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Interventions using high technology communication devices: a state of the art review

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ABSTRACT

Background/Aims

In the last 20 years the range of high technology augmentative and alternative communication (AAC) aids has rapidly expanded. This review aimed to provide a "state of the art" synthesis, to provide evidence-based information for researchers, potential users and service providers.

Methods

Electronic databases were searched from 2000 to 2010, together with reference lists of included papers and review papers. The review considered work of any design which reported an intervention using high tech AAC with people who have communication difficulties (excluding those with solely hearing or visually loss) published in peer-reviewed journals.

Results

Sixty five papers reporting interventions using high tech AAC were identified. There was evidence that high technology AAC may be beneficial across a range of diagnoses and ages. The evidence however is currently drawn from studies using designs considered to be at high risk of bias.

Conclusion

The review suggests that the high level of individual variation in outcome requires a greater understanding of characteristics of clients who may or may not benefit from this technology. Also, the wide range of outcomes measured requires further work in the field to establish what a "good outcome" from intervention may be.

INTRODUCTION

Augmentative and alternative communication (AAC) systems have great potential to enhance the lives of individuals with communication difficulties by promoting interlinked elements of independence, social relationships and education. The American Speech-Language Hearing Association [1] defines AAC as a set of procedures and process for maximising functional and effective communication. The term encompasses unaided modes that rely on a user's body to convey messages; for example gestures, signs and facial expressions and aided AAC requiring a transmission device. These devices

may be electronic and commonly referred to as high technology AAC; or non-electronic and described as low technology assistive devices [1].

While there is some lack of clarity in the field regarding terminology, low technology (low tech) systems or devices are usually considered to include communication books or boards (non-powered), written words, photographs, line drawings and pictograms. High technology (high tech) systems are commonly distinguished by being powered. The literature describes custom made communication aids which provide voice output (VOCAs), also referred to as speech generating devices (SGDs). In addition, there is software which can be used on standard personal computers or laptops which provides a voice output. Technology is also available which enables people to access a personal computer or laptop to achieve written communication output.

Authors have described how practitioners face challenges in successfully using these devices with clients. Campbell et al. [2] for example highlighted that practitioners are unsure of when and how to implement AAC systems due to a paucity of research evidence. Schlosser [3] described how practitioners faced a difficult task when matching appropriate systems to individuals with disabilities. It has also been suggested [4] that practitioners and users may have limited access to available systems or services due to funding issues and limited specialist knowledge.

 If speech-language pathologists are to include this technology in therapy interventions, there is a requirement for research evidence to be readily accessible to support evidence-based practice regarding which devices should be provided for who and at which point in treatment. High tech AAC systems are expensive to purchase and repair, and funding may fail to meet total device costs, or include adequate speech-language pathology support [5]. The training of communication partners is also a neglected area for funding.

Decision-making regarding costly provision requires effectiveness evidence to draw upon. While there is a growing body of research exploring the use of high tech aids, published reviews to date have tended to consider predominantly low tech aids. Systematic reviews which have included both high and low tech aids have tended to examine use in specific clinical populations [6 7]. Authors of these reviews have suggested that much available evidence regarding AAC is inconclusive, in particular in regard to generalisation and maintenance of use. Iacono et al. [5] reported that there has been a tendency to provide high tech aids when low tech aids may offer advantages. In addition, the

definition of outcomes to be measured offers a considerable challenge when the goal of intervention encompasses enabling individuals to access life [8].

In view of the increasing range of sophisticated technology being developed to support people with communication impairments, it is important to examine published work regarding the interventions using these devices. Evaluation of study findings is needed in order to provide evidence-based information for funders, potential users, and service managers, and to underpin evidence-based practice amongst speech-language pathologists [9]. This review therefore was undertaken as a "state of the art" review [10] to present an assessment of the current state of knowledge in the field. The work encompassed both quantitative interventions studies and qualitative papers reporting views of service users and providers. Findings regarding the qualitative studies are reported elsewhere [11]. In this paper we consider primary studies reporting evaluations of interventions.

METHODS

Search strategy: Relevant published literature was identified via searching of the CINAHL, Cochrane library, EMBASE, MEDLINE, PsychINFO, CSA, and Web of Science electronic databases. Search terms used related to conditions (for example learning disability, cerebral palsy), impairment terms (such as language disorder, communication impairment), AAC terms (such as speech generating device, assistive aids) and finally commonly used devices (such as Toucan^{TM}). The full search strategy may be obtained from the authors. In addition to this electronic database searching, we scrutinised the reference list of included papers and review papers for additional citations of relevance.

Inclusion/exclusion criteria: The review considered studies of any design published in peer-reviewed journals between 2000 and 2010 that were reported in English. The population under consideration was any person who has a communication difficulty not resulting from a primary auditory or visual loss. The review also encompassed studies reporting data from relatives/significant others of these people with communication difficulties, together with staff delivering services. The review examined "high technology" communication devices only. Due to some inconsistency of terminology in the field we took the pragmatic decision to define high tech devices by exclusion as those alternative and augmentative communication methods or devices which are powered and cannot be described as low technology. Software that could be used only as a treatment tool during therapy sessions was excluded for example computer programmes used for word finding drills or articulation practice.

Quality appraisal: Due to the inclusion criteria encompassing work across the hierarchy of study designs we assessed the quality of the included papers using the quality domains developed by West et al. [12]. This framework identifies five quality domains to be considered when appraising the risk of bias in studies encompassing: the comparability of participants; the intervention; outcome measurement; analysis method; and funding source. Study design terminology is used variously by different researchers in different disciplines. We adopted the typology used by the Centre for Reviews and Dissemination [13] which classifies experimental studies as those which allocate participants to intervention or control groups (randomised controlled trials or quasi-experimental studies); and observational designs where interventions are determined by usual practice or "real world" choices rather than allocation. These include cohort studies which compare participants who did or did not receive an intervention over time, case control studies which match "cases" and "controls" from the same population, before and after studies where measurements are taken at baseline and follow up, case series designs where there may be a single measurement point or observations taken over time, and case studies with a single participant.

Selection of publications for review: The initial search retrieved 2883 unique citations. All retrieved literature was screened at title and abstract level for relevance, and those that had potential for inclusion were taken through to full paper appraisal and extraction of data. Following the initial sifting 299 papers were examined as full papers with inclusions and exclusions checked by a second member of the research team. A flow chart illustrating the process of inclusion and exclusion is available from the authors.

RESULTS

Study characteristics: The review identified 65 papers, most with small numbers (1-5) of participants. The studies encompassed work from ten different countries (33 North America, 7 Italy, 6 Germany, 5 Australia, 5 UK, 4 Sweden, 1 each from South Africa, Japan, New Zealand, The Netherlands). The origin of a final paper was unclear. Interventions using the full range of high tech devices encompassing VOCA/SGDs, voice output computer software, and input/controls such as speech recognition technology and brain-computer interfaces were reported. An extraction table detailing each study is available from the authors if required.

Study quality: Using the appraisal outlined above, the most significant quality issues noted across the set were: a preponderance of case study and case series designs; small sample size (only

three papers reported work with ten or more participants); an absence of studies using comparator interventions; and no work using random allocation. In many cases the intervention was ill-defined with a short period between baseline and follow up measures; and authors reported descriptive data rather than detailed or statistical analysis. Many papers had considerable heterogeneity of participants in regard to type and level of communication need.

Intervention outcomes: The outcomes reported encompassed a wide range of measures, with the most commonly used being a count of initiation or response attempts using an AAC device (23 studies). Nine used linguistic analysis (such as Quantitative Production Analysis), and eight evaluated the effectiveness or intelligibility of communicative attempts. Four papers included the use of standardised language test scores, and two evaluated comprehension. There was a single study using rating of behaviour, one considered of ease of use, four provided some description of use and one study rated client satisfaction.

Participant characteristics: Participants included people with acquired non-progressive and progressive neurological disorders, autism/autistic spectrum disorder, and other developmental disorders. There was considerable heterogeneity of participants in some studies, with diversity in terms of age, diagnosis, or pattern of communication difficulties.

Acquired non-progressive neurological disorders

The most commonly reported adult client group was use of high tech AAC in people with aphasia resulting from a variety of non-progressive causes (14 studies) with all but one using computer software interventions. The largest group concerned aphasia resulting from a cerebro-vascular accident (CVA). The only study evaluating a VOCA intervention [14] investigated the use of TouchSpeak[TM] in 30 people with severe aphasia following CVA. Following the intervention thirteen participants had no functional usage of the device, five were dependent users, five were independent users and seven were extensive users. Another paper [15] outlined use of the SentenceShaper To Go[TM] portable device and found benefits in terms of the number of correctly used words and fluency retelling a message. Evaluations of the SentenceShaper[TM] program [16 17 18] describe gains in narrative production however little carry over to spontaneous use. Four further papers [19 20 21 22] found positive outcomes with people who have aphasia, including gains in formal language assessments and grammatical structures. A single paper [23] described less beneficial outcomes from software interventions, reporting varying success in use of the C-Speak[TM] Aphasia program.

Four studies evaluated use of voice recognition computer programs in this client group. Two [24 25] reported successful use of the DragonNaturallySpeaking^{TM} program with a recognition accuracy of up to 65%. Wade et al. [26] reported insufficient accuracy levels for reliable usage although Dahl et al. [27] described that problems of accuracy could be resolved by using SentenceShaper^{TM} alongside voice recognition programs.

The use of AAC in people who have locked in syndrome was described in four papers. One, [28] outlined that three of the six participants continued to use the technology following completion of the trial. Papers by Lancioni et al. [29 30 31] evaluated use of a microswitch and computer with voice output device. The results indicated that frequency of responding was increased by using the system. One further paper relating to adults with non-progressive neurological disorders [32] described the use of a laptop computer with word processing software for a male following total glossectomy and layngectomy. The paper disappointingly provided only general description regarding outcomes however.

Acquired progressive neurological disorders

Papers included in this review described interventions for people with Amyotrophic lateral sclerosis (ALS)/ Motor neurone disease, primary progressive aphasia and Alzheimers disease.

Eight studies investigated use of brain-computer interface (BCI) technologies for people with ALS and found gains using the Thought Translation Device^{TM}, an EEG-based (slow cortical shift) tool, enabling some participants to select letters to spell words [33 34 35 36 37] turn their communication device on and off [38 39] or enable yes/no responses [40].

Patee et al. [41] compared a text to speech AAC device to sign language for a person with primary progressive aphasia and apraxia of speech. They reported that there was a greater increase in correctly used words using sign language, and the participant rated the device as less useful and less easy to use than sign language. One paper [42] assessed usage in people with dementia, comparing a message board with pre-recorded speech output with no speech output. The results indicated that there were more single word utterances and fewer total utterances when the AAC device included speech output.

Autism/Autistic spectrum disorder (ASD)

Thirteen papers related to high tech AAC use with people who have autism or autistic spectrum disorder. Studies by Olive et al. [43 44] described positive effects such as increased total requesting

and decreased episodes of challenging behavior following milieu teaching combined with a VOCA, and Functional Communication Training and a VOCA. Schlosser et al. [45] investigated use of a VOCA for five children with autism requesting food at snack time, and found variable outcome across participants. Other studies [46 47 48] outlined evidence of positive impacts on requesting using a single recorded message on a SGD.

The effectiveness of different AAC interventions was compared in three studies. One [49] examined use of a SGD versus a Picture Exchange Communication System (PECS). Requesting increased using both systems, with preference based only on whichever was nearer. Other studies in this client group compared a SGD versus PECS and found little difference in outcomes between them [50], and compared peer-mediated naturalistic interventions with and without a SGD reporting a significant increase in communicative behaviours using the SGD [51]. An additional paper [52] outlined that improvement in comprehension could result from use of a VOCA. The use of AAC by children with autism in the home setting was explored in three papers [53 54 55]. The authors of this work concluded that AAC could be used successfully and have beneficial effects on communication effectiveness and engagement rating.

Cerebral Palsy

Twelve papers were identified which described the use of AAC with children or adults who have cerebral palsy. One [56] which evaluated the introduction of Swedish DragonDictate[TM] and Infovox[TM] systems outlined gains in with recognition accuracy of 26-60%. Another [57] assessing the use of DragonDictate[TM] reported that while one participant withdrew from the study, the other achieved gains in computer access efficiency of 40%.

Hawley et al. [58] developed a limited vocabulary system with computerised training package for a home environment which achieved a recognition accuracy of around 95%, operating around twice as fast as a switch control system. Another study [59] employed user movements to access a computer via a "camera mouse" with six of the ten participants able to use the technology to spell out communications. A system which detects minute facial muscle or eye movements in addition to brain waves, enabling movement of a computer cursor to make communication choices (Cyberlink[TM]) was evaluated in one paper [60]. Two children achieved an 80% success rate in changing a picture on a computer using the system. An EEG-based BCI system was used by an adult with severe cerebral palsy with a 70% correct response rate for copy spelling following training in one study [61].

A Swedish study [62] described the use of Blissymbols[TM] on a SGD. The authors described progress with reading, writing and communication for the two child participants, however outcomes are not clearly reported. Another study [63] described the use of TALK[TM], a text-storage and retrieval system. The single participant tested with the system achieved a conversational rate of 64 words per minute, and in another paper [64] the same authors described successful use of a pre-storage device. The Speech Enhancer[TM] (a portable voice processor unit with speakers and feedback to the user) was found to be effective in improving intelligibility as rated by an experienced listener [65]. Other positive outcomes reported were increased unprompted use of a VOCA [66]; and an increase in assertiveness, longer utterances, language and literacy [67].

Other developmental disorders

AAC interventions for children described as having multiple or complex developmental disorders were outlined in eleven papers. In one [68] gains in syntactic complexity using a SGD were outlined however pre-post test score change was smaller for the SGD than for a communication board. Interventions evaluated by Lancioni et al. [69 70 71 72] increased the number of utterances used by children with "severe intellectual disability".

DiCarlo & Banajee [73] assessed use of a VOCA with two adults, one diagnosed with Angelman syndrome and the other a chromosomal abnormality. The frequency of initiations during snack time increased for both participants (16-41% and 4-27%) with a reduction in unclear initiations and prompted behaviours. Another paper [73] compared the effectiveness of PECS versus a VOCA. All participants increased the number of spontaneous requests during the intervention, half acquired use of PECs earlier and for half there was no difference between acquiring use of the VOCA versus PECS. Sevcik et al. [75] also reported positive outcomes following the introduction of a SGD however provided only general description. Other studies described beneficial effects in a child with apraxia of speech [76]; a three year old with lobar holoprosencaphaly [77] and a 17 year old with multiple disabilities [78].

DISCUSSION

We reviewed the literature on interventions using high tech augmentative and alternative communication aids and identified 65 papers published in the last 10 years. Papers were found evaluating the use of a wide range of technology (speech generating devices/voice output

communication, voice output software on personal computers or laptops used as a communication aid, and technology which provides access to personal computers or laptops).

The findings of this review suggest that these devices may be beneficial to enhance communication across a broad range of diagnoses and age ranges. The reported variability in outcome within groups of individuals using the same system is important to note however. There was a considerable range of outcome measures used by authors. Studies described devices enabling communication at very different levels, ranging from indicating a yes/no response to sentence generation, with a predominance of frequency of utterance or accuracy measures. Some authors of included papers highlighted the limitations of baseline and follow up measures and measures taken in controlled environments which did not take functional usage into account.

While we were able to identify a substantial body of papers evaluating interventions using high technology AAC, that there is currently a lack of high quality evidence of effect. This is due to a lack of good quality studies rather than there being evidence of a lack of effect. It is important to note the predominance of case series or case study designs in the field representing only level IV evidence [79]. There is currently a dearth of studies with comparator arms, which while presenting challenges must be a future priority if the evidence base is to be strengthened. While considered to be the design most subject to bias, case studies are commonly used and reported in the healthcare literature. It has been argued [13] that they can be a helpful source of information about adverse events, can generate hypotheses, provide more participants, longer follow up and are more generalisable than controlled trials. However, they have significant limitations in terms of providing conclusive evidence of effectiveness. The evidence from these case studies should be used to underpin stronger designs in future research.

The review included a comprehensive search of electronic databases, and citation checking, however did not encompass hand searching of journals which may have identified additional references. The definition of high technology versus low technology is subject to some lack of clarity in the literature and it is possible that papers of relevance were excluded using our criteria. The area where we considered that there was most potential for debate was in relation to the use of computer-based technology with people who have aphasia. We endeavoured to distinguish between software intended for intervention purposes only versus that designed to enable functional communication.

Some of the programs identified (such as SentenceShaper™) could be considered to be on the margins of AAC.

Much of the work, while describing generally positive outcomes (which may be attributable to publication bias), reports variability in response to intervention amongst participants. Future work would benefit from endeavouring to recruit using closer matching of individual communication levels rather than the tendency towards sampling by diagnostic category. There is an urgent requirement to extend our understanding of the needs and characteristics of clients who may or may not benefit from high tech AAC technology. Some papers suggested that aspects such as visual semantic processing or cognitive functioning may impact on the response to intervention. In particular consideration needs to be given to controlling for attention as many of the studies cited above provided fairly intensive teaching and support of communication in general, which may have affected the outcomes whether with or without AAC. If characteristics of people who successfully use high tech AAC can be identified, this would provide important information for decision-making regarding provision. Further research would also be helpful to compare the use of different devices, and the benefits of low tech versus high tech systems. There was the suggestion that for some individuals low tech interventions may be more beneficial.

Many studies described their limitations in terms of a being undertaken in a highly controlled context with lack of consideration of functional use and environmental factors. Issues relating to fidelity of the intervention regime may adversely impact on outcomes outside these research environments. A minority of the papers evaluated use in a home context. Further work exploring how effective the technology is in aiding communication in a functional setting is needed.

Considerations of controlled versus more functional settings raises issues regarding the measurement of AAC intervention effectiveness. There is currently debate regarding what the consideration of a successful outcome should be [79]. The identification of appropriate outcomes following intervention presents a significant challenge for the field. Outcomes could encompass successful introduction of a device, evaluation of client experiences, training of conversational partners, and/or ongoing satisfaction. The literature examined in this review used a wide variety of measures however many were frequency counts of communication utterances. It is recognised across the field of communication impairment that outcome measures need to cover a range of communication tasks and purposes, and that the individual's own views are important. A greater

emphasis on developing functional measures of high tech AAC intervention effectiveness seems warranted.

Acknowledgements

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