For the purposes of this study, the GA was adapted such that larger sessions, i.e. containing a significantly larger set of words, were generated. Successfully generated sessions' words were sorted, grouped by their level of perceived complexity and a sample of each grouping was presented to the participant in an arbitrary order.

Participants were tasked with first of all identifying each target word, and then gauging the perceived complexity of each term, classifying it as being 'easy', 'medium' or 'hard'. Participants were encouraged to provide reasons for each of their decisions. A measure of both word naming/identification and classification accuracy was taken, whereby the participants' expectations were compared to the GA's projected results.

In total, 10 participants took part in the study, all either trained or training as speech and language therapists and with varying levels of experience with aphasic individuals. The participants produced 30 sessions, each of which consisted of 9 words. Thus, the perceived difficulty of a set of 270 words, yielding 151 unique terms, was analysed. Many participants made incorrect decisions, which were heavily influenced by the quality of the images on show and, in some cases, their decision to either use an abbreviated version of the target word, or a synonym for the word in question.

Participant	Naming Accuracy	Classification Accuracy
P01	$21/27 \ (0.778)$	$14/27 \ (0.518)$
P02	$16/27 \ (0.592)$	$21/27 \ (0.778)$
P03	26/27 (0.963)	$22/27 \ (0.815)$
P04	25/27 (0.926)	$19/27 \ (0.704)$
P05	25/27 (0.926)	$16/27 \ (0.592)$
P06	26/27 (0.963)	$20/27 \ (0.741)$
P07	23/27 (0.852)	$21/27 \ (0.778)$
P08	23/27 (0.852)	$21/27 \ (0.778)$
P09	26/27 (0.963)	$24/27 \ (0.889)$
P10	$24/27 \ (0.889)$	$22/27 \ (0.815)$
Total	235/270 (0.87)	$200/270 \ (0.741)$

Table 1: Overall session results for all participants.

All participants, with the exception of P02, were largely capable of identifying the target terms. In fact, excluding the performance of P02, the average accuracy for the remaining participants was 0.901. While participants' performance on classification tasks was not equally as impressive, the various issues experienced can account for the disparity between both results. Table 2 depicts the number and types of errors encountered by participants throughout.

In some cases, participants were not forthcoming with the reasons for their classification decisions and as such, errors may have gone unreported. IMG refers to any instance where the quality of the selected image interfered with either the target word's identification or classification. ABBR refers to the use of an abbreviated version of the target word, rather than the word in its entirety. SYN refers to participants choosing a synonym rather than the target term.

While the issues encountered were higher in relation to identification tasks than classification tasks, synonyms and abbreviations were deemed to be correct responses in identification tasks. However all classification-related errors were directly responsible for participants providing an incorrect response. While the participants largely agreed with the GA's projected results, some concerns were raised in relation to the often misleading and unclear imagery used throughout the study. It was also noted that too high a weighting had been applied to particular word characteristics.

Error Type	Identification Tasks	Classification Tasks
IMG	29	20
ABBR	3	3
SYN	5	2
Total	35	25

 Table 2: Types and number of errors encountered throughout classification or identification tasks

4. CONCLUSION

This paper has presented Ogma, a novel approach to the generation and delivery of continuous speech and language therapy for aphasic individuals. A study has been conducted, which assessed, in particular, of Ogma's offline-GA's fitness function. Ogma's approach has been shown to yield high accuracy results when compared to the expected outcomes of trained Speech and Language Therapists, though some notable errors were encountered. Future experiments will enable an in-depth analysis of Ogma's potential for generating continuous sessions, which are tailored to the idiosyncrasies of the individual.

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