Systematic Review of Technology-Based Psychoeducational Interventions for Language Disorders

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Abstract

The objective of the study is to examine interactive psychoeducational intervention technologies for language disorders. There were selected and analyzed studies centered on using interactive technologies in speech therapy published between 2007 and 2017. A total of 32 studies met the selection criteria. The analysis revealed a different rank regarding the use of psychoeducational intervention interactive technologies for language disorders. Most studies are based on interventions focused on web technologies according to the main delivery mode and display user interface in terms of communication tools.

1. Introduction

Special education efforts are becoming increasingly visible in terms of information and communication technologies (ICT) at children with speech disorders, in order to optimize therapeutic effects. In recent years, there has been an increasing interest in the application of innovative technologies to correct speech disorders. Boucenna et al. (2014) note that there have been new developments of ICT-based approaches for the therapy and education of children with speech disorders. Traditional speech therapy methods rely on a direct interaction between patient and therapist (Saz et al., 2009), which is achieved by means of a set of activities developed by the therapist for the diagnosis and treatment of the patient's speech disorders. Unlike traditional methods, the actual ones provide interactive applications based on a semi-automatic intervention in speech therapy, which greatly helps therapists. Educators increasingly adopt new technologies, especially in special education (Campigotto et al., 2013) due to the strong potential in the individualization of teaching, learning and communication (Rodríguez & Cumming, 2016). The technologies that are used in speech education are varied, including software, video and audio content, communication-assisting technology, interactive computer programs, Internet-based speech–language therapy, Interactive Multimedia Learning Object, iPad application, platforms, video games, mobile applications, virtual environments and avatars. Kötteritzsch and Gerling (2015) argue that future directions in speech disorders therapy using ICT involves interdisciplinary

approaches that integrate the best practices from conventional therapies, tracking technologies, adaptive algorithms, empowering users to achieve community interaction.

The integration of technologies for speech therapy is a "worthwhile addition" (Fatima et al., 2012) for children with speech disorders. Danubianu and Tobolcea (2016) estimate that speech therapy systems based on computer use are helpful for therapists by creating a special environment for learning. Using these tools to correct speech disorders is beneficial because, as Saz et al. (2009) argue, new technologies facilitate language acquisition skills and can reduce the time required for the therapist's expertise to provide the interactive component of the intervention. Shahin et al. (2015) highlight the fact that technology-based therapy offers the possibility to reduce the amount of work of speech therapists and the time and costs put in by families. Suta et al. (2014) believe that another benefit is the ability to create intervention programs tailored to the specificities and needs of patients. If speech disorders are not corrected, there may occur social negative effects (Danubianu and Tobolcea, 2016), such as low self-confidence, social interaction issues and poor ability to live independently.

Development of new technologies to correct language deficiencies becomes a priority if we consider the current statistics. There are 2.5 million people in the United Kingdom (UK) and 7.5 million people in the United States that have a speech or language disorder (Frost and McCrindle, 2016). Also in Russia, 10-25% of children have difficulty in reading in the early school years (Vasilyeva, 2016). It is important that new technologies for speech disorders therapy be developed and applied correctly, so they may provide support to therapists and benefits to patients (Schröder et al., 2007). With their help, there will be applied the most appropriate methods that would allow for exercises adapted to the patients' individual therapy needs. Stahmer et al. (2011) propose the validation of various technologies for individualized treatment of language disorders depending on the characteristics of the patient, family and practitioner.

The systematic analysis highlights how interactive technologies support psychoeducational intervention strategies in correcting speech disorders. Baxter et al. (2012) have analyzed studies conducted between 2000 and 2010 focused on the use of high augmentative and alternative communication (AAC) technology to correct speech disorders. A systematic analysis based on the frame PRISMA has been conducted by Chen et al. (2016) regarding virtual therapies for correcting speech disorders. Some tests are very specific, focusing on the exploration of studies based on the use of information and communication technologies to correct speech disorders. Ramdoss et al. (2011) conducted a systematic review on the use of computer-based educational interventions to improve *literacy skills* (reading, writing and vocabulary) for students with autism spectrum disorders. Grynszpan et al. (2014) have started a meta-analysis of studies based on innovative technology-based interventions for children with autism. Wainer and Ingersoll (2011) have examined items based on computerized interventions for building communication and social skills in *autistic* people with the help of the PsychINFI and PubMed databases. Another specific analysis of the studies conducted between 1990 and 2013 in terms of the technologies used for correcting autism at teenagers has been undertaken by Odom et al. (2015) and highlighted their impact on academic achievement, adaptive behavior, communication, independence, social skills and vocational skills. Worthington (2016) has proposed a revision of specialized studies on the treatment and technologies used in the rehabilitation of apraxia. Unlike previous analyses that focused on presenting analytical studies (Boucenna et al., 2014), the present study provides a systematic, detailed analysis on the types of technologies used in correcting speech disorders.

2. Methods

2.1. Identification of studies

To identify studies in the field, there was conducted a comprehensive search of studies focused on the use of interactive psychoeducational intervention technologies for language disorders. There were analyzed only studies in English that were published in peer-reviewed journals between 2007-2017. The study relies on the Cochrane Handbook for Systematic Reviews

of Interventions Version 5.1.0. and a current study on the systematic analysis of information and communication technologies used in psychoeducational interventions for depression (Zhao et al., 2017). These two markers provide updated guidance on the standards and methods for carrying out a complex systematic review.

2.1.1. Search strategy

There was applied a comprehensive search of studies published in journals indexed in international databases, such as Scopus, Taylor and Francis, Web of Science, ERIC. The used keywords included various combinations of terms frequently used in speech disorders therapy: language disorders, speech therapy, speech disorders, language therapy, language technologies.

2.1.2. Operational definition of the main variables investigated

The studies focused on the use of interactive psychoeducational intervention technologies for language disorders have been analyzed in relation to the following variables: the main mode of delivery; communication tools. According to the main mode of delivery, there are three categories (Zhao et al., 2017): web-based, mobile-based and combination. The communication tools are diverse, for example, playback video, display user interface.

In Table 1 there are shown the results of the descriptive analysis of the studies, organized according to the main language disorders (Aphasia, Apraxia, articulation disorder, Autism Spectrum Disorders, Dysartria, Dyslexia/Reading difficulties, Hearing disability, Velo-pharyngeal Insufficiency, voice disorders). For each category of disorder there are mentioned the author or authors of the research, the target group, the type of interactive technologies, research methods and key results.

Table 1.

Language disorder	Author(s)	Target population	Technologies	Application	Results
Aphasia	Cherney & Halper (2008)	adults	computer script training program	- development of three individual scripts, recorded as software and sequential practicing at home	There was found improved verbal communication, increased confidence and satisfaction in using the software.
	Koul et al. (2008)	adults	augmentative and alternative communication	- evaluating the ability to produce examples of graphic icons at different levels of complexity, using a speech generating device	The results indicate that technologies based on augmentative and alternative communication interventions can be effective in facilitating communication for people with severe chronic Broca's aphasia.
	Lojek & Bolewska (2013)	adults	Afa-System	- pretesting (one to three sessions); - 30 hours of therapy for 15 weeks; - several days after completion of treatment (one to three sessions of post-testing)	The study results confirm the importance of using computer-assisted types of technologies for neuropsychological rehabilitation.
	Marshall et al. (2016)	adults	EVA Park, a virtual reality platform	- exploring the effects of intervention on communication and language skills, confidence and feelings of social isolation	The intervention resulted in achieving significant progress in terms of functional communication.
	Rogalski et al. (2016)	adults	Internet-based speech–language therapy (SLT)	- using the customized Web application Communication Bridge	Two months after completion of surgery, the results of the evaluations indicated increased confidence in communication.
Apraxia	Shahin et al. (2015)	children ages 4-16	"Tabby Talks"	- developing a speech processing engine for	The system accurately performs the checking of

		years		automatic delivery of speech therapy; - an interface for therapy management	pronunciation at a rate of 88.2% in terms of phenomenon and at a rate of 80.7% in terms of speech
Articulation disorder	Grogan-Johnson et al. (2011)	elementary school children	interactive videoconferencing (telehealth)	- providing intervention materials via live interactive videoconference	Live interactive videoconferencing is a viable method to correct sound articulation disorders
	Toki & Pange (2010)	preschool children	software	- creation of a software application for e-learning activities to improve speech articulation problems	The learning outcomes of integrated e-learning activities for articulate language in preschool were above average compared to other methods.
Autism Spectrum Disorders (ASD)	Aziz et al. (2014)	children with ASDs and their parents	Educational App	flowchart of the application (Aziz et al., 2014, p. 72)	Children can pursue learning by listening to the sound and afterwards interacting with the image of the object. The application can also help their parents to understand their children's needs.
	Barbu et al. (2015)	people	Open Book System	- Natural Language Processing Components; - Integration Engine; - User Interface	The applicability and usefulness of the Open Book technology were evaluated and analyzed to demonstrate that the tools help the easier production of texts so that these may be understood by people with ASD.
	Beaumont & Sofronoff (2008)	7.5–11years	Junior Detective Training Program	- development of skills and social understanding	In the treatment group, there were improved the social skills in relation to parents and knowledge of emotion coping strategies.
	Cassidy et al. (2016)	adolescents and adults	XpressiveTalk	Expressive visual text-to-speech	Interactive technologies become tools of intervention to improve the processing of emotions and the development of attention in adults with ASD.
	LaCava et al. (2007)	8–11 years	The Interactive Guide to Emotions	- building skills to recognize emotions	The results show improvements in the recognition of emotions on faces.
	Lee & Hyun (2015)	children	"Special Friend, iRobiQ"	- interlocutor friend (Talking Friend); - monitor for the supervisor of children with speech-language disorder (Helping Friend)	Children have learnt to initiate conversations with the robot in terms of changing emotional expressions.
	Mintz (2013)	children	HANDS software	- using a flexible web-based toolkit to develop specific intervention sequences according to the needs of children	Teachers have identified key factors of using mobile applications: awareness of the difficulty, motivation to change one's behavior, preference for intervention-based technologies.
	Mitchell et al. (2007)	14–15years	Virtual environment/ virtual cafe	- building social awareness	Most participants have shown progress in social understanding.
	Silva et al. (2014)	children	Platform myTroc@s.net	- user-tuned content customization	Experimental research results show that the new method requires the achievement of better results due to increased involvement of children in education.
	Whalen et al. (2010)	preschool children	Teach Town Basic	- providing verbal instructions and guiding students in problem-	The preschoolers in the treatment group had made greater progress than those in

				solving activities	the control group in terms of receptive language.
	Yun et al. (2016)	children	robot-assisted behavioral intervention	- examining the feasibility of a robotic surgery intervention system for children with autism	Effectiveness of the robot-assisted behavioral intervention is verified at children with autism. The system facilitates social formation of children with autism through human-robot interaction.
Dysartria	Saz et al. (2009)	children and young speakers	CASLT software - Computer-Aided Speech and Language Therapy	- development and evaluation of a semi-automated system for providing interactive speech therapy for people with impaired speech	Automatic speech recognition (ASR) can provide effective verification of pronunciation at the level of simple words, and the new pronunciation verification (PV) system is useful in detecting the absence of phoneme pronunciations.
Dyslexia (Reading difficulties)	Abtahi (2012)	children	Interactive multimedia learning object (IMLO)	- direct observation of dyslexic children while using the prototype; - observation through the playback video; - interviewing teachers	Children have found that learning with IMLO was motivating, fun, easy. By distributing content in small steps, dyslexic children could perform the task in a short time.
	Parr (2012)	children	text-to-speech technology (TTST)	- developing metacognitive strategies, dialogue and collaboration skills, the ability to respond in writing, self-efficacy and self-representation	TTST facilitates reading strategies (expression, fluency, response), which enables children's access to a variety of interactive and collaborative reading situations.
	Vasilyeva (2016)	second-grade students	interactive computer programs "Furor", "Expo" and "Chibis"	- creating a program for optimizing the operation of visual mechanisms and the possibility of improving reading difficulties	The results showed the positive effect of sessions based on the development and strengthening of visual mechanisms and their indirect influence on the development of reading skills.
Hearing disability	Navarro-Newball et al. (2014)	children with the age between 3 and 10 years	Video game, Talking to Teo	- the use of a speech recognition module for the interaction with the user	Therapists observed increased interest, initiative and persistence of the children in completing exercises.
Language-based disabilities	Frost & McCrindle (2016)	all persons	Kinect	- providing an interactive application for speech therapy that can be used by patients in their own homes	The application provides new possibilities for creating systems of therapy and rehabilitation at home that are attractive, affordable and tailored to individual needs.
	Popovici & Ardeleanu (2014)	elementary school children	Logopedix software	- improving speech disorders in children with dyslalia, language delays, and dyslexia	The results show significant differences in children with delays in vocabulary acquisition as a result of using the software Logopedix.
	Rodríguez & Cumming (2016)	first-grade students	Language Builder	- using an iPad with the Language Builder application to develop language skills for students with disabilities	The data showed significant progress at students from the experimental group compared to those from the control group in terms of building sentences. No significant differences between the two groups in terms of expressive and receptive vocabulary.
	Schipor et al. (2013)	children	computer assisted speech therapy	- developing a framework for automatic recognition of emotions	The results show that there is a good consistency between emotional external and self-assessments.
	Suta et al.	middle-	educational	- development of	Students who were part of the

	(2014)	school students	software	educational software for the rehabilitation of speech disorders (dyslalia, delays in language development, reading and writing disorders, rhythm and fluency disorders)	intervention program based on the use of educational software have produced immediate results in correcting pronunciation disorder.
	Tambyraja et al. (2014)	kindergarten and first-grade children	video-recorded therapy	- determining the association between the therapy time focused on literacy and specific factors for children provided with speech-language pathologists (SLPs)	Children provided with services of speech-language pathologists (SLPs) with many years of experience and/or use of therapy in class were given more time to correct speech disorders.
Velo-pharyngeal Insufficiency	Castillo et al. (2015)	preschoolers	TheraSpeech	- processing and analysis of digital signals with Mel Frequency Cepstral Coefficient	The goal is to detect speech disorders of the specific etiology of phonemes such as plosives, affricates, and fricatives.
Voice disorders	King et al. (2012)	school-age children	Video games	- testing video games by programmers; - observing children while using the video games; - conducting a case study on a child with hyperfunctional voice disorder.	Using video games for therapeutic purposes determines a high level of commitment and motivation in children of school age.

Based on the descriptive analysis of studies, it is possible to conduct a synthetic analysis by mode of delivery and communication tools (Table 2).

Table 2.

Language disorder	**Author(s)**	**Main mode of delivery**				**Communication tools**			
		Web-based	Mobile-based	Robotics	Combi-nation	playback video	Forum	Phone calls	Display user interface
Aphasia	Cherney & Halper (2008)	x							x
	Koul et al. (2008)	x							x
	Lojek & Bolewska (2013)	x							x
	Marshall et al. (2016)	x							x
	Rogalski et al. (2016)	x							x
Apraxia	Shahin et al. (2015)				x				x
Articulation disorder	Grogan-Johnson et al. (2011)	x				x			
	Toki & Pange (2010)	x							x
Autism Spectrum Disorders	Aziz et al. (2014)		x						x
	Barbu et al. (2015)	x							x
	Beaumont & Sofronoff (2008)	x							x
	Cassidy et al. (2016)	x							x
	LaCava et al.	x							x

	(2007)					
	Lee & Hyun (2015)			x		
	Mintz (2013)		x			x
	Mitchell et al. (2007)	x				x
	Silva et al. (2014)			x		x
	Whalen et al. (2010)	x				x
	Yun et al. (2016)			x		
Dysartria	Saz et al. (2009)	x				x
Dyslexia (Reading difficulties)	Abtahi (2012)	x			x	
	Parr (2012)	x				x
	Vasilyeva (2016)	x				x
Hearing disability	Navarro-Newball et al. (2014)	x				x
Language-based disabilities	Frost & McCrindle (2016)	x				x
	Popovici & Ardeleanu (2014)	x				x
	Rodríguez & Cumming (2016)		x			x
	Schipor et al. (2013)	x				x
	Suta et al. (2014)	x				x
	Tambyraja et al. (2014)	x			x	
Velo-pharyngeal Insufficiency	Castillo et al. (2015)	x				x
Voice disorders	King et al. (2012)	x			x	

2.2. Results

Analysis of the studies on psychoeducational interventions using different technologies to correct speech disorders reveals the following results depending on the main mode of delivery and communication tools. In relation to the main mode of delivery, it was found that most studies (25) are focused on web-based technologies, while other studies (3) focus on mobile technologies, some studies (3) on combined technologies and only one study involves the use of robots (Figure 1).

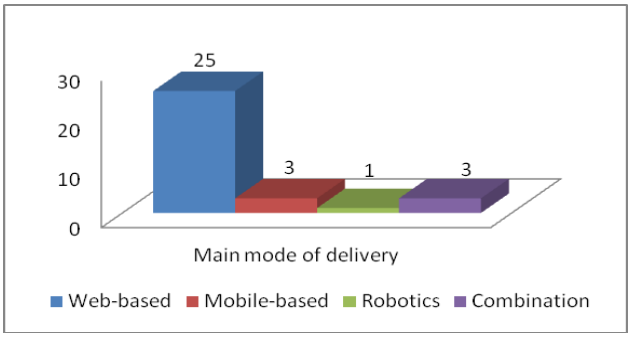

Figure 1. Graphical representation of the frequencies obtained by analyzing the studies based on the use of technologies according to the main mode of delivery

Depending on the communication tools, centralized data show that most studies (28) exploit the display user interface, unlike others (4) that made use of playback video (Figure 2).

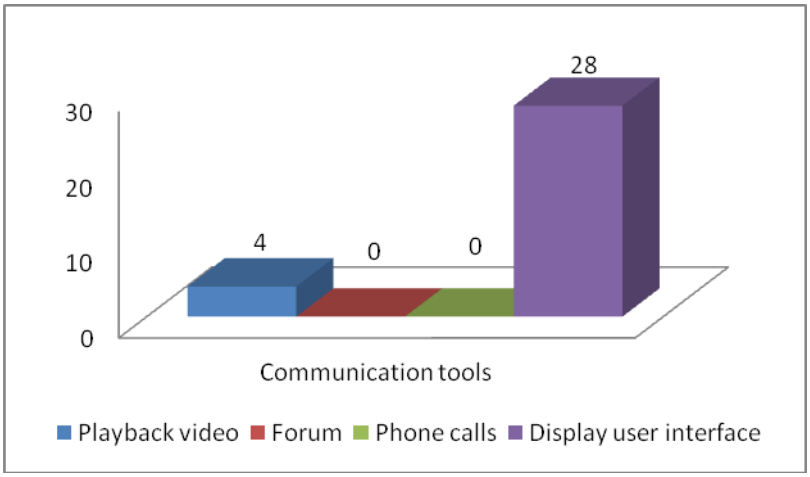

Figure 2. Graphical representation of the frequencies obtained by analyzing the studies based on the use of technologies according to the communication tools

3. Discussions

The results provide evidence for the efficiency of information and communication technologies for speech disorder therapy. Previous studies also confirm the usefulness and necessity of using modern technology to correct speech disorders (Grynszpan et al., 2014). The benefits of applying these technologies are multiple and efficiency is even more increased if we rely on an interdisciplinary approach.

If we consider the *types of technologies* used to improve and correct deficiencies of language, there may be observed a prevalence of the web technologies focused on creating specific educational software, virtual platforms, augmentative and alternative communication systems, computer training programs, internet-based-speech-language therapy, books or electronic guides, virtual communication environments, interactive multimedia learning object, computer reading strategies, video games, computer assisted speech therapy. The latest technologies consist in the use of robots, as revealed by the study of Yun et al. (2016). Surely in the coming years there will be developed advanced technologies for speech disorder therapy. Regarding the *spectrum of speech disorders*, it is clear that of all studies, 11 are aimed at children or people with Autism Spectrum Disorders. There are also a number of studies that relate more to impaired language, indicating the vagueness and lack of long-term effects of psychoeducational interventions. Regarding the *age of the participants* in these studies, it appears that most studies are designed for children from kindergarten and elementary or secondary school, except for the studies in the field of aphasia that are conducted on adults. In terms of the *impact resulting from the application of technologies on psychosocial development*, we have noticed positive effects as a result of the improvement of verbal communication (Cherney and Halper, 2008; Koul et al, 2008), functional communication (Marshall et al., 2016), receptive language (Whalen et al., 2010), vocabulary (Popovich and Ardeleanu 2014), pronunciation (Suta et al, 2014), neuropsychological rehabilitation (Łojek and Bolewska, 2013), confidence in the ability to communicate (Rogalski et al., 2016), articulation of sounds (Grogan-Johnson et al., 2011), school learning outcomes (Toki and Pange, 2010; Silva et al., 2014), easy understanding of text (Barbu et al., 2015), social skills (Beaumont and Sofronoff, 2008), attention (Cassidy et al., 2016), processing and recognition of emotions (La Cava et al., 2007; Lee and Hyun, 2015; Cassidy et al., 2016), understanding social reality (Mitchell et al ., 2007), visual mechanisms (Vasilyeva, 2016), reading skills (Parr, 2012), motivation and engagement in learning activities (King et al., 2012). Whereas the emphasis had previously been on information and communication

technologies to facilitate learning outcomes, there can be seen current changes in the sense of building socio-emotional and behavioral skills for training key skills and abilities. Systematic analysis of studies in psychoeducational interventions based on information and communication technologies to correct speech disorders is useful for researchers in the field as it provides a clear and updated view on the types of technologies used and the results obtained. Based on knowledge of studies in recent years, there can be implemented research based on new technologies to correct language deficiencies. Also, such analyses can be further achieved in order to know and identify the best technologies in speech disorders therapy.

4. Conclusions

In this study there were systematically analyzed 32 specialized articles from the last 10 years in the domain of psychoeducational interventions based on information and communication technologies to correct speech disorders. According to the results, most studies report on psychoeducational interventions that used web-based technologies depending on the main mode of delivery and the display user interface and communication tools. The results of this systematic review provide support for further studies in this area to assess the use of technology-based psychoeducational interventions for people with speech disorders.

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