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Effects of Auditory Sound Cueing in Proximal and Distal Object Naming Using a Multi-Touch Interactive Word Wall in Rehabilitation: A Preliminary Study

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Abstract

The multi-touch interactive word wall has been shown to be of educational benefit in schools but not in rehabilitation settings. Usually, naming objects is clinically tested using items placed on a desk (horizontal plane) for (proximal) picture naming. For neurological patients in rehabilitation we aim to introduce a multi-touch interactive vertical (distal) word wall (a vertical plane) using auditory sound cues. A controlled trial for 24 neurological impaired patients (both inpatients and outpatients) with naming difficulties randomly assigned to the diagnostic cueing group. They received 30 minutes of conventional speech therapy plus cueing trial. The control group, included 21 special education students from a local public school, participated in the examination of distance effect on naming. No statistically significant difference was found between errors in proximal and distal naming in both patients ($t(22)=0.238$, $p=0.814>0.05$) and students ($t(21)=0.568$, $p=0.576>0.05$).

Patients made statistically significant more errors than students in proximal naming ($t(43)=6.738$, $p=0.000<0.05$), as well as in distal naming ($t(43)=6.957$, $p=0.000<0.05$), which included verbal paraphasic errors and "don't know" errors, while students made more semantic paraphasic errors. Cueing trial showed statistically significant more errors without auditory sound cues than with auditory sound cues ($t(22)=-8.068$, $p=0.000<0.05$), as they relate to proximal (horizontal) and distal (vertical) naming tasks. Evidence supports the use of interactive vertical wall (distal) as cueing trials for object naming for patients with difficulty with unnamed word. Furthermore, distance seems to have no effect on naming ability. Research is needed to control for eye tracking movements.

Keywords: interactive wall, proximal naming, distal naming, auditory sound cues, rehabilitation

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Introduction

The diagnostic approach to the rehabilitation of patients with naming difficulties requires standardized testing with continuous picture objects to examine word retrieval as well as accuracy of word recall (Lavoie M., Macoir J., Bier N., 2017). Neurologically impaired individuals with naming problems face difficulties retrieving specific words during conversation or during structured object and picture naming activities in oral and written speech (Lavoie M., Macoir J., Bier N., 2017). Naming ability is also investigated by assessing the spontaneous speech of a person or by structured procedures including naming objects in visual naming projects (objects-pictures) with parallel use of visual, semantic or phonological cues, definition naming (answer to questions concerning semantic determination of a specific or non-specific word) and associative naming (production of words that belong to the same semantic category with the target-word). These stimuli are almost always given on a proximal horizontal field (desk or screen so that the patient looks down) but seldom on a distal vertical wall (patient looks up from a wheelchair or chair). The causes of naming errors can be identified in every stage of word retrieval. So, naming errors can be a result of conceptual deficits, semantic deficits, syntax deficits, phonological deficits and deficits concerning the connection of these elements. Naming disorders reveal in various forms such as the inability to find words, the pauses, the use of circumlocutions (Tsantali E., Lekka S., Tsolaki M., Kazi E., Kazis A., 2016). Moreover, there are replacements of words with others from the same semantic category, phonemic paraphasias (neologism), overextensions (fruit for apple) and sub-extensions (tomatoes for vegetables) of concepts (Crystal D., 1982).

Similar naming problems are presented in children with special needs. For instance specific language impairments, developmental disorders and other neurological problems imply difficulties in language and speech. Children with difficulties in language and speech functions in their majority have problems in naming and as a result the conceptual acquisition of words and the communication are complicated. A lot of researches have investigated the naming ability of children with language impairments and naming difficulties. Error types which were found vary from semantic and ‘’don’t know’’ (Lahey M., Edwards J., 1999) to phonological in naming pictures and more unrelated without semantic relationship in naming actions (Dockrell J.E., Messer D., 2007) as well as semantic errors, unrelated errors, omissions and circumlocutions (Ketelaaars, Pauline M., Hermans, Alphonsus S.I., Cupevus, Juliane, Jansonius, Kino, Varhoeven, Ludo., 2011). Errors of children are related to semantic and pragmatic gaps in language, limited attention, impaired ability of representation and generally to their limited ability in several linguistic tasks (Sheng L., McGregor K.K., 2010).

Knowledge about factors that can affect the performance of people with naming disorders is still unsatisfactory. Conceptual feature used for naming have been studied, including the frequency of words, the age of their acquisition, as well as the context in which the word appears and seem that can affect word retrieval ability in picture naming task (Kavé G., Goral M., 2016). Another crucial factor is distance. Naming pictures in close and far distance has been also investigated, however there is no consensus on whether the distance affects the naming or not. Both proximal-distal naming convey the same information about the object, consequently the same mechanisms of word retrieval are activated. This implies that the performance of people with naming difficulties in naming pictures is not affected by the picture’s distance (Bar-Anan Y., Liberman N., 2007). On the other hand, the closer the distance that the stimulus is to whom receives it, the greater quantity of sensory information and specific knowledge about the stimulus. As the stimulus is removed far on distance, this information tends to disappear (Bar-Anan Y., Liberman N., 2007). In proximal naming tasks the material is usually horizontally placed on a desk in front of the subject tested and across from the examiner to provide a practical environment for testing. In normal aging research it is well known that as sensory information starts to degradate so do the cognitive abilities of individuals decline. These include processing time and the abilities to attend to multiple tasks, whereas verbal abilities do not degredate at the same rates.

For the rehabilitation of naming, word retrieval practices are more effective than errorless learning (Middleton El., Schwartz Mf., Rawson Ka., Traut H., Verkuiten J., 2016). Moreover, one of the basic principles of this theory is that there is repetitive education over time. Studies have shown that many educational instances extended longer in time are more effective than those which are gathered in shorter intervals. Traditional approaches include intense lan-

guage and speech therapies usually for long-term patients with naming problems (Darkow R., Floel A., 2016). There has been little research so far about innovative approaches related to technology, such as naming in a computer or exercises based on video (Darkow R., Floel A., 2016). In more traditional methods of naming treatment, cues used along with picture naming are the most usual means used in therapies. Cues are usually phonemic or semantic. Some researches support the superiority of phonemic cues (Pease D.M., Goodglass H., 1978). Other researchers believe that the appropriate cue should be chosen every time according to the language feature in which the deficit is present (Zannino G.D., Barban F., Caltagirone C., Carlesimo G.A., 2015). If the deficit is present at the phonological system, then the phonemic cues should be used. If it is present at the semantic system, the semantic cues should be used. Of course, there are a lot of researchers which support a combination of all cues. Except the semantic and phonemic cues, there are also auditory sound and colour cues which were used in many studies in order to facilitate the procedure of naming.

Perceptually, the colour facilitates the visual recognition of an object and the auditory sound as well. The colour and sound of an object during naming pictures increase the activation of neurons in bilateral occipital regions and the right anterior fusiform region, which are activated during the perception and completion of a visual form (Hocking J., Price C.J., 2008). As a result, the visual form of an object is retrieved more easily to the brain. Therefore, their use is recommended for the treatment of naming difficulties. Finally, the use of technology (computer, smart tablet) has been a popular method in aphasia rehabilitation in recent years. Its effectiveness has shown that computer use can be just as efficient in treatment as that with a clinician (Zheng C., Lynch L.,Taylor N., 2016). Literature review shows that the use of technologies is effective in naming as well and brings long-term improvement (Lavoie M., Macoir J., Bier N., 2017).

Technology includes interactive walls. Interactive white board has been a useful technology tool in education but not often in rehabilitation. For schools these vertical walls have been used in the field of mathematics (Duroisin N., Temperman G., De Lièvre B., 2015), (Tunaboylu C., Demir E., 2017), (Young J., Hamilton C.,Cason M., 2017), (Önal N., 2017) and in the subject of technology (Brecka P., Valentova M., 2017), having positive effects on the performance of secondary school students. Apart from interactive white boards, other technological tools have been also used to improve education. Smart boards showed significant positive effect on learning environmental science among children with intellectual disability and digital devices (phonics applications) were used as an alternative way to teach letter-sound knowledge in first year classrooms with positive results (Nicholas, Maria, McKenzie, Sophie and Wells, Muriel A., 2017).
Interactive word walls have also been used as effective tools for issues related to vocabulary (Jackson J., Tripp S., Cox K., 2011), (Jackson J., Narvaez R., 2013), (Puspita E., Muhajir R., 2016) and grammar (Syam R., 2015). There is no research that indicates its effectiveness in the field of rehabilitation.

In this preliminary work, we present an interactive wall that is vertical (distal) and provides auditory and visual feedback using sensor technology. We believe this can increase patients' motivation as well as more accurately examine naming abilities with cued visual/auditory input. This reduces the barriers of communication and can provide a benchmark for future naming rehabilitation programs. Therefore, the present study aimed to evaluate the effects of additional vertical auditory sound cues with an interactive word wall in patients with word retrieval difficulties in a rehabilitation setting.

Materials

For the initial diagnosis of people with naming problems and investigation of their initial level of function, the Visual Naming Examination of the Boston Naming Test (Segal S., Goodglass H., Kaplan E., Weintraub S., 1983) was used. In the present research the Visual Naming Examination of the summary form of Boston Diagnostic Aphasia Examination in Greek (Messinis L., Panagea E., Papathanasopoulos P., Kastellakis A., 2013) was used. Examination of naming consists of 3 parts (naming answers, Boston naming examination, investigation of special categories).
In order to investigate the effect of distance in naming pictures, printed and laminated pictures of 12 objects were used. Finally, the investigation of the sample's performance in naming pictures with auditory sound cues (is an auditory sound cue that the object made) was held using an interactive wall which includes pictures of objects and their corresponding sound. The interactive wall is from the company La Tata Robotica (Amplo E.) in a local rehabilitation centre in the city of Thessaloniki Greece. This

specific wall has white background and includes the 12 pictures of objects. Pressing with the hand on each picture, the sound of the object is heard.

Methods

Sample of the research

The sample of the research consists of 24 neurological impaired inpatients (21 with stroke and 3 with some sort of brain tumour) attending the rehabilitation centre. All of the patients were having difficulties in naming as indicated by the Visual Naming Examination of Boston Diagnostic Examination Greek version (Messinis L., Panagea E., Papathanasopoulos P., Kastellakis A., 2013). In the investigation of proximal and distal naming, a sample of students with special needs in a local school, where the author worked, was used. The sample consists of 21 students who were formally diagnosed premorbidly with special needs (12 with general learning disabilities, 3 with dyslexia, 3 with intellectual disabilities, 2 with developmental disorders and 1 with specific language impairment). All participants and experimenters both in the rehabilitation facility and school adhered to international ethical standards relating to participating for this study.

Procedure

Once the request for research was approved by the Rehabilitation Centre, a formal statement was given to the patients and their attendants for signing as well. Before the meeting with the patients, the pictures of objects (horizontally) were given to an independent group of 25 healthy adults for proximal naming to determine whether the pictures represent clearly the objects asked for naming and are easily understood by the healthy population. All named each of the 12 pictures, without any differentiation, exactly with the same name. For the experimental group of patients, the Visual Naming Examination of Boston with 3 tests was firstly administered to determine patients' level of naming ability. Afterwards, the investigation of proximal and distal picture naming was conducted. At first, pictures of objects, printed and laminated in a large card and placed on a horizontal field (desk), were used for proximal naming. Each item was shown and the patients were asked to name it, without any verbal cues. The participants were informed that they could take breaks if they wished but were encouraged to finish both naming tasks in a single sitting. Practice stimuli were given at the beginning of each session. The distance between the patient and the picture was 80 centimetres for both the proximal (horizontal) and distal (vertical) conditions. Each participant was tested individually in a quiet room with no distractions. For the distal condition, the patients were asked to name the same pictures, in a smaller dimension (70% smaller than the proximal photo), from the same distance and without any help given. The next phase included naming the same pictures on the interactive wall with sensory auditory sound cues. After naming each picture, the sound of the object in the picture was heard as the examiner touched each item on the interactive vertical wall. If the initial naming was correct, the sound was served as an additional positive reinforcement. If the initial answer was incorrect, the auditory sound cue help was given by the researcher and then the patients were again asked to rename the object in the picture. Only one trial of each cueing session was used and if the patient failed the examiner said "nice try." The same conditions were used with students investigated proximal and distal naming, during lessons delivered by the teacher for children with special needs in the integrated classroom. Due to lack of a second interactive wall, additional auditory cues were not used in the school setting.

An error categorization for the answers of patients (in the rehabilitation facility) and students (in special school) for proximal and distal naming was created by the researcher using a combination of error categories included in Boston Naming Examination. Upon completion of all conditions, an additional analysis, the error analysis for naming categorizations made by Lethlean J.B.and Murdoch B.E. in 1994 in their study, was conducted by the experimenter. The word errors were separated into the following categories including:

- Semantic paraphasia
- Multiple paraphasic words
- Semantic negation
- Lexical paraphasia
- Neutral/empty syntax (say it as you want)
- Don't know
- No response
- Question to examiner
- Personal experience
- Incomplete
- Comments out of the target
- Perceptual relationship
- Phonemic paraphasia
- Pseudo-words with phonemic relationship
- Phonemic cue/first letter
- Stereotypic repetition/persistence

- Circumlocution
- Unrecognised correct

Results

Results in Boston Naming Test

Results for the Boston Naming Test indicated that patients performed better in the test of special categories with letters, numbers and colours. Their worst performance was in Boston naming examination, in which they had to name pictures. Most errors in the test of Naming, were productions from target words, verbal paraphasias with semantic relationship, as well as verbal paraphasias without semantic relationship. For the Boston naming examination, most errors were found in the categories of verbal paraphasias with semantic relationship and other productions out of target.

Results in proximal and distal naming, with and without auditory cues

The results show that patients make almost the same number of errors in proximal and distal naming. From the t-test control emerged that there is no statistically significant difference between errors made by patients in proximal and distal naming ($t(22)=0.238$, $p=0.814>0.05$).

Moreover, another thing that emerges is that patients in rehabilitation make more errors without sound help than with sound help. From the t-test control emerged that there is statistically significant difference between errors made by patients when they are given sound help and when they are not given sound help ($t(22)=8.068$, $p=0.000<0.05$). Essentially, we can say that patients make more errors in case they are not given auditory sound cues.

Concerning the students in special school, the results show that students make almost the same number of errors in proximal naming and distal naming as well. From the t-test control emerged that there is no statistically significant difference between errors made by students in proximal and distal naming ($t(21)=0.568$, $p=0.576>0.05$).

Errors between patients and students in proximal and distal naming were compared. From the t-test control emerged that there is statistically significant difference between the number of errors made by patients and students both in proximal ($t(43)=6.738$, $p=0.000<0.05$) and distal naming ($t(43)=6.957$, $p=0.000<0.05$). Overall, patients make more errors than students both in proximal and distal naming. The correlation coefficient of Pearson was used for the correlation of errors made by patients and students in proximal and distal naming, with and without sound help. From the analysis conducted, a statistically significant positive correlation was found among errors made by patients in proximal naming, distal naming ($r=0.951$, $p=0.000<0.05$), without auditory sound cues ($r=0.884$, $p=0.000<0.05$) and with auditory sound cues ($r=0.889$, $p=0.000<0.05$). Moreover, there is statistically significant positive correlation among errors made by patients in distal naming and errors made by patients without auditory sound cues ($r=0.9129$, $p=0.000<0.05$) and with auditory sound cues ($r=0.908$, $p=0.000<0.05$). Finally, statistically significant positive correlation was noted with errors made by patients without auditory sound cues and errors made by patients with them ($r=0.952$, $p=0.000<0.05$). From the analysis conducted concerning the students, emerged that there is statistically significant positive correlation between errors made by students in proximal and distal naming ($r=0.972$, $p=0.000<0.05$).

Errors of patients and students in proximal and distal naming are categorized into 19 categories. Most errors of patients in proximal and distal picture naming were verbal paraphasias, no response and “don’t know” errors. Verbal paraphasia, as error category, also appeared in Boston naming examination. Furthermore, the patients in both tests made very little comments out of target, unlike the Boston Naming Test in which the comments out of target were in the first place.

Errors of students in proximal and distal picture naming are mostly semantic paraphasias. It is worth noted that this error category was presented in a small percentage to patients. Moreover, errors related to phonemic paraphasia were observed in students’ answers. This is not the case for this category in patients’ answers in both tests.

Discussion

In the present study, the performance of patients with naming problems in proximal and distal picture naming was initially investigated. The results showed in rehabilitation patients make several similar errors in proximal naming as well as in distal naming. The total number of errors between proximal and distal naming is slightly different but not statistically significant ($t(22)=-0.238$, $p=0.814>0.05$). Therefore, dis-

tance does not affect the ability of patients in naming pictures.

Students with special needs made apparently less errors in proximal and distal naming than the patients in rehabilitation setting. The total errors of students in proximal and distal naming differed slightly. No statistically significant difference between the answers of students in proximal and distal naming ($t(21)=0.568$, $p=0.576>0.05$) was noted. Therefore, distance does not appear to affect the ability of students in naming pictures. Moreover, the comparison made between errors of the two groups showed that there is statistically significant difference in both proximal ($t(43)=6.738$, $p=0.000<0.05$) and distal ($t(43)=6.957$, $p=0.000<0.05$) naming. Therefore, patients make statistically significant more errors than students in both tests.

The categories of errors made by patients in proximal and distal naming were verbal paraphasias, “don’t know” errors and no responses. Errors of students showed that they were different than those of patients in the two tests. Students made more semantic and few phonemic paraphasias.

From the results it can be clearly seen that patients make more errors without auditory sound cue than with it. From the statistical analysis emerged that this difference is statistically significant ($t(22)=-8.068$, $p=0.000<0.05$). Therefore, we can conclude that auditory sound cues contribute to improving the patients’ ability in naming pictures.

Finally, it was investigated the correlation between errors made by patients in proximal and distal naming, with and without sound help. It was found that errors of patients in proximal naming have statistically significant positive correlation with errors in distal naming ($r=0.951$, $p=0.000<0.05$), errors without sound help ($r=0.884$, $p=0.000<0.05$) and errors with sound help ($r=0.889$, $p=0.000<0.05$). Statistically significant positive correlation emerged also among errors in distal naming and errors without sound help ($r=0.9129$, $p=0.000<0.05$) and errors with sound help ($r=0.908$, $p=0.000<0.05$). Moreover, errors before and after sound help have statistically significant positive correlation between each other ($r=0.952$, $p=0.000<0.05$). The same investigation conducted to students and it was found that there is statistically significant positive correlation between errors in proximal and distal naming ($r=0.972$, $p=0.000<0.05$).

From the above useful and practically applicable conclusions can be yield. The positive contribution of auditory sound cues to the improvement of patients’ ability in naming pictures is the most important finding. This has implications and can be used as a starting point in naming difficulties treatment programs. Error categories made by each group is another useful element emerged by the research and can be also taken under consideration in treatment programs. We cannot rule out the effect of head movement as a head brace was not used as a control. Also a sex and age matched control group would serve to control for differences in the rehabilitation group, as in this research there was not a control group for the rehabilitation group.

In future research more patients with neurological disorders and naming difficulties to be included, as for example patients with dementia and Alzheimer.

Furthermore, in this study the ability of naming pictures with the help of auditory sound cues was investigated only to patients and not to students, as in proximal and distal picture naming, because the interactive wall could not be transferred to the school.

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Appendix

Table 1. Age of patients and students

	N	Mean	Standard deviation	Maximum	Minimum	Range
Patients	24	78,67	8,127605	90	60	30
Students	21	9,28	1,616875	12	6	6

Table 2. Real auditory sound cue associated with object picture

Object picture	*Description of auditory sound cue*
Stairs	The sound of someone climbing stairs
bell	The sound of a door bell ringing
mobile phone	The sound of a mobile phone calling
cup	The sound of a drink falling within the cup
cat	The sound of a cat meowing
clock	The sound of an alarm clock ringing
thunder	The sound of a strong thunder falling to earth
music note	The sound of a music melody
bird	The sound of a bird singing
car	The sound of a car starting and making noise
door	The sound of a door closing
faucet	The sound of the water dripping from the faucet

Table 3. Error categories in Boston Naming Test

	Naming answers		Boston naming examination	
	Total errors	%	Total errors	%
Pseudo-word or non real word	0	0%	1	0,48%
Phonemic paraphasic errors	1	2,27%	0	0%
Verbal paraphasia with semantic relationship	10	22,73%	74	35,75%
Verbal paraphasia without semantic relationship	12	27,27%	52	25,12%
Neologism	0	0%	0	0%
Multiple paraphasic words	0	0%	4	1,93%
Other productions out of target	17	38,64%	61	29,47%
Circumlocution	4	9,09%	14	6,76%
Persistence	0	0%	1	0,48%
Total	44		207	

Table 4. Results for errors made by patients (1) in proximal and distal naming and (2) with and without sound help.

	Mean	Standard deviation	Minimum	Maximum	P
Proximal naming	6,39	2,81	1	11	0.814
Distal naming	6,35	2,77	1	12	
Without sound help	6,17	2,92	1	12	0.000
With sound help	4,52	3,17	0	11	

Table 5. Results for errors made by students in proximal and distal naming

	Mean	Standard deviation	Minimum	Maximum	P
Proximal naming	1,82	1,53	0	5	0.576
Distal naming	1,77	1,38	0	5	

Table 6. Results for the comparison of errors between patients and students

	Group				P
	Patients		Students		
	Mean	Standard deviation	Mean	Standard deviation	
Proximal naming	6,39	2,81	1,82	1,53	0.000
Distal naming	6,35	2,77	1,77	1,38	0.000

Table 7. Results for the correlation of errors made by patients in proximal and distal naming, with and without sound help.

		Proximal naming	Distal naming	Without sound help	With sound help
Proximal naming	R	1	,951**	,884**	,889**
	P		,000	,000	,000
Distal naming	R	,951**	1	,919**	,908**
	P	,000		,000	,000
Without sound help	R	,884**	,919**	1	,952**
	P	,000	,000		,000
With sound help	R	,889**	,908**	,952**	1
	P	,000	,000	,000	

Table 8. Results for the correlation of errors made by students in proximal and distal naming

		Proximal naming	Distal naming
Proximal naming	R	1	,972**
	P		,000
Distal naming	R	,972**	1
	P	,000	

Table 9. Error categories of patients and students in proximal and distal naming

	Proximal naming				Distal naming			
	Patients		Students		Patients		Students	
	Total errors	%	Total errors	%	Total errors	%	Total errors	%
Semantic paraphasia	11	7,24%	20	57,14%	8	5,29%	19	55,88%
Multiple paraphasic words	6	3,95%	0	0%	0	0%	0	0%
Semantic negation	2	1,31%	0	0%	4	2,65%	0	0%
Verbal paraphasia	28	18,42%	2	5,71%	29	19,20%	2	5,88%
Neutral/empty syntax	0	0%	0	0%	1	0,66%	0	0%
Don't know	26	17,10%	2	5,71%	30	19,87%	2	5,88%
No response	28	18,42%	0	0%	33	21,85%	0	0%
Question to the examiner	6	3,95%	0	0%	2	1,32%	0	0%
Personal experience	2	1,31%	0	0%	1	0,66%	0	0%
incomplete	1	0,66%	0	0%	0	0%	0	0%
Comments out of target	9	5,92%	0	0%	18	11.92%	0	0%
Perceptual relationship	11	7,24%	2	5,71%	12	7,95%	2	5,88%
Phonemic paraphasia	0	0%	2	5,71%	0	0%	4	11,76%
Pseudo-words with phonemic relationship	0	0%	0	0%	0	0%	0	0%
neologisms	1	0,66%	0	0%	0	0%	0	0%
Phonemic cue/ first letter	0	0%	0	0%	0	0%	0	0%

Unrecognized correct	1	0,66%	0	0%	0	0%	1	2,94%
Stereotypic repetition/persistence	7	4,60%	0	0%	8	5,29%	0	0%
circumlocution	13	8,55%	4	11,43%	5	3,31%	4	11,76%

Figure 1. Pictures used in the investigation of proximal and distal naming

Figure 2. Interactive word wall