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ORIGINAL ARTICLE

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Effectiveness of speech therapy in adults with intellectual disabilities

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Background: This study investigated the effect of speech therapy in a heterogeneous group of adults with intellectual disability.

Method: Thirty-six adults with mild and moderate intellectual disabilities (IQs 40–70; age 18–40 years) with reported poor speech intelligibility received tailored training in articulation and listening skills delivered in two 3-month periods. Pre- to post-changes in speech intelligibility and receptive vocabulary were assessed using standardized tasks.

Results: The results showed a positive effect of treatment on speech intelligibility and receptive vocabulary, irrespective of severity of intellectual disability, hearing loss and intellectual disability aetiology.

Conclusions: Speech therapy for people with intellectual disability can be effective at adult age and hearing loss should not prevent treatment. Continued attention to speech can help augment verbal communication skills in this population.

KEYWORDS
speech disorders, speech intelligibility, speech-motor control, treatment

1 | INTRODUCTION

Speech intelligibility is a crucial factor in verbal communication. For many persons with an intellectual disability, communication breakdown resulting from reduced speech intelligibility is a major problem. As it allows the exchange of needs and feelings, facilitates thinking and contributes to developmental and learning processes, communication by speech is an important part of social and mental well-being, and a lack of verbal communication may lead to diminished social skills, behavioural problems and isolation (Bott, Farmer, & Rohde, 1997). Given that verbal communication constitutes the main means of communication for people with intellectual disability, especially mild and moderate intellectual disabilities (Bradshaw, 2001; Healy & Walsh, 2007; McConkey, Morris, & Purcell, 1999; Roberts, Price, & Malkin, 2007), it is essential that they are able to make themselves understood through speech. The development of assessments to evaluate and interventions to improve speech production and intelligibility in this population are thus indispensable. By investing in improving the quality of their speech, one can improve communication and, by extension, their quality of life in general.

While modern advances in the medical sciences have improved the health of children and adults with intellectual disability, the development of communication skills remains a concern. In practice, it is often simply accepted that by adolescence people with intellectual disability have reached a plateau in learning and continued communication intervention is not seen to have any value. Furthermore, communicative interventions until adolescence mainly aim at improving expressive and receptive language skills. The speech-production problems are often taken for granted and seen as a characteristic of the disability itself rather than the result of distinct underlying deficits that may be sensitive to therapy. This notion may also derive from a lack of diagnostic assessment procedures for both cause and manifestation of the speech problems in people with intellectual disability, as well as a lack of validated treatment methods for improving their speech output. Few studies have investigated treatment possibilities for speech problems in adults with intellectual disability and, at present, it is unclear whether any such targeted treatments would benefit this group of speakers.

As alluded to above, many authors claim that speech and language skills begin to plateau when a child with intellectual disability reaches adolescence, with most studies concerning children under the age of 15 years (Fowler, Gelman, & Gleitman, 1994). With respect to children with Down syndrome, research suggests that—without intervention—the speech and language difficulties are not resolved when they grow up and that speech intelligibility remains a problem throughout life (van Borsel, 1996; Chapman, Seung, Schwartz, & Bird, 2000; Timmins et al., 2009; see also Cleland, Timmins, Wood, Hardcastle, & Wishart, 2009). Several possibilities for enhancing communication skills in adults with Down syndrome have been explored and proposed throughout the years (Leddy, 1999; Roberts et al., 2007) and a recent series of studies has shown that adolescents and adults with Down syndrome can learn new speech and language skills, suggesting that interventions could be effective at any age (Chapman, 2006; Chapman, Hesketh, & Kistler, 2002; Chapman et al., 2000). More specifically focusing on their speech-production deficits, a recent literature review suggests that in adults with Down syndrome, these problems could be due to both linguistic influences and impairments in the speech-motor control system and there are indications that speech therapy can remediate some of the resulting deficiencies by providing advice and training to help optimize verbal communications or reduce the severity of the speech problems (Coppens-Hofman, Maassen, van Schrojenstein Lantman-de Valk, & Snik, 2012). Unfortunately, no results are known for (young) adults with intellectual disabilities other than Down syndrome.

This study therefore sets out to investigate the effect of speech therapy in a heterogeneous group of adults with intellectual disability. However, to determine the best possibilities for improving the quality and intelligibility of their speech output, it was first necessary to ascertain the exact nature of the speech difficulties in this diverse population. In a previous study (Coppens-Hofman, Terband, Snik & Maassen, 2016), the present authors accordingly analysed and specified the types of speech errors in a Dutch sample of 36 adults with mild or moderate intellectual disability of mixed aetiology. Recordings of spontaneous speech and responses to a picture-naming task were transcribed by blinded experts using a broad phonetic transcription protocol. The transcriptions were then analysed with respect to segmental and syllabic characteristics and processes. In addition, intelligibility ratings of the spontaneous speech samples from 25 naive listeners were obtained and evaluated. The combined results indicated that the development of the phonemic and syllabic inventories was completed irrespective of intellectual disability severity, intellectual disability aetiology or whether or not they suffered hearing loss. At the same time, the speech of our participants was characterized by an overall high rate of segmental and syllabic errors that was associated with the level of cognitive functioning. Speech errors were inconsistent and comprised a large range of both typical and atypical phonological processes. The frequencies of specific types of errors were found to be related to the intelligibility ratings. The observed speech difficulties could not be explained by weakness or paralysis of the speech muscles or other sensorimotor deficits alone and were interpreted to indicate speech-motor control and planning difficulties.

Subsequently, an intervention that specifically targeted the charted type of speech errors to thus improve speech intelligibility was developed. The participants from the earlier study were offered tailored training in articulation and listening skills delivered in two 3-month periods separated by a 3-month intermission. Based on the predictors of speech intelligibility formulated in the previous study (Coppens-Hofman, Terband, Snik & Maassen, 2016), the pre- to post-changes were evaluated in terms of speech intelligibility through a phonological error analysis of the participants' word production on a picture-naming task and additionally assessed changes in their receptive vocabularies. In this report, the treatment, assessments and outcomes are described in detail.

2 | METHOD

2.1 | Participants

The study was approved by the Medical Research Ethics Committee of the Author affiliation (which is accredited by the European Network of Research Ethics Committees). The 36 adults with intellectual disability (age range 18–40 years; mean 28 years; 19 men and 17 women) who had participated in the previous study in which the present authors characterized their speech problems (Coppens-Hofman, Terband, Snik, & Maassen, 2016) were invited to attend tailored intervention. Following the Dutch regulations (Central Committee on Research Involving Human Subjects, 2002) and the regulations of the International Association for the Scientific Study of Intellectual and Developmental Disabilities (Dalton & McVilly, 2004), the participants and their legal representatives received written and oral information on the study and intervention in advance, with all legal representatives, parents, and caregivers giving their written consent. The participants all gave their oral consent after having been orally informed by their parents or primary caregiver.

In all cases, the parents/caregivers had earlier typified the participants' speech as poorly intelligible and supported their desire to improve the quality of their speech output. Inclusion was based on the level of their intellectual disabilities, that is, IQ 40–70 (DSM IV—mild and moderate), with 16 participants having been classified with mild (IQ 55–70) and 20 with moderate intellectual disability (IQ 40–55). Their speech problems had not been assessed prior to our studies by any diagnostic tests, the cause of their poor speech intelligibility was unclear, and none of the participants had previously received speech therapy. Exclusion criteria were as follows: cleft lip/cleft palate, spastic dysarthria, severe behavioural problems and a diagnosis of dementia or autism. The aetiology of the intellectual disability was known in 22 cases. A detailed overview of the participants is provided in Appendix A.

2.2 | Procedures and experimental design

Figure 1 presents an overview of the experimental design. All participants received treatment during two periods of 3 months separated by a 3-month intermission. For reasons of logistics and time management, the participants were randomly divided into two groups, with the second group starting the intervention 3 months after the first group. Before and after each treatment period, a concise speech and hearing assessment (MSH) was carried out. Elaborate speech-production and hearing assessments were conducted prior to and after completion of the intervention, when also vocabulary and memory were tested. Speech recordings, assessments and examinations were all conducted by the second author.

2.3 | Treatment

The treatment comprised weekly individual sessions each lasting 30 min and was delivered by the third author, a certified and experienced speech-language pathologist/therapist with prior experience in working with persons with intellectual disability. All 36 participants completed the intervention and received the same number of treatment sessions. The treatment involved specific articulation training in combination with training in listening skills and comprised all speech sounds and all combinations of speech sounds of Dutch in word-initial, word-medial and word-final position (at the beginning, in the middle and at the end of the word) and words in sentences. The general content of the intervention was the same for each participant, building up from single speech sounds to words, but the level was adjusted to individual needs, interests and abilities.

Each treatment session comprised 10 min of repetition of the exercises of the previous session, 15 min of new exercises and 5 min of recapitulation. Articulation training constituted the larger part of the intervention and comprised practising and explaining the pronunciation of speech sounds and words, distinctions between speech sounds, oral motor skills, speaking skills and communicative skills. Auditory training consisted of minimal pairs (auditory discrimination), listening in noise, rhyme, auditory memory and concentration. The exercises were taken from widely used methods for the treatment of phonological and auditory perception problems in children (age range 4–12 years) such that the subject matter always related to the interest of the participant (hobbies, favourite TV shows, etc.). A detailed description of the content and composition of the intervention can be found in the treatment protocol that is provided in Appendix B.

Three to four months after the intervention, an interactive evaluation was scheduled with the primary caregivers and/or parents of each participant as well as with the participants themselves. The second author had a 1-hr personal interview with each participant in which they were asked about their experiences during treatment and whether and how they felt the treatment had helped them (or not). During the meeting with the caregivers/parents, the second author discussed the observations the speech therapist had recorded during and after the intervention along with the experiences reported by the participants, and compared these with the views of the caregivers/parents. Based on these evaluations, an official report containing personalized recommendations regarding communication strategies and exercises was compiled for each participant. These were later presented to and discussed with the parents/caregivers.

2.4 | Data collection

Both baseline and endpoint measurements consisted of speech-production, word-understanding (receptive vocabulary), hearing and auditory-memory assessments. To prevent any stress or arousal, all assessments were conducted in a quiet, comfortable and familiar room in the participant's own care centre, residential group or sheltered work facility. The hearing examination was conducted by an experienced audiologist 2 weeks before the start of the treatment and comprised the

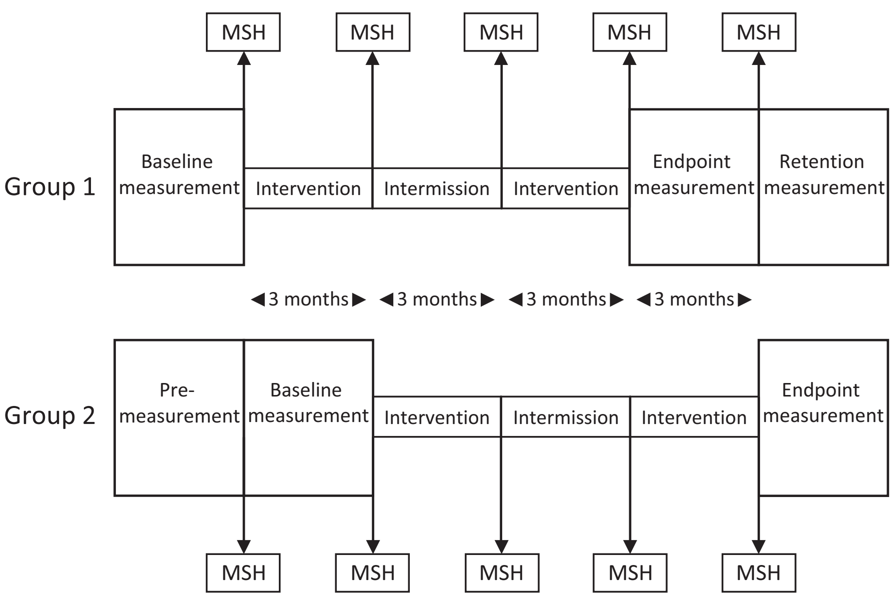

FIGURE 1 Experimental design. MSH = concise speech and hearing assessment. Baseline and endpoint measurements comprised elaborate speech-production and hearing assessments and assessment of receptive vocabulary

TABLE 1 Overview of the variables determined by the phonetic accuracy and phonological error analyses (segmental and syllable structure comparison of target word and produced utterance)

Phonetic accuracy measures		
PCCI		Proportion syllable-initial consonants correct
PSSC		Proportion syllable structures correct
PClusCI		Proportion syllable-initial consonant clusters correct
Phonological error measures		
PSubCI		Proportion substitutions of syllable-initial consonants
PSubCF		Proportion substitutions of syllable-final consonants
PNormProc		Proportion typical substitutions of syllable-initial consonants
	Fronting	Consonants made posterior to the alveolar ridge are substituted by another consonant that is made at or in front of the alveolar ridge
	Stopping of fricatives	Fricative or affricate replaced by a plosive
	Nasalization	Nasalization of a non-nasal consonant
	Gliding	A plosive replaced with a glide (mostly/j/ or/ʋ/)
PAbnProc		Proportion atypical substitutions of syllable-initial consonants
	Backing	A labial, alveolar or dental consonant substituted by a velar/k g ŋ/or glottal/ʔ/ consonant
	Abnormal stopping	Abnormal stops (non-fricative consonant replaced by a plosive)
	H-sation	Replacing a consonant with/h/
	Denasalization	Replacing a nasal consonant with a homorganic stop
PDel		Proportion deletions of consonants in any position (single, cluster; initial, final)
PIC1Del		Proportion deletions of single consonants in syllable-initial position
PIC2Red		Proportion reductions of syllable-initial clusters of two consonants
PIC3Red		Proportion reductions of syllable-initial clusters of two consonants
PICIRed		PIC2Red + PIC3Red

assessment of the pure tone threshold, the bone-conduction threshold and speech audiometry (Speech Audiometry with Pictures-test; Crul, 1984, 1994). Auditory memory was assessed with the Dutch “school-readiness curriculum” test (In den Kleef, 1997) by the second author. One week prior to the baseline speech recordings, a first meeting was arranged to allow the participants to get used to the interviewer/therapist, the recorder and the setting. During this visit, the participants completed the Peabody Picture Vocabulary Test (PPVT) to assess the level of word understanding, as an indication of their understanding of the instructions and stimuli materials to be given during the test sessions. To assess any progress in receptive vocabulary after treatment completion, they again completed the PPVT during the endpoint examination.

The speech-production data consisted of recordings of the verbal output on the Dutch Logo-Art picture-naming task (Baarda, de Boer-Jongsma, & Haasjes-Jongsma, 2005), which consists of 128 easily recognizable pictures that image words of everyday life. The Logo-Art was developed to test articulation in children in the ages of 4–8 years and includes all vowels, diphthongs, consonants and consonant clusters used in the Dutch language in all positions (word-initial, word-medial and word-final).

All recordings were made with the interviewer and participant seated at opposite sides of a table, allowing eye contact. A silent observer familiar to the participant (in most cases the primary caregiver) was present in the room. A professional solid-state recorder (Marantz PMD620) was used to obtain the digital speech recordings. As several participants found the external microphone threatening, the internal microphone was placed at approximately 40 cm distance of the speaker’s mouth. All recordings were made in wav-format at 705 kbps and 44.1 kHz. The duration of the recording sessions varied from 30 to 45 min, depending on the movements and pace of the client. No client

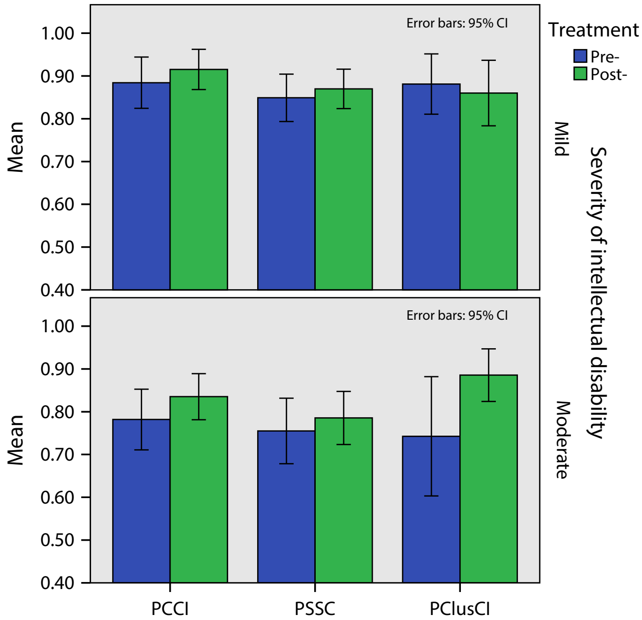

FIGURE 2 Mean pre- and post-treatment scores on the three measures of phonological accuracy: proportion consonants correct in syllable-initial position (PCCI), proportion syllable structures correct (PSSC) and proportion consonant clusters correct in initial position (PClusCI). [Colour figure can be viewed at wileyonlinelibrary.com].

was rushed. The tests of the endpoint assessment were the same as those conducted during the baseline assessment.

2.5 | Data processing and analysis

All recordings of the picture-naming task were transcribed by two independent speech-language pathologists (blinded for both study goal and participants) according to broad phonetic transcription procedures. Yells, grunts and coughs, as well as utterances produced while the participant was chewing or had fingers or objects in or over the mouth, were systematically excluded. Transcription reliability was established by comparison of the two transcriptions of the same utterances. Mean inter-rater reliability was 94%. The transcription of the first transcriber was used in the data analysis. A phonological error analysis was performed on all transcripts with the Logical International Phonetics Program (LIPP) transcription analysis system (Intelligent Hearing Systems, 2012). This resulted in three measures of phonetic accuracy and seven phonological error measures. A detailed explanation of these outcome measures is included in Table 1.

Statistical analysis was carried out by means of repeated-measures analyses of variance (RM ANOVAs), featuring a layered approach. The level of significance was set at $p < .05$, while $p < .10$ were denoted as trends. First, the relationships between the different within-subject

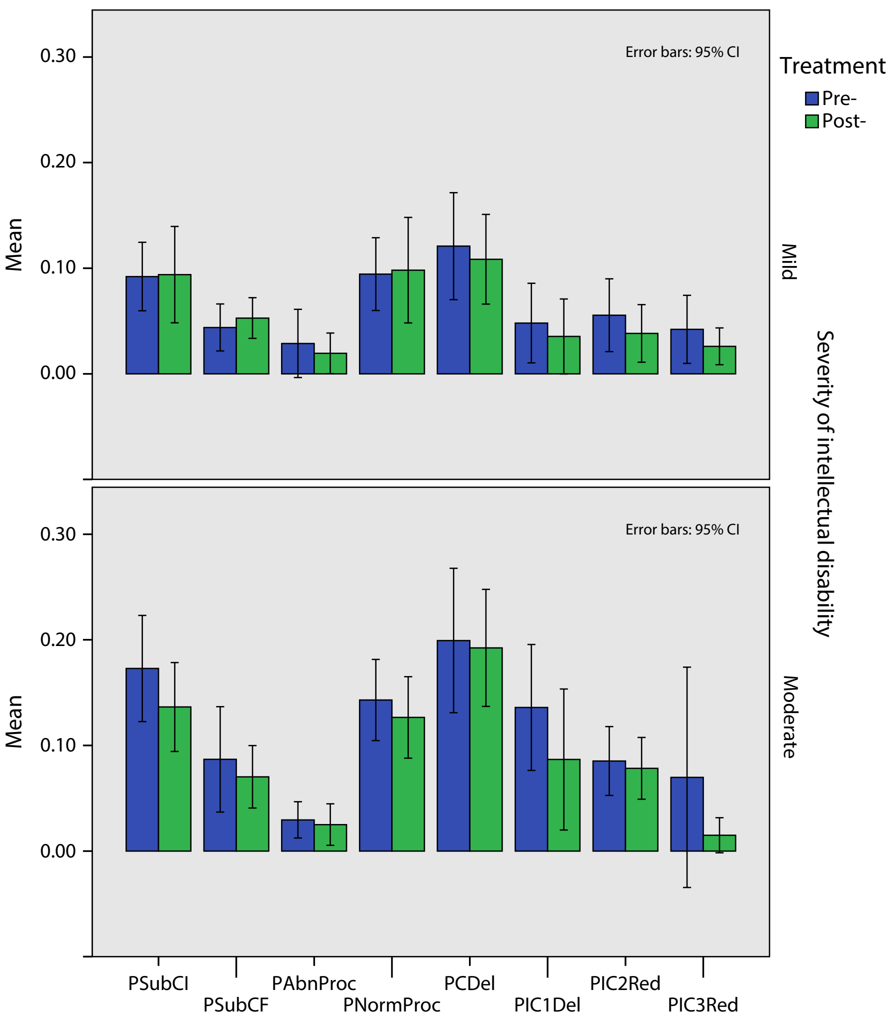

FIGURE 3 Mean pre- and post-treatment scores on the seven phonological error measures: proportion substitutions of single consonants in initial position (PSubCI), proportion substitutions of single consonants in syllable-final position (PSubCF), proportion abnormal substitution processes (PAbnProc; h-sation, abnormal stopping, backing and denasalization), proportion normal substitution processes (PNormProc; fronting, stopping of fricatives, nasalization and gliding), proportion consonant deletions (PCDel), proportion deletion of consonants in syllable-initial position (PIC1Del) and the proportion reduction of consonant clusters in syllable-initial position containing two and three consonants (PIC2Red and PIC3Red). [Colour figure can be viewed at wileyonlinelibrary.com].

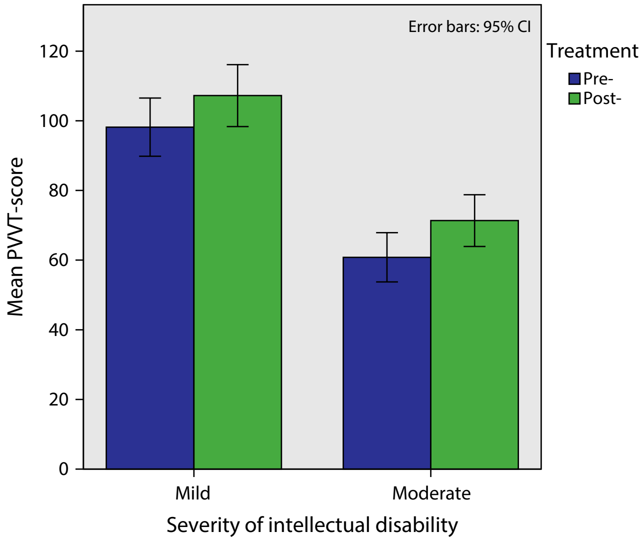

FIGURE 4 Mean pre- and post-treatment scores on the Peabody Picture Vocabulary Test (PPVT). [Colour figure can be viewed at wileyonlinelibrary.com].

(pre- to post-scores) and between-subjects (severity of intellectual disability, hearing loss and intellectual disability aetiology) factors were explored using a multivariate RM ANOVA (with all outcome measures as the dependent variables, i.e., PCCI, PSSC, PClusCI, PSubCI, PSubCF, PAbnProc, PNormProc, PCDel, PIC1Del, PIC2Red, PIC3Red and PVVT score). Where appropriate, the influence of specific factors on the dependent variables were further investigated by means of univariate tests.

Second, the effect of treatment on the participants' speech intelligibility was assessed for the two study groups separately based on the distinctive predictors derived for each group in our earlier study (Coppens-Hofman, Terband, Snik & Maassen, 2016). In the case of the mild group, a multivariate RM ANOVA was administered with pre- to post treatment as within-subjects factor and PCCI, PClusCI, PNormProc and PIC3Red as dependent variables, whereas a multivariate RM ANOVA with pre- to post treatment as within-subjects factor and PCCI, PClusCI and PIC2Red as dependent variables was administered for the moderate group.

3 | RESULTS

3.1 | Between-subject factors

First, the influence of between-subject factors severity of intellectual disability, hearing loss and intellectual disability aetiology was investigated for the phonetic accuracy measures (PCCI, PSSC, PClusCI), phonological error measures (PSubCI, PSubCF, PAbnProc, PNormProc, PCDel, PIC1Del, PIC2Red, PIC3Red) and receptive vocabulary measure (PVVT score) as dependent variables using a multivariate RM ANOVA (with pre- to post treatment scores as within-subjects factor). The results revealed a significant main effect of treatment [$F(12,13) = 3.487$, $p = .017$, $\eta^2_{partial} = 0.763$]. No further main or interaction effects were obtained.

To check whether the absence of any effects involving the three between-subjects factors was due to a lack of power resulting from the number of factors in the model, the influence of each of the between-subject factors separately was investigated subsequently using separate multivariate RM ANOVAs. The results revealed a significant main effect of severity of intellectual disability [$F(12,23) = 2.636$, $p = .022$, $\eta^2_{partial} = 0.579$] accompanied by a significant main effect of treatment [$F(12,23) = 7.029$, $p = .000$, $\eta^2_{partial} = 0.786$]. No significant main or interaction effects were obtained for hearing loss or intellectual disability aetiology. These two latter factors were accordingly ignored for the remainder of the analyses, with univariate tests being conducted for pre- to post scores and severity of intellectual disability only.

3.2 | Within-subject factors

Figures 2–4 present means and 95% confidence intervals for the dependent variables, while the univariate tests of the RM ANOVA

TABLE 2 Results of the univariate tests of the RM ANOVAs

	Pre- to Post-scores			Severity of intellectual disability			Pre- to Post-scores × Severity of intellectual disability		
	$F(1,34)$	p	$\eta^2_{partial}$	$F(1,34)$	p	$\eta^2_{partial}$	$F(1,34)$	p	$\eta^2_{partial}$
PCCI	15.265	.000**	.310	5.520	.025*	.140	1.363	.251	.039
PSSC	5.700	.023*	.144	4.593	.039*	.119	0.199	.658	.006
PClusCI	2.723	.108	.074	1.093	.303	.031	4.935	.033*	.127
PSubCI	3.146	.085†	.085	4.779	.036*	.123	3.838	.058†	.101
PSubCF	0.144	.707	.004	1.996	.167	.055	1.613	.213	.045
PAbnProc	1.878	.180	.052	0.052	.821	.002	0.232	.633	.007
PNormProc	0.332	.568	.010	2.372	.133	.065	0.837	.367	.024
PCDel	1.297	.263	.037	4.632	.039*	.120	0.103	.751	.003
PIC1Del	2.591	.117	.071	4.782	.036*	.123	0.903	.349	.026
PIC2Red	8.266	.007**	.196	2.857	.100	.078	1.510	.228	.043
PIC3Red	1.556	.221	.044	0.076	.784	.002	0.465	.500	.013
PVVT	55.678	.000**	.621	22.090	.000**	.394	0.320	.575	.009

Statistically significant contrasts are denoted by *$p < .05$ and **$p < .01$, while †denotes a statistical trend ($p < .10$).

TABLE 3 Results of the multivariate RM ANOVAs on the group-specific speech-intelligibility indicators

Severity of intellectual disability	Model	*F*	*df*1	*df*2	*p*	Partial eta-squared	Observed power
Mild	PCCI; PClusI; PNormProc; PIC3Red	3.514	4	12	.040*	0.539	0.694
Moderate	PCCI; CPClusI; PIC2Red	5.356	3	17	.009**	0.486	0.863

Statistically significant effects of treatment are denoted by **p* < .05 and ***p* < .01.

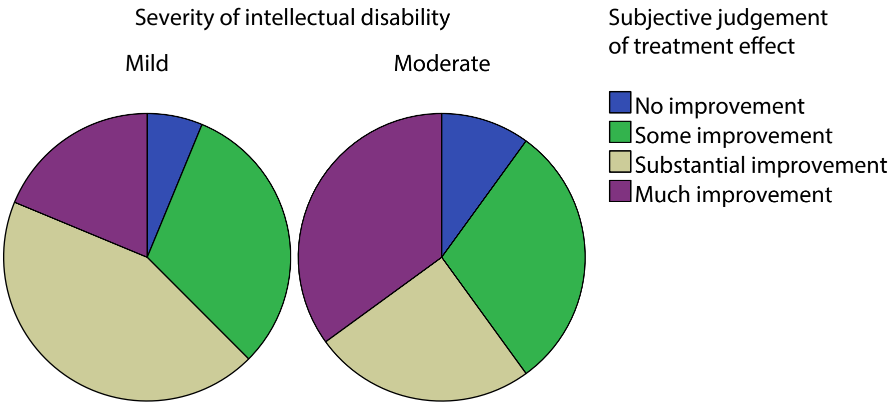

FIGURE 5 Therapist's judgement of the participants' improvement in quality and level of communication after intervention. [Colour figure can be viewed at wileyonlinelibrary.com].

(with pre- to post-scores as within-subject factor and severity of intellectual disability as between-subjects factor) are presented in Table 2. Results showed a significant pre- to post-increase in the proportions of consonants correct (PCCI) and syllable structures correct (PSSC; Figure 2; Table 2). Furthermore, results also revealed a significant decrease of the proportion reductions of consonant clusters in syllable-initial position containing two consonants (PIC2Red) and a trend effect of treatment in the same direction for the proportion substitutions of single consonants in initial position (PSubCI; Figure 3; Table 2). Finally, our analysis yielded a highly significant positive effect of treatment on receptive vocabulary (PPVT scores; Figure 4; Table 2).

Besides significant treatment effects, the univariate tests of the RM ANOVA also revealed a number of significant differences as a function of severity of intellectual disability (i.e., for proportion consonants correct in syllable-initial position [PCCI], proportion syllable structures correct [PSSC], proportion substitutions of single consonants in initial position [PSubCI], proportion consonant deletions [PCDel], proportion deletion of consonants in syllable-initial position [PIC1Del] and receptive vocabulary [PVVT]; Table 2). Additionally, there were significant interactions between pre- to post-scores and severity of intellectual disability for PClusCI (proportion consonant clusters correct in initial position) and PSubCI (proportion substitutions of single consonants in initial position). Further investigation revealed that only the moderate intellectual disability group showed significant progression on these two measures following treatment (PClusCI: $t = -2.246$, $p = .037$, $\eta^2_{partial} = 0.210$; PSubCI: $t = 3.149$, $p = .005$, $\eta^2_{partial} = 0.343$ [paired *t*-tests]; Figures 2 and 3).

Finally, the relationship between the progression on the segmental and syllabic level was investigated by computing Pearson's correlation coefficients between the improvement on the phonetic accuracy measures, that is, PCCI (proportion consonants correct in syllable-initial position), PSSC (proportion syllable structures correct) and PClusCI (proportion consonant clusters correct in initial position). Results showed significant correlations between improvements in PCCI and PSSC ($r = .491$, $p = .002$) and between the improvements in PCCI and PClusCI ($r = .350$, $p = .036$), but not between improvements in PSSC and PClusCI.

3.3 | Speech intelligibility

The results of the separate repeated-measures MANOVAs for the two study groups, contrasting group pre- to post-scores with the group-specific predictors, showed strong effects for both groups (Table 3), indicating that the intelligibility of the participants' speech had significantly improved (Figures 2 and 3) as a result of treatment.

3.4 | Speech-language therapist reports

Results of the therapist's evaluations of the participants' improvement in quality and level of communication after the intervention are presented in Figure 5, while detailed descriptions per participant are given in Appendix C. Speech output had improved in almost all of the participants (Figure 5). With respect to communicative behaviour in general, the large majority showed increased communicative initiative and more self-confidence. The greatest improvements were noted as having been elicited by positive feedback, compliments, topics coinciding with the participant's interests, and the weekly personal attention from the speech-language therapist (Appendix C).

4 | DISCUSSION

In the present study, it was explored whether it is possible to help adults with intellectual disability improve their verbal communication skills through speech therapy. Based on an analysis of the specific types of speech errors and their relation with intelligibility in a sample of 36 adult speakers with mild or moderate intellectual disability our group conducted earlier (Coppens-Hofman, Terband, Snik & Maassen, 2016), an intervention programme was formulated for these impaired speakers aimed at improving the group-specific deficits and thus speech intelligibility. Treatment was delivered in two 3-month periods with a 3-month interval and consisted of individual, 30-minute weekly sessions of articulation training in combination with training in listening skills.

In summary, the results indicate that the speech of our participants had improved on several domains following treatment. First, they produced significantly higher proportions consonants correct in syllable-initial position and syllable structures, and showed a trend towards making fewer substitutions of syllable-initial consonants. Second, both groups showed positive treatment effects for the two sets of group-specific intelligibility predictors. Our findings thus indicate that the participants made fewer speech errors after treatment and that the intelligibility of their speech had increased. It can thus be concluded that the speech therapy was effective for our group of participants. This is confirmed by the subjective judgements of the speech-language therapist, which indicate improved speech after intervention in almost all of the participants.

Besides the improvement on mentioned speech-production measures, treatment also showed a positive effect on receptive vocabulary, implying that the participants had improved their level of word recognition and understanding. This result is especially striking as vocabulary was not targeted in the therapy; the treatment programme consisted purely of articulation training in combination with training in listening skills (i.e., auditory discrimination). The intervention was the same for all participants, but individually adapted to the level and, more importantly in this respect, to the interests of the participant. The therapist noted that all participants were well motivated throughout the intervention: they were always eager to start the weekly session and disappointed when it ended. Their caregivers also reported that during the 3-month intermission and after treatment completion, their clients showed frustration and expressed their disappointment with the absence of sessions. Moreover, the subjective judgements of the effects of treatment indicate a large increase in communicative initiative and self-confidence in almost all of the participants. Apparently, aimed attention to the clients' everyday interests and increased communication with them might lead to improved language and improved communicative abilities as well. Further research investigating long-term effect retention with objective measures of communicative proficiency is warranted.

No differences were found based on hearing or intellectual disability aetiology, neither in the speech intelligibility and error patterns before treatment, nor in the treatment effect. Although one should always be careful with null results, the present authors believe this finding is of importance for two reasons. First, the effectiveness of speech therapy does not seem to depend on the cause of the intellectual disability, nor on any hearing problems. Clinically, this implies that hearing impairment should not be a reason for not offering speech therapy. Although several studies did report hearing loss to be related to poor speech intelligibility in these speakers with intellectual disability (Coppens-Hofman et al., 2012), our results suggest that hearing loss does not constitute a barrier to improving intelligibility by means of speech therapy.

Second, the fact that predominantly differences in the number—and not the pattern—of speech errors were found to be associated with intellectual disability severity (Coppens-Hofman, Terband, Snik & Maassen, 2016) and no differences that were attributable to hearing loss or intellectual disability aetiology suggests that it is the impairment in cognitive functioning that lies at the core of the speech-production problems in adults with intellectual disability. As the present treatment programme only involved simple, straightforward articulation and listening exercises, it is worthwhile to explore other techniques to optimize the intervention to the specific learning (dis)abilities of the individual client. One may, for example, vary training paradigms and stimuli (Perrachione, Lee, Ha, & Wong, 2011) or incorporate principles of motor learning (Maas et al., 2008). Furthermore, the strong beneficial effect of our speech-training programme on receptive vocabulary prompts the exploration of techniques to adjust the treatment to higher-level psycholinguistic abilities.

The present study is meant to be a further step towards optimizing care and support for those individuals with an intellectual ability that suffer from concomitant communication problems. In this first test, the content and procedure of the speech-therapy programme were kept the same for all participants with only minor adaptations to suit the needs and interests of the individual client. The results revealed a few differences in the effect of the treatment that were associated with the severity of the intellectual disability. The adults with moderate intellectual disability showed a larger proportion of consonant clusters correct and fewer substitutions of initial syllables after treatment, whereas no improvement was found for the mild group on these measures. More structured trials are needed that investigate and compare the effects of other targeted interventions aimed at improving hearing and speech in this population to help unravel which (parts of the) treatments are the most effective for which individuals.

In conclusion, the present study shows that adults with mild and moderate intellectual disabilities can improve their speech and language skills, demonstrating that speech therapy for people with intellectual disability can be effective at adult age. These findings suggest that continued attention to speech can help augment the verbal communication skills in this population.

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APPENDIX A

OVERVIEW OF THE PARTICIPANTS

	Age at Baseline	Gender	Cause of intellectual disability	Severity of intellectual disability	WBQ pre	Age WBQ pre	WBQ post	Hearing loss	Type of Hearing loss	Hearing Aid	Group
101	22;1	F	Down syndrome	Moderate	65	6;5	65	No			1
102	23	M	Down syndrome	Moderate	64	6,5	66	Yes	Conductive	No	1
103	36;1	F	Down syndrome	Moderate	34	4;5	34	Yes	Mixed	Yes	1
104	35;8	M	Oxygen deficiency	Moderate	29	3;11	45	No			1
105	28;4	M	Trauma	Mild	81	7;11	93	No			1
106	40;2	F	Unknown	Moderate	64	7;11	66	Yes	Perceptive	No	1
107	37;1	F	Unknown	Moderate	56	6;5	73	No			1
108	23;2	F	Unknown	Mild	88	9;11	88	Yes	Perceptive	Yes	1
109	21;4	M	Unknown	Moderate	47	5;5	55	No			1
110	33;7	F	Down syndrome	Mild	111	15;11	111	No			1
111	32;1	M	Down syndrome	Moderate	72	10;11	87	Yes	Conductive	No	1
112	32;3	F	Unknown	Moderate	80	9;11	86	Yes	Conductive	No	1
113	30;6	M	Unknown	Mild	73	7;11	86	Yes	Perceptive	No	1
114	30;9	F	Down syndrome	Mild	58	5;5	69	Yes	Perceptive	Yes	1
115	31;11	F	Microcephaly	Moderate	26	3;11	39	No			1
116	22;11	M	ESES syndrome	Mild	81	7;11	89	No			1
117	30;6	F	Unknown	Moderate	31	3;11	45	Yes	Conductive	No	1
118	20;11	M	Unknown	Mild	86	9;11	99	No			1
119	32;7	F	Down syndrome	Moderate	66	6;5	72	Yes	Perceptive	No	2
120	28;2	M	Microcephaly	Moderate	35	4;5	62	No			2
121	18	M	Down syndrome	Moderate	80	9;11	95	Yes	Mixed	No	2
122	34;1	M	Brain damage	Mild	142	35;11	159	No			2
123	34 6	M	Unknown	Moderate	75	7;11	100	No			2
124	26;11	M	Down syndrome	Moderate	53	5;5	56	Yes	Conductive	Yes	2
125	26;8	M	Unknown	Mild	121	15;11	121	No			2
126	28;9	F	Turner syndrome	Mild	124	15;11	128	Yes	Perceptive	No	2
127	24;11	M	Down syndrome	Mild	72	7;11	72	Yes	Perceptive	Yes	2
128	36;9	M	Unknown	Moderate	72	7;11	87	No			2
129	37;4	F	Brain damage	Mild	123	15;11	134	No			2
130	23;9	F	Unknown	Mild	91	10;11	112	No			2
131	36;8	F	Oxygen deficiency	Mild	109	15;11	131	Yes	Perceptive	Yes	2
132	27;3	M	Unknown	Mild	119	15;11	130	No			2
133	18;11	F	Brain damage	Mild	92	9;11	94	No			2
134	28;6	M	Fragile X syndrome	Moderate	79	9;11	93	Yes	Conductive	No	2
135	27	F	Down syndrome	Moderate	72	7;11	71	No			2
136	36;9	M	Unknown	Moderate	116	15;11	130	No			2

APPENDIX B

TREATMENT PROTOCOL

Session structure for each of the two treatment periods

1. Repeating exercises from the previous session: 10 min
2. Introduction and practice of new exercises: 15 min
3. Recapitulation of the session/game: 5 min

TREATMENT GOALS

The main goals of the intervention were overall the same as they were based on the participant's intelligibility predictors established prior to the treatment. For each participant, specific, individual treatment goals were determined based on their specific speech errors and phonological and auditory perception problems. Sessions could vary per participant depending on which goal needed the most attention, while the exercises were adjusted to the participant's level and interests. When a goal was achieved, the next goal was introduced. Articulation training comprised practising and explaining the pronunciation of speech sounds and words, phonological distinctions (minimal pairs) between speech sounds, oral motor skills, speaking skills and communicative skills. Auditory training consisted of phonological distinctions (minimal pairs) between speech sounds (auditory discrimination), listening in noise, rhyme, auditory memory and concentration.

1. Participants can pronounce (produce) all Dutch single consonants and vowels at the word and sentence levels and in spontaneous speech.
   Material: Visual stimuli, for example, colour cards, pictures from the Logo-Art articulation test (Baarda et al., 2005), transparencies (slides) and drawings. To learn vowels, pictures taken from the Dutch dyspraxia programme (Erlings-van Deurse, Freriks, Goudt-Bakker, Van der Meulen, & de Vries, 1993) were used, with a gesture to support the consonant. Consonant production was practised in spontaneous speech by talking about the client's favourite topics (e.g., music, pictures, movies, hobbies).
   ↓
2. Participants can pronounce (produce) all Dutch consonant clusters and diphthongs at the word and sentence levels and in spontaneous speech.
   Material: Visual stimuli, for example, colour cards, pictures of the Logo-Art articulation test (Baarda et al., 2005), transparencies (slides) and drawings. To learn diphthongs, pictures from the Dutch dyspraxia programme (Erlings-van Deurse et al., 1993) were used, with a gesture to support the consonant. Consonant clusters were practised in spontaneous speech by talking about the client's favourite topics (music, pictures, movies, etc.).
   ↓
3. Participants can distinguish (perceive) all Dutch speech sounds in words when they only differ on one aspect (e.g., voiced/bet/versus unvoiced/pet/).
   Material: Pictures from the Metaphon phonological intervention programme (Dean, Howell, Hill, & Waters, 1990), with the participant pointing out the right word as pronounced by the therapist.
   ↓
4. Participants can pronounce (produce) words consisting of more than one syllable sufficiently intelligibly (i.e., pronouncing distinct sounds and syllables) at both word and sentence levels and in their spontaneous speech.
   Material: Drawings and pictures depicting multisyllabic words (e.g., "paddenstoel," "paraplu," "vrachtauto"). Additional cues such as "footsteps" or other drawings were used to help visualize the different syllables.

APPENDIX C

SPEECH-LANGUAGE THERAPIST EVALUATIONS PER PARTICIPANT

	Age at Baseline	Gender	Subjective judgement of improvement	Influencing factors/Cause of speech improvement after a year of intervention	Comments
101	22;1	F	Some	Lower speech rate, awareness of the different speech sounds	
102	23	M	Much	Is always highly motivated, growing self-confidence	
103	36;1	F	Some	Improved concentration	Her moods, anger and frustration influence her speech a lot
104	35;8	M	None	Personal attention improved language, not speech	Is talking a lot more and to many more people (communicative initiative), knows a lot more words
105	28;4	M	Some	Speaks louder and with more self-confidence	Elements of apraxia of speech, replaces phonemes inconsequent
106	40;2	F	Much	Gestures are supporting phonemes, visual cues are helpful	Elements of apraxia of speech
107	37;1	F	Much	Personal attention and compliments trigger improvement	
108	23;2	F	Substantial	Aware of the different phonemes/sounds, due to feedback	
109	21;4	M	Substantial	Personal attention, interest in his stories and practising the different sounds led to improvement in speech and language	Suspected of apraxia of speech
110	33;7	F	Some	Speaks louder and slower leading to improved intelligibility	
111	32;1	M	Substantial	Repetition and imitation were helpful in improving speech	
112	32;3	F	Much	Giving her more self-confidence, positive feedback and compliments improved language and speech	
113	30;6	M	Substantial	Is now aware of the different phonemes due to auditory feedback	Position of teeth influences his speech production
114	30;9	F	Much	Reducing environmental noise and speaking slower both lead to understandable speech	
115	31;11	F	Some	Imitation and gestures were very helpful	Severe Gilles de la Tourette, behavioural problems. Language seems improved a lot.
116	22;11	M	Substantial	More self-confidence when talking to other people	Communicative initiative improved
117	30;6	F	None	More self-confidence when talking to other people	Speech seems not improved, but she is talking a lot more
118	20;11	M	None	There is still a lot of tension in his speech	
119	32;7	F	Substantial	Compliments, attention led to improved speech and listening skills	Positive attention and positive feedback improve speech
120	28;2	M	Much	Has more attention for and focus on speech and language	
121	18	M	Some	Motivation is an important element in intelligible speech	Motivation less at the end
122	34;1	M	Some	Lowering speech rate helps improve speech quality	Suspected of apraxia of speech, inconsequence in speech errors

(Continued)

APPENDIX C (Continued)

	Age at Baseline	Gender	Subjective judgement of improvement	Influencing factors/Cause of speech improvement after a year of intervention	Comments
123	34; 6	M	Much	Lowering speech rate, separating the words and carefully using every syllable help improving speech quality	Awareness of speech and calmness improves speech a lot
124	26; 11	M	Some	Continuing the speech therapy is important	
125	26;8	M	Substantial	Lowering speech rate, personal attention and focus on speaking help improve speech quality	Attention deficit: focusing attention improves speech
126	28;9	F	Substantial	Lowering speech rate in long words helps improve speech quality	Reading and concentration help improving speech quality
127	24;11	M	Substantial	Improving his hearing with hearing aids was of help	
128	36;9	M	Much	Personal attention helps improve speech quality and use of language	
129	37;4	F	Substantial	Lowering speech rate, using every syllable, less stress and more attention helps improve speech quality	Attention and less stress improves speech quality immediately
130	23;9	F	Much	Lowering speech rate, personal attention and compliments help improve speech quality	
131	36;8	F	Some	Individual attention, awareness of the different speech sounds made speech quality better	
132	27;3	M	Much	Personal attention and listening to his stories help improve speech quality	Less stress and less urge to speak fast helps a lot in improving his speech
133	18;11	F	Some	Personal attention, care and understanding are important factors in improving her speech quality	
134	28;6	M	Some	It helps a lot when the conversation is about all that interests him	
135	27	F	Substantial	Positive feedback and attention helped improve speech	
136	36;9	M	Substantial	Interaction with people and attention for what he wants to tell you helps to improve his message and quality of speech	Dysfluencies in speech, improvement by less stress