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INTRODUCTION

Models of speech production in humans and experiments with songbirds suggest that recursive auditory feedback can fine-tune speech production (Guenther & Vlaudusich, 2012) and facilitate vocal learning (Fehér et al., 2017). Persons with nonfluent aphasia are often aware of production errors while speaking but are typically unable to correct them in real time, perhaps due to an impairment in processing auditory feedback (Behroozmand et al., 2017). We hypothesized that training people with nonfluent aphasia with recursive post-production playbacks of their own speech would give them time to assess errors and improve their production. We developed and tested an automated method for applying verbal self-feedback recursively for training patients over multiple sessions.

METHOD

We used a cross-over design to compare the effect of a verbal self-feedback (experimental treatment) to that of a script training (control treatment) on speech fluency in two adults who were dominant English speakers and were diagnosed with mild chronic nonfluent aphasia (AE2: 50 years, female and AE3: 53 years, male) through the Western Aphasia Battery-Revised (Kertesz, 2007). We developed a smartphone App for feedback training and measured speech fluency in two participants that received both experimental and control treatments sequentially, in counterbalanced order. Each treatment comprised two-hour daily sessions over three weeks, with two weeks washout between treatments. Both treatments used scripts, each comprising eight sentences.

Verbal self-feedback involved two steps. First, the participants read a text on their smartphone and listened to the prerecorded audio of that text. The participants then repeat the sentence. Second, the app immediately played back the just-recorded production of the participant, which became the stimulus for the next repetition. The second step was iterated nine times per sentence per script.

Script training involved three steps. First, the participants read aloud the text displayed on the screen or repeated the prerecorded audio of the sentence after listening to it. Second, they chorally produced the sentence together with the prerecorded speaker. Lastly, they independently repeated and recorded their production of the sentence.

Direct treatment effects were measured by comparing speech fluency scores of the first day of treatment with the last day of treatment on trained scripts. Multiple-baseline assessment (three times per assessment phase) of speech fluency measures from sentence repetitions of an untrained script was used to determine generalization of treatment effects. Nonoverlap of All Pairs was used to estimate effect size (Parker & Vannest, 2009).

RESULTS

Table 1 shows significant direct and generalization of treatment effects for both treatments on most measures of speech fluency in both patients. AE3 did not show improvement in speech initiation latency following script training.

Speech Fluency Measures for AE2

		Trained Scripts				Untrained Script			
Tx	**Measure**	**Mean Pre-Tx**	**Mean Post-Tx**	**SE**	**NAP Est**	**Mean Pre-Tx**	**Mean Post-Tx**	**SE**	**NAP Est**
Verbal Self-Feedback	Speech initiation latency	546 ms	306 ms	0.02	**0.86****	398 ms	215 ms	0.014	**0.92****
	Speech event duration	6.468 s	4.69 s	0.019	**0.84****	4.546 s	3.749 s	0.021	**0.80****
	Speech rate (word per minute)	75.61	117.90	0.01	**0.94*****	89.56	108.11	0.021	**0.78****
	Articulation rate (syllable per second)	2.28	3.20	0.007	**0.98*****	1.918	2.31	0.02	**0.79****
Script Training	Speech initiation latency	664 ms	300 ms	0.02	**0.84****	780 ms	613 ms	0.031	**0.60***
	Speech event duration	6.44 s	4.28 s	0.01	**0.92****	5.716 s	4.916 s	0.026	**0.71****
	Speech rate (word per minute)	84.09	103.58	0.02	**0.77****	71.07	82.36	0.027	**0.71****
	Articulation rate (syllable per second)	2.17	3.45	0.006	**0.98*****	1.514	1.76	0.024	**0.76****

Speech Fluency Measures for AE3

		Trained Scripts				Untrained Script			
Tx	**Measure**	**Mean Pre-Tx**	**Mean Post-Tx**	**SE**	**NAP Est**	**Mean Pre-Tx**	**Mean Post-Tx**	**SE**	**NAP Est**
Verbal Self-Feedback	Speech initiation latency	815 ms	273 ms	0.013	**0.92****	970 ms	270 ms	0.021	**0.87****
	Speech event duration	10.33 s	8.99 s	0.026	**0.72****	11.81 s	10.59 s	0.030	**0.65***
	Speech rate (word per minute)	87.98	103.73	0.024	**0.80****	69.37	82.87	0.029	**0.70****
	Articulation rate (syllable per second)	1.94	2.36	0.023	**0.85****	1.53	1.843	0.028	**0.72****
Script Training	Speech initiation latency	298 ms	430 ms	0.053	0.29	220 ms	395 ms	0.023	0.30
	Speech event duration	9.07 s	8.53 s	0.057	**0.58***	10.90 s	9.95 s	0.024	**0.63***
	Speech rate (word per minute)	88.55	101.70	0.051	**0.72****	81.24	88.59	0.024	**0.63***
	Articulation rate (syllable per second)	1.87	2.40	0.024	**0.92****	1.82	1.98s	0.024	**0.64***

Table 1: Mean, standard error (SE) and Nonoverlap of All Pairs (NAP) estimate of speech fluency measures for AE2 and AE3. Single asterik(*) denotes significant weak improvement, double ** denote significant medium improvement and triple *** denote significant strong improvement. NAP is computed at 95% confidence interval. Speech event duration is measured in seconds (s) and speech initiation latency is measured in miliseconds (ms).

CONCLUSION

Both participants showed improvement on most of the measures following both treatment blocks. Verbal self-feedback may be a promising tool to improve speech production efficiency in nonfluent aphasia.

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