Computer-Aided Rehabilitation

Computer-aided rehabilitation refers to the use of computers in the rehabilitation of Communication Disorders. The term rehabilitation is used to refer to the process of restoration or accommodation of communication skills following an acquired communication disorder. Within the field of communication disorders, the use of computers within rehabilitation has been most extensively studied in relation to the topic of aphasia due to stroke or other brain injury. For this reason, the following entry will focus largely on this condition alone, although the principles may also be applied to other acquired communication disorders to a greater or lesser extent.

General principles of rehabilitation are introduced first, before a description of how computers are used within rehabilitation. Examples of different computer packages are described, followed by a summary of the relevant research evidence. A discussion of the benefits and limitations of computer-aided rehabilitation are presented before a final summary and an indication of future areas for development.

Rehabilitation Principles

Rehabilitation of aphasia is typically guided and administered by a qualified speech and language therapist / pathologist (henceforth therapist). The therapist will first assess the nature of a person's communication disorder and then identify appropriate activities and exercises to address that individual's specific communication needs. In addition to in-person therapy activities, exercises may include computer-based practice. Computer-aided practice offers an opportunity to extend and increase the intensity and dose of therapy in line with the

now generally accepted principle that neurological rehabilitation requires repeated practice of a skill.

How are Computers Used?

Structured and repetitive computer-based exercises can be used to supplement and extend the practice provided by a speech and language therapist. Computers may additionally be used to support online tele-rehabilitation and enable continued access to a speech and language therapist across a distance (for example, where a person lives in a remote setting that cannot be easily or regularly reached by a community speech and language therapist). Equally, remote rehabilitation can be used to reduce the physical travel demands on the person with aphasia, without diminishing their opportunity to work with a therapist. (See telepractice for further details.) Most research evidence generated to date has explored the use of computer-aided rehabilitation in people who are comparatively chronic in presentation (i.e. those who have been living with aphasia for a period of three or more months) and who present with mild to moderate levels of aphasia. Here, researchers have demonstrated positive therapeutic outcomes for people who may be several years' post-acquisition of their communication disorder.

Examples of Computer-Aided Rehabilitation

Computers have been used to explore a wide variety of communication difficulties experienced by people with aphasia. Some examples include the practice of naming abilities, the rehearsal of targeted conversations using a virtual agent, the practice of gesture production and practice of conversation with an online communication partner. A description of each example is presented below.

Treatment of Naming

The most common type of therapy software implemented in rehabilitation addresses naming difficulties (Anomia). Anomia is a key feature of aphasia and is exemplified by a difficulty in being able to find and produce a desired word. Computer software packages have been widely used to support the rehabilitation of anomia through exercises which present an identified set of vocabulary items and provide varying levels of support to enable a person with aphasia to identify them. Exercises may target both receptive understanding of a word or expressive production of that word, either in spoken or written form. For example, in training receptive vocabulary, a computer may present an image of a target word (e.g dog) alongside three related images (e.g. "cat", "mouse" and "bear"). The person with aphasia will hear the word "dog" as a spoken word – presented through the computer's speakers. They will then be asked to identify the correct picture from the selection of four options by clicking on the chosen image using a mouse or a touch screen to make their selection. The computer will identify whether the correct image has been selected and may give feedback to the person about whether their answer was correct in the form of a visual prompt such as the appearance of a tick or a cross as well as an audio prompt to indicate either a positive or negative choice. Tasks such as the one above may be adapted to increase or decrease their demands for an individual user. For example, the number of picture choices presented may be increased to six or reduced to two. Similarly, the choice of picture alternatives may be altered so that the images become visually alike or that the names of the pictures share more phonological information (e.g. "dog" may be presented alongside "log", "dot" and "doll" – see phonology). This offers the therapist an opportunity target specific facets of naming difficulties – for example, phonological deficits.

To train expressive vocabulary, similar methods are employed. An image may be presented of an object and the person with aphasia is encouraged to name that given object aloud. The person may be presented with several cues to help them 'find' the given word. For example,

the first written letter of that word may be presented visually, or the first phoneme of the word may be presented auditorily upon the press of a button. The task may again be simplified by presenting either the full written or spoken word for the user to repeat or a video of a person saying that word aloud.

In addition to the treatment of nouns, computers offer additional potential to work on other classes of words – such as verbs – by using video in place of a still image. This dynamic presentation offers an advantage over traditional paper-based picture resources which are used away from the computer.

For all treatments of naming, exercises such as those described are repeated numerous times for a chosen set of target words – facilitating the neurological consolidation of the identified skill.

Conversation Practice

Whilst the largest body of evidence for the effective use of computer-aided rehabilitation of communication is focused around naming, there is also evidence to support its use as a tool at conversational level. Leora Cherney and colleagues report the use of a software which supports scripted conversation. Here, individuals can rehearse a series of spoken conversational turns using a virtual agent (an animated talking head) who speaks aloud the scripted utterances in response. Scripts personally-relevant for each individual are devised in collaboration with a speech and language therapist. Scripted conversation practice can also provide varying levels of support to enable a person to say their target lines aloud. For example, people can begin their practice by hearing their part of the script spoken aloud in addition to seeing their target sentence in written form. They can produce their "lines" in chorus with the computer. With practice, an individual might work towards independent and

un-prompted production of their “lines” in response to allotted turns in conversation, thus moving towards a more naturalistic conversational situation.

Gesture Practice

Using similar repetition principles to those previously described, gesture recognition has been used to train individuals with very severe expressive aphasia to produce a series of communicative pantomime gestures which could be used to stand in for vocabulary they are unable to produce verbally. (For example, a “C” shaped hand being raised to the mouth might be used to indicate “drink”.) Roper and colleagues report a technology where individuals observe a video demonstration of a gesture and are invited to repeat it. Gesture recognition technology monitors an individual’s gesture production and gives feedback (in the form of an “applause” sound effect) if the gesture has been produced correctly. Again, exercises can be repeated numerous times to consolidate learning. In addition, this software additionally makes use of aspects of gamification to encourage repetition – awarding points for each gesture correctly produced.

Virtual Environments

Online virtual environments offer opportunities to carry out remote, unscripted conversational practice with a therapist, via the use of an avatar. Marshall and colleagues report an example where individuals use a computer with a microphone headset to connect to a tailor-made virtual environment. Within the environment the individual with aphasia is represented by a virtual avatar whose voice is conveyed through use of their microphone. The online environment includes virtual versions of everyday spaces such as shops, cafes and houses and individuals can use their avatars both to negotiate elements of the landscape and to interact with other members of that virtual environment. Speech and language therapists connect to the same environment and are similarly represented via avatars. Daily

appointments to meet a speech and language therapist “in-world” provide opportunities to practice conversation and work on communication goals. The virtual environment is intended to provide a safe space for practice with the aim that individuals might subsequently transfer their developed conversational skills to an outside setting.

Apps

Beyond the methods described above, there are a growing number of apps offering opportunities to practice language activities. At present, limited research has been undertaken to explore and report the effects of many of these programs, however their increasing availability creates a necessity to understand their contribution in greater detail.

Compensatory Use of Computers

In addition to the recovery of impaired skills in aphasia, computers can also be used to stand in for those abilities which have been reduced. For example, a person with limited ability to express themselves through spoken sentences may benefit from being able to construct sentences which can be spoken aloud using a handheld device. Or, a person with limited reading ability may benefit from text-to-speech software - which can capitalise on an intact understanding of spoken language to read aloud written digital content such as emails, web pages or eBooks. Further information regarding the compensatory use of computers can be found in Augmentative and Alternative Communication (AAC).

Effectiveness of Computer-Aided Rehabilitation

Research demonstrates that computer therapies can provide effective outcomes for participants with aphasia – particularly in relation to the treatment of naming difficulties. Some evidence is available in relation to computer therapies which target speech beyond the single word level or those which target gesture – although this is currently more limited in scale. Using the available evidence, we can observe that for treatments which target single

words or gestures, improvements are typically limited to the list of words (or gestures) which have been practised. These gains do not automatically generalise to improvements for other words or gestures which have *not* been practised. For treatments which target sentence level practice, there is some evidence of generalisation beyond the specific sentences which have been practised.

In relation to the persistence of treatment effects, evidence suggests that improvements observed because of computer-aided rehabilitation are largely maintained in the short term (i.e. the newly established skills persist for up to two months after practice has ended). Less is currently known about their persistence after two months or more.

Considering the applicability of computer-aided rehabilitation, research indicates that - given appropriate training - participants with aphasia can use therapy technologies to carry out independent practice. The amount of practice reported however, varies from individual to individual. Similarly, although overall figures indicate the benefits of computer-aided rehabilitation, the size of improvement may vary from individual to individual. Little is currently known about the precise factors that contribute to the relative success or failure of computer-aided rehabilitation for people with aphasia.

Benefits of Computer-Aided Rehabilitation

Repeated practice

Computers offer an opportunity for repeated practice of a skill. They can be used by people either within a rehabilitation setting or at home. Specific language/communication exercises can be undertaken at regular intervals to maximise the amount of practice achieved. This is a key strength of computers - which enable the application of neuro-rehabilitation principles of massed practice beyond the levels which can be achieved within the often-limited provision of one-to-one speech and language therapist input. Further use of game-like qualities (such as

the accumulation of points) can also be leveraged to encourage computer-use and motivate repeated practice.

Customisation and the Opportunity for Autonomous Practice

Computer programs enable the presentation of consistent training stimuli and allow exercises to be tailored to accommodate the specific nuances of an individual's communication disorder. Computer-aided rehabilitation can also offer the opportunity for a person to practice in their own time and, once trained, without the dependence on other agents of care – for example, they may not rely on the presence of a therapist or care giver to administer or facilitate all their practice.

Monitoring of Practice

The use of computer software in rehabilitation enables a therapist to monitor the amount and type of practice being undertaken as well as an individual's performance on a given task. This can then be used as an indicator for progress and to refine and inform future decisions around the choice of specific therapy activities and practice items. Where software captures audio recordings of a person's speech production during practice, a therapist can review the recordings to give the person with aphasia feedback on their accuracy.

For online therapy software, automatised data collection can facilitate the centralised collation of "big data" regarding the performance and progress of very large numbers of individuals with aphasia across a wide geographical area. The scale of this data offers opportunities to understand more about the worldwide population of people with aphasia and their responses to therapy along a range of parameters.

Limitations of Computer-Aided Rehabilitation

Importance of Therapist Support

Computers do not provide a substitute to human therapeutic intervention. At present, whilst they offer opportunities for structured and remote practice, they do not fully emulate real-life human interaction. Therapists necessarily play a vital role in the careful selection of appropriate computer rehabilitation packages to suit an individual and in the training of that individual to access them.

Accessibility Issues

Aphasia typically impacts upon a person's ability to engage with computers – both due to the impact upon an individual's ability to read and write and their ability to navigate through sequential information. Individuals with aphasia may also experience visual and physical difficulties related to their brain injury which impact on their ability to interact with computer technologies. Such factors may inhibit an individual's ability to access mainstream technologies without support. Similarly, even specialised computer technology is likely to require some level of training and support to be utilised effectively.

Accuracy of Speech Recognition

At present, computer packages are better able to provide feedback on receptive language exercises (such as the correct identification of an image associated with a spoken or written word) than for expressive language activities which require accurate speech recognition to identify whether a target word has been spoken aloud correctly. For receptive activities, a system can be programmed to identify a correct selection from a limited choice of options. (e.g. clicking on the correct picture out of four choices). Feedback on the accuracy of spoken productions however, is a more complicated technical exercise, requiring the employment of speech recognition software which – at present – is unable to respond reliably to atypical speech and the language productions which typify aphasia.

Summary and Areas for Future Development

At present, we know that computers can be used to effectively extend practice opportunities for rehabilitation exercises in aphasia. This has been demonstrated most clearly for people with chronic aphasia. Future work may aim to explore further the use of computer-aided rehabilitation in the more acute stages following stroke or brain injury. More work is also needed to explore the use of therapies beyond the single word level, for example, to support conversation and the understanding and production of written material. Furthermore, the use of tablets and software apps presents a new and comparatively underexplored field of development in computer-aided rehabilitation. The rise in the use of technology in all walks of life provides increasing impetus to explore the potential benefits and applications of computers and tablets in the rehabilitation of communication disorders.

To date, we have seen the development of computer-aided rehabilitation to include the implementation of novel technologies such as gesture recognition and virtual environments. The continuing advancement of technology offers exciting opportunities to capitalise on the novel environments and capabilities offered by such devices to extend rehabilitation opportunities even further.

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Cross references:

Aphasia, Aphasia Intervention, Technology and Communication Disorders, Telehealth, Telepractice

Further readings

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