CITY UNIVERSITY LONDON

Technological Applications in Aphasia Therapy

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Overview

- Background
  - Rationales for using technology
  - Applications from the literature
- Projects at City University London
  - GReAT
  - Remote Aphasia Therapy
  - EVA
- Conclusions

Rationales

- Efficiency savings
- Delivery of an intensive treatment dose
- Autonomy and self determination for the person with aphasia
- Opportunities for personalisation of therapy materials
- May be more acceptable to clients than paper and pencil materials
- May enable the person to compensate for their impairment
- Opportunities for social inclusion and 'authentic' uses of language
- Face saving

Applications from the Literature: Language Remediation

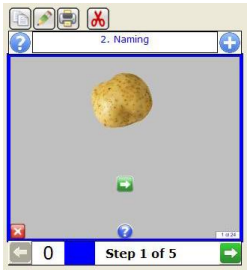
- Computerised delivery of therapy exercises
- Self administered or administered with therapist support
- Can target different aspects of processing and different language modalities
- Can be hierarchically structured and personalised
- Several reports of positive outcomes, e.g. for
  - Word finding (Adrian et al, 2011; Doesborgh et al, 2004; Fink et al, 2005; Laganaro et al 2006; Palmer et al, 2012)
  - Comprehension (Archibald et al, 2009)
  - Verb and sentence processing (Furnas & Edmonds, 2014; Thompson et al, 2010)
  - Discourse (Lee et al, 2009; Cherney, 2010)
  - Speech (Whiteside et al, 2012)

Example: StepByStep ©

(www.aphasia-software.com)

Graded exercises

- Repetition
- Naming
- Spelling
- Word comprehension
- Sentence production



e.g. Mortley, Wade, Hughes & Enderby, 2004; Palmer et al, 2012

Palmer et al 2012

- 34 participants
  - Stroke at least 1 year ago
  - Predominantly mild/moderate aphasia
  - Naming impairment
  - No severe visual or cognitive impairments (screened with a simple computer game)
  - Randomised to intervention and control group

Control group:

Usual care

Communication support groups

Intervention group:

Usual care + Step by Step

Personalised progression through exercises

Supported by volunteer

Advised to practise at least 3 times a week for 20 minutes

5 months

Results

- 11 people completed the intervention with the recommended intensity
- 4 practised less intensively (of these, 3 had no volunteer support)
- 2 lost to follow up @ 5 months
- 4 lost to follow up @ 8 months

Participants undertook an average of 25 hours independent practice with 4 hours volunteer support and 4 hours 23 minutes SLT input

Improved word retrieval for Intervention Group

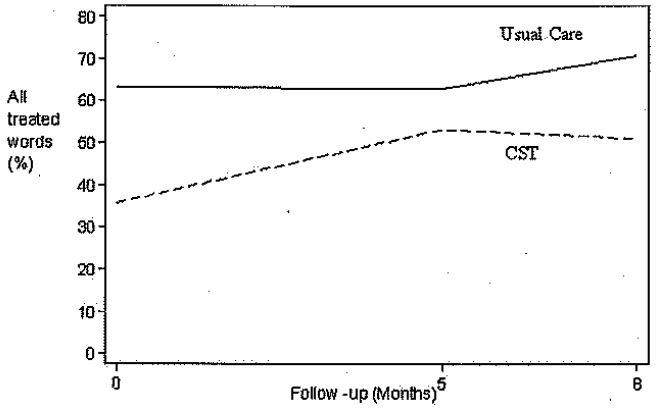
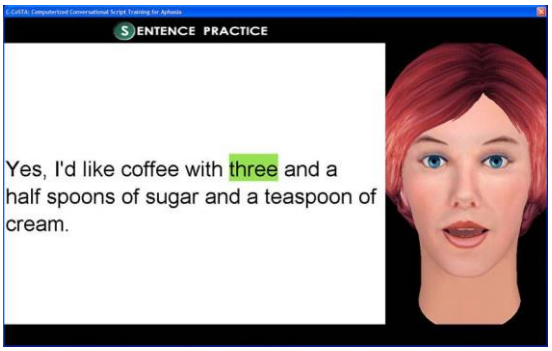


Figure 2. Percentage of words named correctly in intervention and control groups.

AphasiaScripts (Cherney et al, 2012)



AphasiaScripts (Lee et al 2009)

- Practice in personally chosen conversations, such as:
  - Ordering a coffee
  - Talking to a grandchild
- Computer Avatar acts as virtual therapist and conversational partner
- 3 Hierarchical steps
  - Listening to the whole conversation
  - Practising individual sentences (modelled by Avatar)
  - Practising whole conversation (Avatar as partner)
  - Participant can manipulate levels & cues and can record/listen back to their own speech

AphasiaScripts (Lee et al 2009)

- 17 participants received 9 weeks of therapy
- Each worked on 3 individualised scripts
- Improvement measured in:
  - Number of words produced from the script
  - Number of words from script per minute (rate)
- Measures taken from live production of the script with a real therapist

Outcomes

- All bar one participant improved on at least one measure
- Extent of change correlated with amount of practice with the tool
- Severity of aphasia negatively correlated with amount of practice
- Severity of aphasia negatively correlated with content gain

Applications from the Literature: Compensation

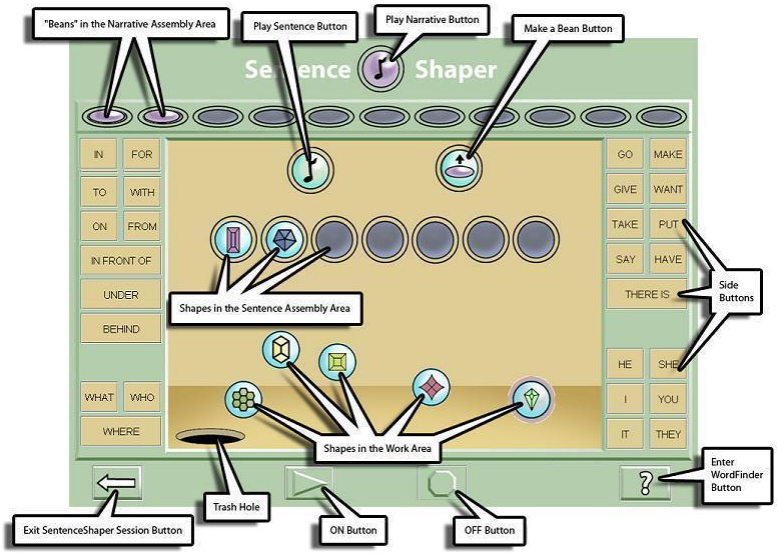
- Uses computer
  - To scaffold, rather than remediate output
  - As a communication aid
  - Examples Sentenceshaper & Touchspeak

Sentence Shaper: The Rationale

- Exploits hidden grammatical potential of people with aphasia
- Reduces the processing load of generating speech
- Provides a 'processing prosthesis'

SentenceShaper (Linebarger et al 2000; 2004; 2007)

- Computer aid that:
  - Stores snippets of recorded speech
  - Replays snippets, when the relevant icon is pressed
  - Allows snippets to be ordered into connected speech:
    - First into sentences
    - Then into narratives
  - Provides lexical supports via side buttons; these store high frequency verbs and prepositions; when the buttons are pressed the machine produces the relevant word; side buttons can be personalised for individual users.



Typical Therapy Programme

- The therapist trains the aphasic person to use the soft ware, e.g:
  - How to record fragments of speech
  - How to order the fragments
  - How to make use of the side buttons
- The aphasic person then practises with SentenceShaper at home
- They may have regular catch up meetings with the therapist
- Their use of the soft ware can be remotely monitored.

Findings

- Practice with SentenceShaper makes speech:
  - More grammatical
  - More informative
- Gains have been observed in aided and *unaided* production; i.e. after a period of practice with SentenceShaper participants produce improved narrative speech even without the aid.

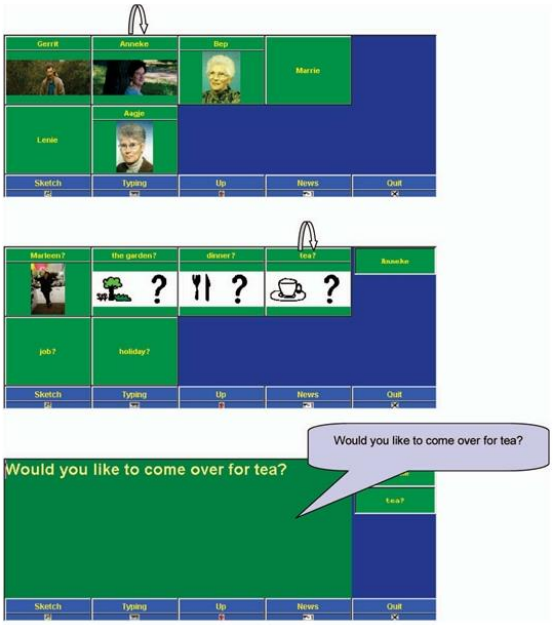
TouchSpeak

- Hand held aid to support communication
- Personalised vocabulary of words, and sentences

Hierarchical organisation of content

Ready made utterances

Represented in words or pictures



Research Findings

(Van de Sandt-Konderman et al, 2007)

- 35 people with severe aphasia
- 12 hours training in the use of a hierarchical vocabulary, e.g.:
- ‘please pass me the remote control’ via:

Home

Living room

Television

Remote Control

Research Findings

(Van de Sandt-Konderman et al, 2007)

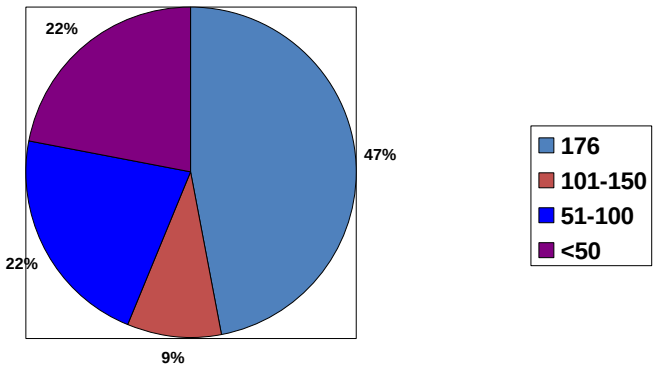
- 12 hours training on functional use of TouchSpeak
- Chose two situations, e.g. Shopping and Telephoning
  - Build personalised vocabulary
  - Practice navigation
  - Use TS in role plays

Evaluation

- Navigation
  - The number of vocabulary items that the person can access after 6 hours training
- Communication
  - Pre/post scores on the Rijndam Scenario Test
- Quality of communication
  - Quality ratings for communication in chosen situations (by participant, SLT, caregiver)
- User satisfaction
  - Participant and caregiver rate satisfaction with TS

Figure 3. Rijndam Scenario Test, item 2. *You are in a clothes shop. You have found a nice sweater and you try it on. The sweater does not fit. Please show me how you communicate this problem.*

Navigation: Size of Mastered Vocabulary



Communication

- Significant gains on the Scenario Test
  - (involves scenarios that are different from those trained with TS)
- Significantly improved ratings of communication in trained situations
- High user satisfaction ratings
  - (70% of participants rated TS as good, very good or excellent)

Conclusions

- Navigation of TS achieved by most participants
- Use of the aid improved communication in target scenarios and beyond
- Participants viewed the aid positively
- Some long term use was achieved, but most discontinued after 2 years

Applications from the Literature: Mainstream Technologies

Mainstream Technologies: Examples

- Copy and Recall Treatment for writing, using text feature of mobile phone (Beeson et al, 2013)
- Use of text to speech software to treat dysgraphia (Estes & Bloom, 2011; Caute & Woolf, in press)
- Use of e readers to address reading impairments (Caute & Woolf, in press)

Projects at City University

- Computer therapy for non verbal modalities
  - GReAT
- Remote delivery of therapy
  - A Feasibility Study
- Virtual social networking opportunities
  - EVA

GReAT

Gesture Recognition in Aphasia Therapy

Project Aims

- To develop a computer gesture therapy tool for independent home based practice
- To pilot the tool with participants who have severe aphasia

Phase 1: Participatory Design

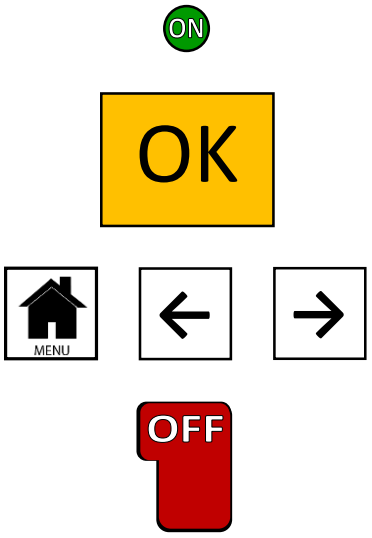
Engaging end users in design process

5 Consultants with aphasia

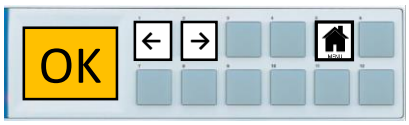
Each took part in 9 participatory design sessions exploring:

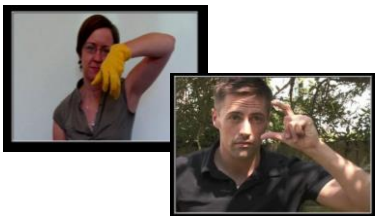
Computer gesture recognition
Presentation options (3D worlds)
Navigation options

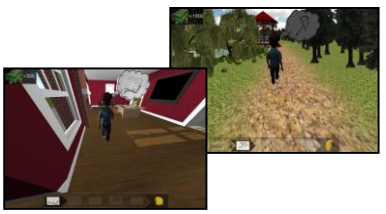
The Prototype



Key Features of GeST







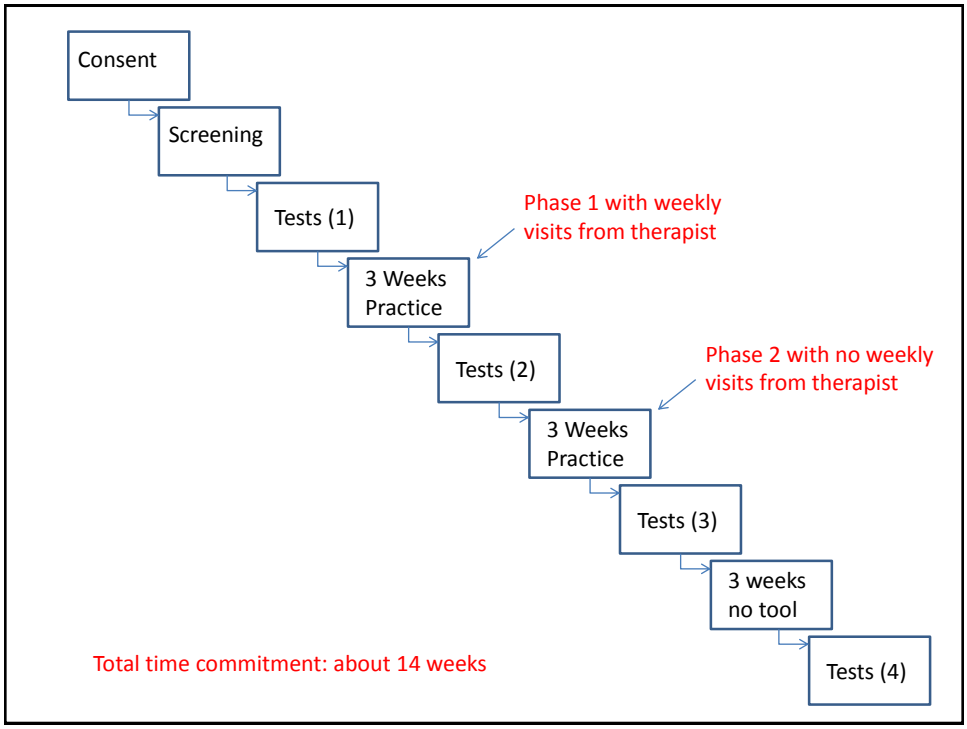
Phase 2: Pilot Study

Questions

- Will practice with GeST improve participants' production of gestures &/or spoken words?
- Will improvements be specific to items that feature in the programme?
- Will gains occur when GeST is used without ongoing therapist support?
- Will gains be maintained after GeST is withdrawn?
- What are participants' views about GeST?
- Is GeST easy and enjoyable to use?

Participants

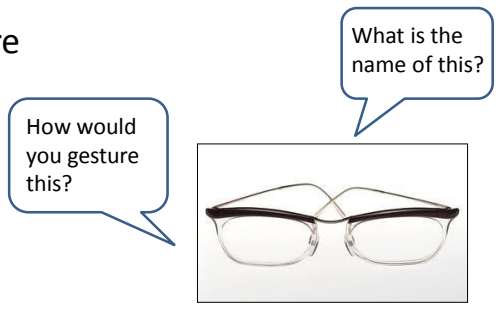
- 9 people with severe aphasia
  - Consent to take part
  - Fluent pre-stroke users of English
  - Naming score <20%
  - Able to recognise pictures
  - No known dementia or other cognitive impairment



Tests

- 60 items
  - Gesture from picture
  - Name from picture

Items:
30 practised with GeST
30 Unpractised



Gestures evaluated by 'blind' assessors

Results

- Significant improvement in gesture scores
- Gains maintained after GeST withdrawn (T4)

- BUT
  - Gains were small & only occurred with therapist support
  - There was no generalisation to unpractised gestures
  - Naming did not improve

Usage Observations

- All show total or partial mastery of
  - Turning GeST on and off
  - Entering levels
  - Navigating between items
  - Gesturing when recognition active

- Less mastery over
  - Changing levels

Participant Views

- High ratings for
  - Enjoyment (8)
  - Positive feedback provided by GeST (7)
  - Mastery of programme (6)
- Mixed preferences for levels

Partner Views: Independence of Use

- *'She uses it all on her own, I don't know how to operate it'*
- *The first session I stayed with L, after that I've helped only if she's found something particularly frustrating'*
- All comment that the participant initiated use of Gest

Conclusions re GeST

- Using GeST improved practised gestures but only with therapist support
- Gains were maintained after GeST was withdrawn
- Gains were small and did not generalise to unpractised items
- There were no benefits for spoken naming
- Most users undertook intensive practice
- Views about GeST were positive and GeST was easily mastered
- More Testing underway

(Marshall et al, 2013)

Charles Wolfson Charitable Trust

BupaFoundation
The Medical Research Charity

Remote Aphasia Therapy: A Feasibility Study

Background and Rationale

- Inadequate aphasia therapy services
  - (Code & Petherham, 2011)
- Patchy community and domiciliary services
  - (Care Quality Commission, 2011)
- Need to serve those who cannot travel to clinics

- Remote delivery via Internet Video Conferencing Technology (IVCT) achieves efficiency while retaining therapist contact

Background and Rationale

- Positive outcomes from remote therapy with other clinical groups:
  - (e.g. Constantinescu et al, 2011)
- Some positive findings for remote aphasia assessment
  - (e.g. Georgeadis et al 2004; Hill et al, 2009)
- Only two preliminary studies of remote aphasia therapy using IVCT
  - (Dechene et al, 2011; Fridler et al, 2012)

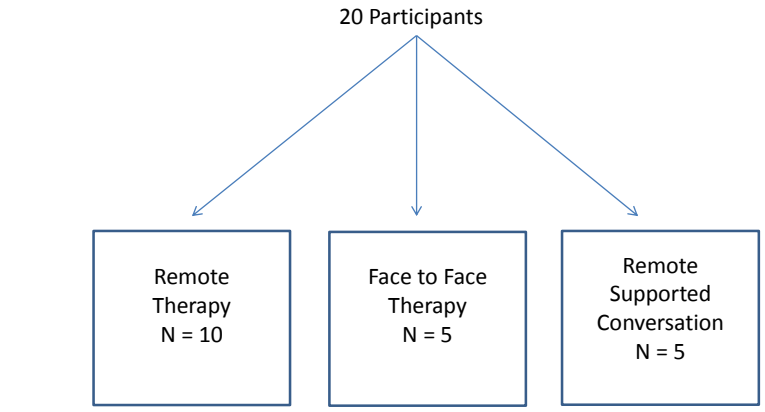
  see Cherney & van Vuuren (2012) for review

Study Questions

- Can the same protocol of word finding therapy be delivered face-to-face and remotely?
  - What are the views of participants?
  - What are the technological challenges ?
  - Is fidelity good?
- Does therapy improve word production in
  - picture naming?
  - conversation?
- Do gains vary across delivery modes?

Method

- 20 participants with aphasia
  - 6 women, 14 men
  - Fluent pre stroke users of English
  - Mean age 57.7 (range: 32 – 76 years)
  - All post left hemisphere stroke
  - Mean 33.2 months post stroke (range 6 – 78 months)
  - Moderate word finding difficulties
  - No significant co-morbidity
  - Not receiving Speech and Language Therapy elsewhere



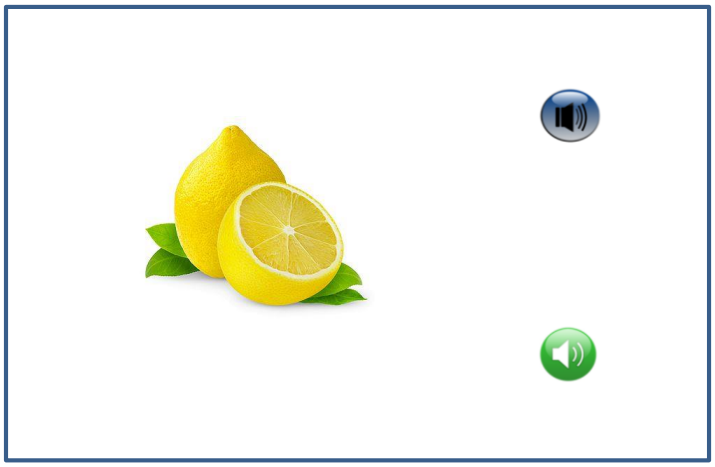
Therapy

- Aims to improve word retrieval
- Practice on 50 words, each targeted once per session
- Tasks specified in a manual, and adapted from the anomia therapy literature
- 8 one hour sessions
- Twice a week
- Supplemented by homework

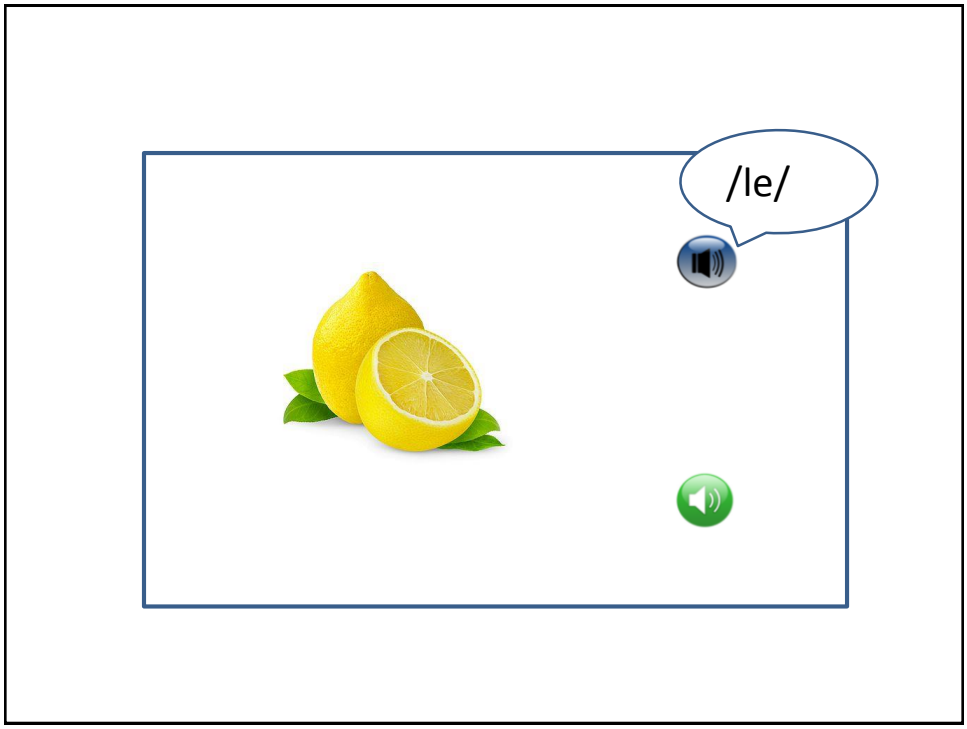
Therapy Example

1	Semantic verification questions	Can you squeeze it? (yes) Is it sweet? (no)
2	Ask participant to name picture	What is this a picture of?
3	Semantic cue	We eat it with sugar on pancakes
4	Sentence completion cue	Sour as a …
5	First phoneme	It begins with /l/
6	First syllable	It begins with /le/
7	Repetition	Ask participant to repeat x3 If participant is unable SLT repeat x3

PowerPoint homework task



All 50 words, several times per week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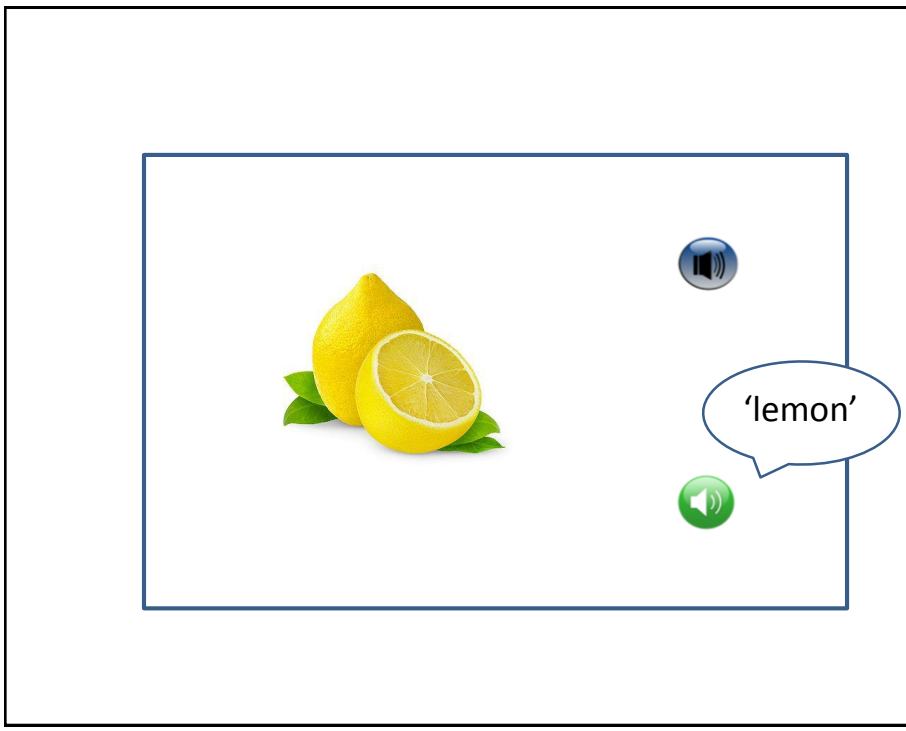

'lemon'

Therapy Delivery

- Face To Face
  - Participants travel to University clinic
- Remote
  - Participants at home with iPad
  - Therapist in the University or hospital clinic
  - Communication via Facetime

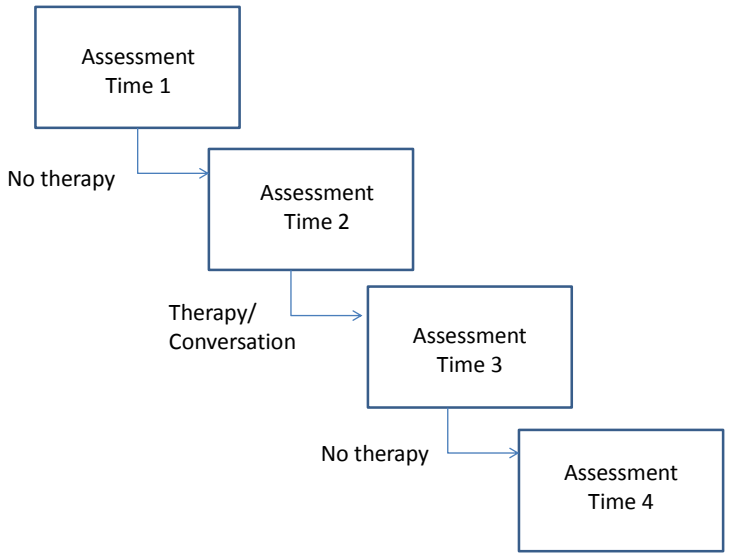
  Platform chosen in consultation with people with aphasia
  Aphasia friendly instructions developed

  All treatment sessions were videoed

Remote Supported Conversation

- Attention control condition
- 8 sessions of conversation, twice a week
- Delivered by SLT students working in pairs
- Students trained in
  - Conversation techniques
  - Technology
- Supported by manual

Design



Outcome Measures

Picture naming assessment conducted at each time point

- 100 items that are difficult to name at baseline
- Words divided into two matched sets:
  - 50 treated (for those receiving therapy)
  - 50 untreated

Administered by non treating therapist

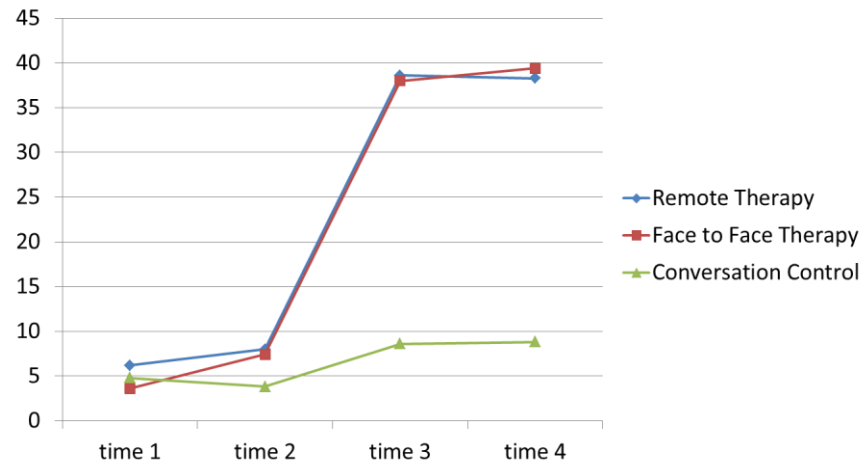
Outcome Measures

Conversation

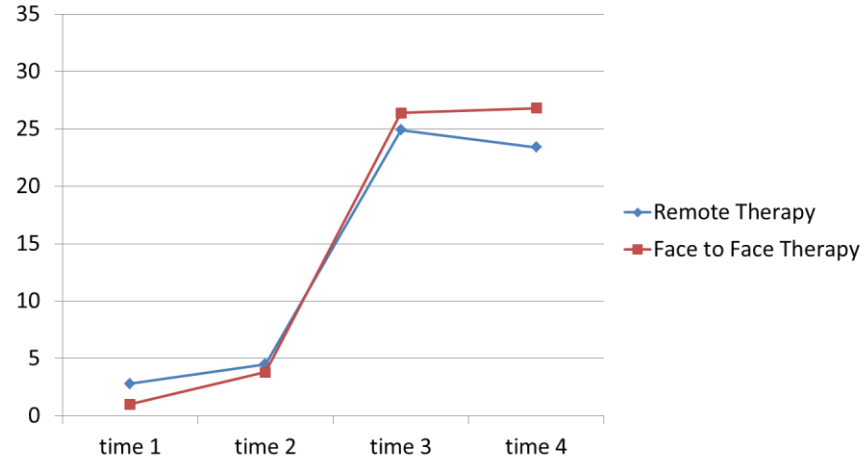
- 10 minute conversation with a familiar partner at each time point
- Topic unconstrained
- Middle 5 minutes analysed using POWERS procedure (Herbert et al, 2013)

Results

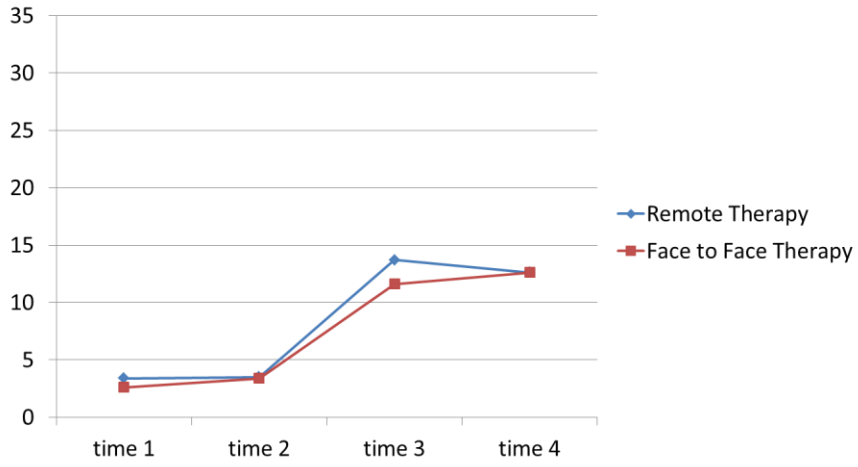
Picture Naming: 100 words



Picture Naming: Treated Words



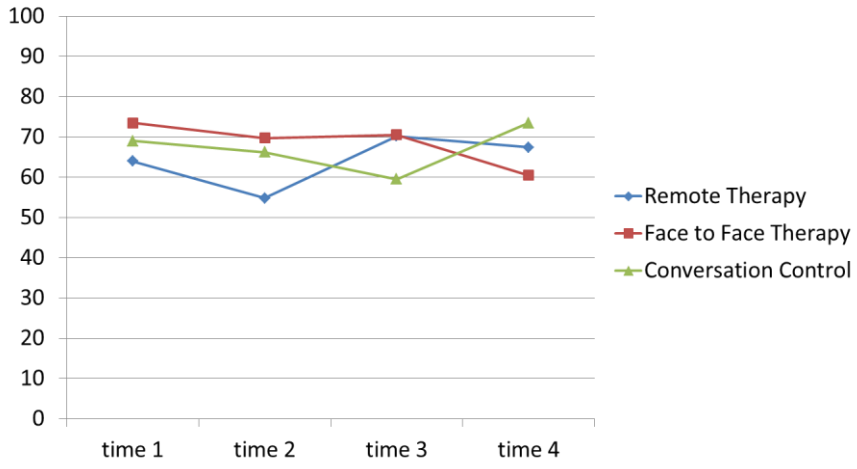
Picture Naming: Untreated Words



Conversation

- Data analysed for:
  - Number of nouns per turn
  - Number of content words per turn
  - Percentage of turns containing at least one content word (Substantive turns)
  - Number of errors
- No change over time
- No interaction between group and time

Percentage of Substantive Turns



Self Rating Scores at End of Therapy (1 = 'easy'; 5 = 'hard')

Function	Mean Rating
Starting the iPad	1
Starting Facetime	1.6
Answering the call	1
Ending the call	2.3
Charging the iPad	1
Connectivity	1
Sound quality	1.4
Visual quality	1

Conclusions

The Good news

- Remote delivery of word finding therapy is feasible
- It can delivered in non-lab conditions, using mainstream technology
- Participant views are positive and participants easily mastered the technological challenges
- Outcomes are no different from face to face delivery with highly significant benefits for treated words

Conclusions

The Less Good News

Opposition to some internet technologies need to be overcome, e.g. in health service managers

Treatment benefits were constrained:

- Modest (although significant) benefits for untreated words
- No benefits for word finding in conversation

But this was probably due to the low therapy dose and/or the nature of therapy. It was not due to delivery.

Evaluating the effects of a virtual communication environment for people with aphasia

EVA

Stroke association

Study Questions

Can we build a virtual communication environment for people with aphasia

Will involvement in the environment:

- Benefit the communication skills of 20 people with aphasia?
- Reduce feelings of social isolation?

Is the environment easy to access?

What are participants views about it?

EVA Park

- An enclosed island for people with aphasia (uses Open Sim)
- Developed through participative design sessions with consultants who have aphasia
- Participants represented by avatars
- Communication is speech based, with optional text support

EVA Park

- Contains distinct regions, e.g.:
  - Houses
  - A Cafe
  - A Tropical Bar
  - A Versatile Counter (e.g. for booking a holiday)
  - A Health Centre
  - A Hair Dressers


Café
PIZZA


Health
Centre

EVA Park Mayoral Elections

Boggis Beefeater

"Read my lips: no new taxes"

EVA Park Mayoral Elections

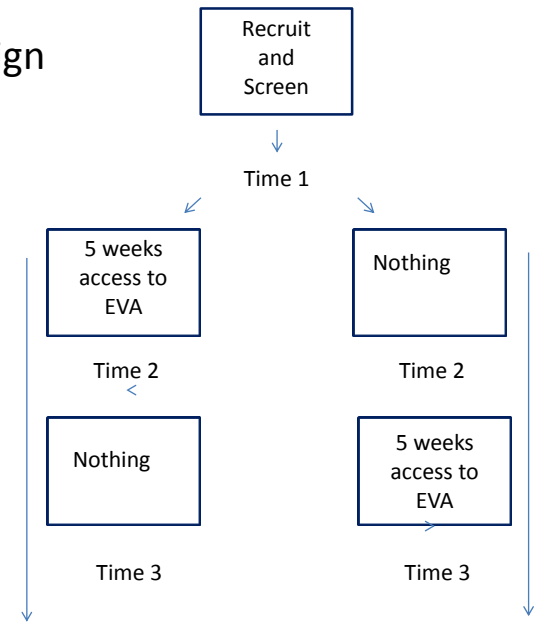
Cybil Wrights

"Equal opportunities for all"

Evaluation Design

- 20 people with aphasia have access to Eva Park
  - 5 weeks intervention (in 4 'live' periods)
  - Daily sessions with support workers
  - Personal goals/programme of activities
  - Unlimited independent access
  - Pre and post intervention testing

The Design



Assessments

Administered T1, T2, T3

Assessments: Communication

- Word retrieval
  - Fluency test (Supermarket, Airport, Health Centre, Restaurant, School, Cinema, Park, Kitchen, Hair Salon, Sports Stadium)
- Narrative
  - Retell a familiar story:
    - Number of words/narrative words
    - Words/narrative words per minute

Assessments: Communication

- Conversation:
  - Randomly partnered with SLT student (different student each time)
  - 10 minute sample analysed with POWERS (Herbert et al, 2013)
- Functional Communication:
  - CADL-2 (Holland et al, 1999)
- Confidence:
  - Communication Confidence Rating Scale for Aphasia (Cherney & Babbitt, 2011)

Assessments: Social Isolation

- The Friendship Scale (Hawthorne 2006)
  - 6 item measure re feelings of loneliness and social connection
- The Social Network Analysis (Antonucci & Akiyama 1987)
  - Number, range and frequency of social contacts

Views of Participants

- Qualitative interviews pre and post EVA
  - Experiences of communication
  - Social activities
  - Use of technology
  - Views of EVA

Access to EVA

- HCI Assessments during access to EVA
  - Week 1
  - Week 5
- Electronic monitoring of access to EVA

Participants: Inclusion Criteria

- Used English prior to stroke
- at least 4 months post stroke
- Good vision and hearing
- Moderate aphasia:
  - 20 – 75% correct in spoken picture naming
  - >80% correct in word to picture matching
  - >70% correct in sentence to picture matching

(Comprehensive Aphasia Test, Swinburn et al 2002):

Examples of Goals

- Breaking messages down into manageable segments
- Improving 'fluency' in target situations, such as:
  - A doctor's appointment
  - Speaking to a receptionist
- Speaking in groups
- Giving a speech

Examples of Activities

- Role plays
  - Ordering a drink
  - Getting a hair do
  - Dealing with an incompetent waitress
  - Reporting a suspicious character to the police
  - Holding a board meeting to discuss a new sports centre in Eva Park
  - Interviewing an election candidate about his policies

Examples of Activities

- Conversation
  - Education and career history
  - Plans for the weekend
  - Past experiences of travel
  - Wife's trip to hospital
  - Latest events in the Eva Park elections
  - Experiences in Eva Park

- ‘I’d already voted and then there was news on so I changed my vote. Was with Pebble Beach, now changed to second guy. Can’t remember his name. Boggis has had an affair with Pebble’s sister.’

Examples of Activities

- Group topics
  - News:
    - Mandela funeral
    - Nigella drug scandal
    - Floods
  - Music
  - The Royal Family
  - Gossip

  - ‘News good .. Music one rubbish, all pop’

Examples of Activities

- Eva Actions:
  - Dancing
  - Swimming
  - Visiting the tree houses, boats, light house
  - Fun day

Views of Participants

- 'Its been very good. I'm still finding new places to go'
- 'Tried them all. Sat on elephant. Swam on turtle. Dancing in Tardis and disco.'
- 'Cut and dyed A's hair. Drunk. Played on the diving board. Had pizza. Had band.'
- 'Fantastic. Chatting.'

Views of Family Members

- When we go to church, he's more confident in having conversations with people, whereas before he would hold back more. Now he's been more spontaneous. Talking about sports etc and I know he's been talking about the same topics in EVA Park. He's had a practice so he's extending what he's talking about outside.

Views of Family Members

- He enjoys social contact – talking to another person who's very good at listening to him. And the sillyness – like the diving board. (He was) disappointed when the mermaid didn't talk back
- Its lovely hearing J laugh. Its lovely to hear J talk

Final Conclusions

- Technology can
  - Support language remediation
  - Provide communication aids
  - Develop strategic skills
  - Support alternative modes of therapy delivery
  - Enrich communication
  - Generate novel opportunities for social uses of language
- User views are positive
- Feasibility is demonstrated for a range of technologies

Final Conclusions

- Projects at City
  - have involved people with aphasia in developing new tools and evaluating existing technologies
  - have exploited the gaming potential of technology
  - Have exploited mainstream Internet Video Conferencing Technology to deliver remote therapy
  - are exploring the therapeutic potential of virtual reality

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References

- Adrian. J. Gonzalez, M. Buiza J. & Sage, K. (2011) Extending the use of Spanish Computer-assisted Anomia Rehabilitation Program (CARP-2) in people with aphasia. Journal of Communication Disorders 44 (2011) 666–677
- Archibald, L., Orange, J., & Jamieson, D. (2009) Implementation of computer-based language therapy in aphasia. *Therapy Archives of Neurological Disorders*, 2 (5), 299-311.
- Best, W., Grassly, J., Greenwood, A., Herbert, R., Hickin, J., & Howard, D. (2011). A controlled study of changes in conversation following aphasia therapy for anomia. *Disability and Rehabilitation*, 33(3): 229–242
- Care Quality Commission (2011) Supporting Life after Services National Report. A review of services for people who have had a stroke and their carers. Available from: http://www.cqc.org.uk/_db/_documents/Supporting_life_after_stroke_national_report.pdf
- Cherney, L. (2010) Oral Reading for Language in Aphasia (ORLA): Evaluating the Efficacy ofComputer-Delivered Therapy in Chronic Nonfluent Aphasia(*Top Stroke Rehabil* 17(6):423–431

References

- Beeson, P., Higginson, K. & Rising, K. (2013) Writing treatment for aphasia: A texting approach. Journal of Speech Language and Hearing Research, 56, 945 – 955.
- Cherney, L. & van Vuuren, S. (2012) Telerehabilitation, Virtual Therapists, and Acquired Neorologic Speech and Language Disorders, Seminars in Speech and Language, 33, 243-258.
- Constantinescu. G., Theodoros, D., Russel, T., Ward, E., Wilson, S., Wootton, R. (2011) Treating disordered speech and voice in Parkinson's Disease online: a randomised controlled non-inferiority trial. International Journal of Language and Communication Disorderers, 46, 1, 1-16.
- Dechene L, Tousignant M, Boissy P, et al. Simulated in-home teletreatment for anomia. International Journal of Telerehabilitation 2011;3(2):3–10
- Doesborgh , S., van de Sandt Koenderman , M., Dippel , D., van Harskamp , F., Koudstaal, P. & Visch Brink, E. (2004). Cues on request: The efficacy of Multicue, a computer program for wordfinding therapy, Aphasiology, 18:3, 213-222, DOI: 10.1080/02687030344000580

References

- Drew, R. L. and Thompson, C. K., 1999, Model-based semantic treatment for naming deficits in aphasia. Journal of Speech Language and Hearing Research, 42, 972–989.
- Estes C & Bloom R (2011). Using voice recognition software to treat dysgraphia in a patient with conduction aphasia. *Aphasiology*, 25 (3), 366-385.
- Fink, R., Brecher, A., Sobel, P., & Schwartz, M. (2005) Computer assisted treatmentof word retrieval deficits in aphasia. Aphasiology, 19, 10/11, 943 – 954.
- Fridler, N., Rosen, K., Herzberg, O., Lev, A., Kaplan, D., Hildesheimer, M., Menahemi-Falkov, M., Feldman, Y., Grosberg, D., and Shani, M. (2012). Tele-Rehabilitation Therapy vs. Face-to-Face Therapy for Aphasic Patients. eTELEMED 2012 : The Fourth International Conference on eHealth, Telemedicine, and Social Medicine. ISBN: 978-1-61208-179-3
- Furnas, D. & Edmonds, L. (2014) The effect of computerised Verb Network Strengthening Treatment on lexical retrieval in aphasia. Aphasiology, 28 (4), 401 – 420.
- Georgeadis AC, Brennan DM, Barker LM, Baron CR. Telerehabilitation and its effect on story retelling by adults with neurogenic communication disorders. Aphasiology 2004;18:639–652
- Greenwood, A., Grassly, J., Hickin, J., Best, W. (2010) Phonological and orthographic cueing therapy: a case of generalised improvement. Aphasiology, 24 (9), 991-1016.
- Herbert, R., Best, W., Hickin, J., Howard, D., & Osborne, F. (2013). *Profile of word errors and retrieval in speech (POWERS)*. Publisher: JR Press.
- Hill AJ, Theodoros DG, Russell TG, Ward EC, Wootton R. The effects of aphasia severity on the ability to assess language disorders via telerehabilitation. Aphasiology 2009;23:627–642.
- Lagarno, M., Di Pietro, M. & Schnider, A. (2006) Computerised treatment of anomia in acute aphasia: Treatment intensity and training size. *Neuropsychological Rehabilitation*, 16 (6), 630 – 640.

References

- Lee, J., Kaye, R. & Cherney, L. (2009) Conversational script performance in adults with non-fluent aphasia: treatment intensity and aphasia severity. Aphasiology, 23, 885 – 897.
- Linebarger, M., Schwartz, M., Romania, J., Kohn, S. & Stephens, D. (2000). Grammatical encoding in aphasia: Evidence from a 'processing prosthesis'. Brain and Language, 75, 416 – 427.
- Linebarger, M, McCall, D, Virata, D, & Berndt, R (2007) Widening the temporal window: Processing support in the treatment of aphasic language production, Brain and Language, 100, 53 – 68.
- Marshall, J., Roper. A.., Galliers, J., Wilson, S., Cocks, N., Muscroft, S., & Pring, T. (2013) Computer delivery of gesture therapy for people with severe aphasia, Aphasiology.
- Mortley, J, Wade, J., Hughes, A. & Enderby, P. (2004) Effectiveness of computerised rehabilitation for long term aphasia: A case series study. British Journal of General Practice, 54, 856 – 857.
- Palmer, R., Enderby, P., Cooper, C., Latimer, N., Julious, S., Paterson, G., Dimairo, M., Dixon, S., Mortley, J., Hilton, R., Delaney, A., Hughes, H. (2012) Computer therapy compared with usual care for people with long-standing aphasia poststroke: a pilot randomized controlled trial. Stroke, 43, 7, 1904 – 1911.

References

- Thompson, C., Choy, J., Holland, A. & Cole, R. (2010) Sentactics ® Computer-automated treatment of underlying forms. *Aphasiology*, 24 (10), 1242 – 1266.
- Van De Sandt-Koenderman, W.M.E., Wiegers, J., Wielaert, S., Duivenvoorden, H., & Ribbers, G. (2007) A computerised communication aid in severe aphasia: An exploratory study. Disability and Rehabilitation, 29, 22, 1701 – 1709.
- Whiteside, S. P., Inglis, A. L., Dyson, L., Roper, A., Harbottle, A., Ryder, J., Cowell, P. E., & Varley, R. A. (2012). Error reduction therapy in reducing struggle and grope behaviours in apraxia of speech. *Neuropsychological Rehabilitation*, 1-28.