

*A systematic review of speech, language,
and communication interventions for
children with Down syndrome from 0 to 6
years*

Article

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1 **A systematic review of speech, language, and communication interventions for children**
2 **with Down syndrome from 0 to 6 years**

3
4 **Abstract**

5 **Background:** Speech and language acquisition can be a challenge for young children with Down
6 syndrome, and while early intervention is important, we do not know what early interventions
7 exist and how effective they may be. **Aims:** to systematically review existing early speech,
8 language, and communication interventions for young children with Down Syndrome from birth
9 up to 6 years, and to investigate their effectiveness in improving speech, language, and
10 communication outcomes in children with Down syndrome. Other outcomes are changes in
11 parental behaviour and their responsiveness **Methods:** We conducted a systematic search of
12 relevant electronic databases to identify early intervention studies targeting speech, language and
13 communication outcomes in children with Down syndrome published up to May 2020. Eleven
14 studies which met the inclusion criteria were synthesised and appraised for quality using the
15 PEDro-P scale. There was a total of 242 children. We identified three types of intervention:
16 communication training and responsive teaching, early stimulation programme and dialectic-
17 didactic approach. **Main contribution:** The findings from nine out of the 11 studies reported
18 positive outcomes for children’s language and communication up to 18 months following the
19 intervention. All nine studies reported interventions which were co-delivered by parents and
20 clinicians. However, there was also a de-accelerated growth in requesting behaviours in the
21 intervention group reported by one study as well as a case of no improvement for the
22 intervention group. Three studies provided some evidence of improvements to parent outcomes,

1 such as increased parental language input and increased responsiveness. However, there was a
2 moderate to high risk of bias for all studies included. **Conclusions:** The findings from the review
3 suggest that interventions which have high dosage, focus on language and communication
4 training within a naturalistic setting and are co-delivered by parents and clinicians/researchers
5 may have the potential to provide positive outcomes for children with Down syndrome between
6 0 and 6 years of age. Due to the limited number of studies, limited heterogenous data and the
7 moderate to high risk of bias across studies, there is an urgent need for higher quality
8 intervention studies in the field to build the evidence base.

9 **What is already known on the subject?**

10 Speech and language acquisition is usually delayed in children with Down syndrome, yet there
11 are currently no standard interventions for children under 6. A number of research-based
12 interventions exist in the literature, yet it is unknown how effective these are.

13 **What this study adds**

14 This is the first systematic review which specifically and exclusively focuses on parent and non-
15 parent mediated speech, language, and communication interventions for children with Down
16 syndrome between 0 and 6 years of age. It complements three existing recent reviews, each of
17 which have a slightly different focus. O'Toole et al. (2018) focus only on parent-mediated
18 interventions, excluding interventions not mediated by parents. Neil and Jones (2018) reviewed
19 interventions including children and adults, and because of the very wide scope, there is no
20 mention of what early interventions may be like or how effective these may be for young
21 children with Down syndrome, and the authors did not assess risk of bias. Smith et al. (2020)

1 focus specifically on language interventions and exclude those focusing on speech articulation or
2 pre-linguistic skills, and cover a wide age range (0-18). The findings from the review suggest
3 that interventions which have high dosage, focus on language and communication training within
4 a naturalistic setting and are co-delivered by parents and clinicians/researchers may have the
5 potential to provide positive outcomes. We acknowledge that the current evidence-base comes
6 from studies with moderate to high risk of bias hence our conclusions are not definitive.

7 **Clinical implications of the study**

8 Speech and language therapists will have synthesised information and a quick reference point on
9 what type of interventions exist for children with Down syndrome under the age of 6, and
10 evidence of which intervention approaches may be promising in terms of providing positive
11 outcomes. However, it is acknowledged that, due to the limited number of studies and the
12 moderate to high risk of bias inherent in the evidence, there is an urgent need for higher quality
13 intervention studies in the field to build the evidence base.

14 **Introduction**

15 **Speech and language development in children with Down syndrome**

16 Down syndrome (DS) is a genetic condition caused by an additional copy of chromosome
17 21, which results in distinct facial features, health problems and learning disability (Chapman
18 and Hesketh, 2000). It affects approximately 1 in 1000 births (Hughes-McCormack et al. 2020)
19 and makes up the largest population of those identified with an intellectual disability. The
20 average IQ of an individual with Down Syndrome is 50, with a range of 30 – 70 (Chapman and

1 Hesketh 2000). Communication, language, and memory are known to be adversely affected
2 (Laws et al. 2000) and there is much variability within the condition (Davis-McFarland 2008).

3 Although children with Down Syndrome seem to go through the same stages of language
4 development as typically developing children, the pace at which developmental milestones are
5 reached is delayed (O'Toole and Chiat 2006). Children with Down Syndrome produce their first
6 word around 21 months (Stoel-Gammon 2001), compared to typically developing children who
7 usually produce their first word at around 12 months of age (Tomasello 2003). Expressive
8 language tends to be more delayed than receptive language (Fidler and Nadel 2007, Mason-Apps
9 et al. 2020). Social and non-verbal interaction using sign is also a relative strength for some
10 individuals with Down Syndrome (Martin et al. 2009). Regarding language abilities, expressive
11 and receptive grammar, verbal short-term memory, articulation, and phonology tend to be a
12 relative weakness (Martin et al. 2009, Naess et al. 2015). Intelligibility is often adversely
13 affected, as well as speech sound production and speech-motor planning (Buckley and Bird
14 2001) which can compromise joining in conversations and producing narratives (van Bysterveldt
15 et al. 2014).

16 The gap in language outcomes between children with Down Syndrome and typically
17 developing children widens as they reach school age. Some children with Down Syndrome enter
18 school with a spoken vocabulary of approximately 300 words and communicate using 2-4 key
19 word sentences (Buckley and Bird 2001). By 8-9 years of age, the average spoken vocabulary
20 increases to around 450-500 words, ranging from 150-600 words, meaning that by 9 years of age
21 some children with Down Syndrome have fewer than 200 spoken words (Buckley and Bird
22 2001). This may adversely affect later educational and social outcomes, as language ability at

1 school entry has been shown to predict later academic and psycho-social outcomes for typically
2 developing children (Snowling et al. 2011).

3 Hearing loss is a significant contributor to the speech and language deficits experienced
4 by children with Down Syndrome, with 40 to 80% of children with Down Syndrome having
5 hearing impairments (Hans et al. 2010). Children with Down Syndrome who have moderate to
6 severe hearing loss between the ages of 2 and 4 may go on to have more impaired receptive
7 vocabularies, language comprehension and expression, and articulation difficulties compared to
8 children with Down Syndrome who have hearing within the typical range (Laws and Hall 2014).

9 **Existing interventions and previous reviews of interventions**

10 Most individuals with Down syndrome have a speech, language and/or communication
11 deficit that is prominent from an early age. Down Syndrome can be diagnosed prenatally (using
12 amniocentesis and karyotyping of the foetal cell), or at birth, using diagnostic tests (Fidler 2005).
13 The early identification allows for interventions to be administered from a very early age. And
14 although early interventions targeting speech, language, communication outcomes for
15 individuals with Down syndrome have been published as research papers, it is not clear if such
16 interventions are effective and if these should be used in clinical practice. It is, therefore, of
17 foremost importance to identify which early speech and language interventions exist (including
18 clinician delivered, parent/carer-delivered or a mixture of clinician and parent/carer) and which
19 ones may be effective in achieving better speech, language, and communication outcomes for
20 young children with Down Syndrome. It is important to note that the speech, language, and
21 communication difficulties of children with Down syndrome are on top of their learning
22 disability, which has to be taken into account when developing appropriate interventions.

1 Early intervention (intervention in the pre-school years) has been shown to be effective
2 for other clinical populations, such as autism spectrum disorders (ASD) (e.g., Dawson et al.
3 2010), and children with language delay (Buschmann et al. 2009). In recent years, systematic
4 reviews have been used to assess the effectiveness of speech and language interventions for
5 children with ASD (Hampton and Kaiser 2016) and developmental delay (Te Kaat-van den Os et
6 al. 2017). By using this process, researchers can consider all research studies in a field, through a
7 systematic and transparent process in selecting studies and considering the quality of the
8 collective evidence (Marshall et al. 2015, Pring 2004). Furthermore, systematic reviews are
9 important for supporting evidence-based practice.

10 To date, few systematic reviews have specifically focused on early speech and language
11 interventions for young children with Down Syndrome. Neil and Jones (2018) focused on
12 communication interventions for individuals with Down Syndrome which targeted speech,
13 expressive syntax, phonology, and vocabulary, but included both children and adults. They
14 concluded interventions employing behaviour analytic strategies offered promising results for
15 improving communication and language outcomes. The review did not include a risk of bias
16 analysis. O'Toole et al. (2018) completed a Cochrane systematic review focusing exclusively on
17 parent-mediated interventions for communication and language in young children with Down
18 syndrome including only randomised controlled trials (RCTs). The review concluded that there
19 is insufficient evidence to establish the effectiveness of parent-mediated interventions. Another
20 recent systematic review and meta-analysis by Smith et al. (2020) including eight studies (2020)
21 focusing on language interventions for children and adolescents with Down syndrome aged
22 between 0 and 18 years of age concluded that children with Down Syndrome have the potential

1 to respond positively to language intervention. The review included only experimental and quasi-
2 experimental design studies which had a control group, and single case designs were excluded.

3 Additionally, an important aspect of social interaction is parental responsiveness, and
4 evidence suggests that children with Down syndrome had higher mental ability as measured by
5 the Bayley Scale of Infant Development if their mothers had a more responsive interactive style
6 (Mahoney et al. 1985). When discussing interventions for young children, caregivers’
7 interactions with young children in promoting early language and communication development
8 is crucial (Barton 2013), as the child’s family and parents are best placed to support the child’s
9 development (O’Toole et al. 2018).

10 Given the importance of children having the necessary language and communication
11 skills needed for school readiness (and school officially starts between the ages of 4 and 6,
12 depending on the country), it is essential to focus on interventions which target pre-school
13 children, or children who have just started school, to learn which interventions exist, how
14 effective they may be and how the language and communication skills of children with Down
15 Syndrome can be better supported.

16 **Aims and research questions**

17 The aim of the current systematic review was to identify and critically appraise existing
18 randomised controlled trials and quasi-experimental studies of speech, language and
19 communication interventions for children with Down Syndrome aged 0-6 years, and to
20 investigate their effectiveness in improving speech/language/communication outcomes for the
21 children, as well as outcomes for the parents/caregivers in terms of parental responsiveness and

1 changes in communication. Interventions which target expressive and/or receptive speech,
2 language, and communication outcomes, as well as those targeting pre-verbal communication
3 skills, were included. Single case studies/series were excluded because there are multiple biases
4 in these studies, which makes it hard to synthesise the different types of study designs.

5 The research questions are:

- 6 1. Which early speech, language and communication interventions exist for children with
7 Down Syndrome aged 0-6 years of age?
- 8 2. Are speech, language, and communication interventions effective in improving receptive
9 and/or expressive speech and/or language/communication skills of children with Down
10 Syndrome aged 0 to 6?
- 11 3. Are there relevant secondary outcomes such as change in parental language input,
12 communication behaviour and responsiveness?

13 **Method**

14 The current systematic review followed the guidance detailed in the Cochrane Handbook of
15 Systematic Reviews (Higgins et al. 2020, Petticrew and Roberts 2008) and Preferred Reporting
16 Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (prisma-statement.org).

17 *Search strategy*

18 We developed the search strategy considering the Population, Intervention, Comparison,
19 Outcomes (PICO) model (Booth and Fry-Smith 2004). The search terms encompassed three
20 main concepts relating to Down syndrome, intervention, and speech/language/communication

1 outcomes. A comprehensive list of search terms was identified using the key words from
2 relevant review papers and the co-authors' previous work in the field. We did not set a limit
3 regarding publication date. The searches were originally conducted in December 2016 and were
4 updated in May 2020. A list of 18 search terms was established though a process of discussion
5 and modification. They included key words related to Down syndrome, language, speech,
6 communication, intervention, signing, and synonyms (see Appendix 1).

7 *Electronic searches*

8 Separate searches were completed in four electronic databases (ERIC, LLBA, MedLine and
9 PsychInfo) as suggested by a senior librarian at the University of [REMOVED FOR REVIEW]
10 to identify studies published up to May 2020.

11 *Searching other resources*

12 A hand search was also conducted which involved: searching the reference lists and using the
13 Cite Forward function for all included full-text papers, scanning reference lists of review papers
14 and searching several relevant journals identified to be most likely to publish papers on speech
15 and language intervention in children with Down Syndrome, including: *Down Syndrome*
16 *Research and Practice*, *Speech and Language*, *Child Language*, *Teaching and Therapy*, *Early*
17 *Child Development and Care*, *the International Journal of Language and Communication*
18 *Disorders and the Journal of Speech, Language and Hearing Research*. We also contacted two
19 authors who we believed had collected intervention data from children with Down syndrome but
20 had not published these data separately. One author did not respond at all, the other one
21 responded initially that they would try to find the data but then did not respond any further.

1 *Inclusion criteria*

2 The Population, Intervention, Comparison, Outcomes (PICO) model (Booth and Fry-Smith,
3 2004) was utilised to aid the development of inclusion criteria, with the addition of study design,
4 as described below.

5 **1) Population:** children with a diagnosis of Down Syndrome, without additional diagnoses
6 (e.g., ASD and aged from 0 to 6 years 11 months at the start of the study. Studies which
7 included other participant groups (e.g., children with ASD or learning disabilities) were
8 included, if separate results were available for the children with Down syndrome.

9 **2) Intervention:** an evaluation using randomised controlled trial (RCT) and quasi-
10 experimental designs of an intervention focussing on improving receptive and/or
11 expressive speech/language/communication outcomes in children with Down Syndrome.
12 The intervention could be delivered by clinicians or parents, individually or as part of a
13 group, and could target precursor skills (prelinguistic communication) or rudimentary
14 communication skills, such as turn taking, or verbal communication.

15 **3) Comparison:** a control group, which could be no-treatment or usual care, or a different
16 intervention, a group receiving a different dose of the active intervention, or
17 chronological age/developmental age group comparison.

18 **4) Outcomes:** at least one of the immediate post-intervention outcomes would be a measure
19 of expressive and/or receptive speech and/or language skills. This could be measured by
20 standardised or criterion referenced assessments, author created measures, parental
21 reports, spontaneous language samples or observations.

22 *Exclusion criteria*

1 Studies were excluded if: using a single case studies or multiple baseline design, the paper was
2 not available in English, and/or the full text was not accessible.

3 *Selection of studies*

4 After removing any duplicates, the first author and a research assistant independently reviewed
5 the titles and abstracts for all studies that were identified from the initial searches and rejected
6 those studies that did not fulfil the inclusion criteria. Those which met the inclusion criteria, and
7 any papers for which it was hard to decide whether to include/exclude based on the title and
8 abstract, were reviewed in full by two of the co-authors independently. The results were then
9 compared, and any disagreements were resolved through discussion. Details regarding the
10 number of studies included at each stage of the process and reasons for exclusion are shown in
11 Figure 1 following PRISMA guidelines (prisma-statement.org).

12 INSERT FIGURE 1 AROUND HERE

13 *Quality appraisal*

14 To assess the risk of bias and appraise the quality of included papers, we used the speechBITE
15 Physiotherapy Evidence Database quality rating scale (PEDro-P: Perdices et al. 2009,
16 <http://www.speechbite.com>). SpeechBITE is an online database set up to assist clinicians to
17 identify the scientific quality of randomised and non-randomised control trials. The PEDro-P
18 rating scale was appraised for reliability for speech and language therapy literature (Murray et al.
19 2013) and deemed reliable and consistent. It has been used in other systematic reviews of speech
20 and language therapy interventions (Wren et al. 2018).

1 The second and last author completed the PEDro-P training and did the appraisal of the
2 included studies independently, following the PEDro-P rating scale (Perdices et al. 2009), which
3 is suitable for use to appraise the methodological quality of randomised and group comparison
4 studies. Each criterion when met gets a score of 1, and there are 11 criteria. Criterion 1 relates to
5 external validity and is not counted towards the total methodological rating score; thus, the
6 maximum score is 10. Criteria 2 to 9 assess the internal validity and cover randomisation of
7 participants to groups, concealed allocation, and similarity of groups at baseline, blinding of
8 participants, clinicians and assessors, drop-out rates, and intention to treat analysis. Criteria 10
9 and 11 cover the interpretability of findings. A criterion was only considered to be met when the
10 relevant information was clearly stated in the paper. When it was not easy to interpret
11 information, a conservative approach was taken whereby a criterion was assessed as not passed
12 and inferences were not made. Higher scores on PEDro-P were associated with higher
13 methodological quality and greater internal validity. When raters' overall scores differed (and
14 this happened for three studies), agreement was reached by checking the papers again for any
15 criteria where there may have been disagreements and reaching consensus. See Table 3 in the
16 Results section for PEDro-P appraisal.

17 *Data extraction and synthesis*

18 Data extraction was carried out on the participant characteristics, design, location, setting,
19 intervention (type, duration, intensity, and implementer), control condition, treatment fidelity,
20 outcome measures used and response outcomes. Quantitative synthesis was not conducted due to
21 heterogeneity of measures obtained through different study designs and insufficient data
22 available to conduct a meta-analysis.

1 **Results**

2 As Figure 1 shows, the initial electronic search located 1,359 papers which were
3 transported to a reference management programme (EndNote). 175 duplicates were removed
4 which left a total of 1337 papers. After screening titles and abstracts, 358 full-text papers were
5 read and screened against the pre-defined eligibility criteria. A total of 11 studies were identified
6 as being eligible for the review and were subject to quality appraisal.

7 *Description of included studies*

8 *Design, location and settings of studies*

9 Four studies were described as RCTs (Girolametto et al. 1998, Karaaslan and Mahoney
10 2013, Yoder and Warren 2002, Yoder et al. 2014) and the remaining seven studies used quasi
11 experimental designs/group comparison. Three of the studies were conducted in the USA
12 (Weller and Mahoney 1983, Yoder and Warren 2002, Yoder et al. 2014), one in Canada
13 (Girolametto et al. 1998), one in the United Kingdom (Bidder et al. 1975), four in Spain (Sanz
14 Aparicio 1989, Sanz Aparicio and Balana 2002, Sanz Aparicio and Balana 2003, Sanz et al.
15 2011), one in Brazil (Andrade and Limongi 2007) and one in Turkey (Karaaslan and Mahoney
16 2013). The interventions were delivered in community settings and/or in the participants' homes.

17 *Participants*

18 The studies included a total of 242 children with Down Syndrome, with between 8 and 48
19 children with Down syndrome in each study. There were between 4 and 48 children in the
20 intervention group and between 4 and 19 in the control groups. Several studies had two or more
21 active intervention groups of children with Down syndrome. Only one study (Andrade and

1 Limongi 2007) included a control group of 4 typically developing children in addition to having
2 a control group of children with Down syndrome. The children were aged between 0 and 55
3 months at the beginning of the interventions.

4 Tables 1 and 2 present the participant characteristics, and study design and outcomes of the 11
5 included studies.

1 Table 1: Participant characteristics

Study		N (male)	Chronological Age range (months)	Dev/Cog age or quotient at baseline (months), range or mean	Language age, or quotient at baseline (months), range or mean		
Andrade & Limongi (2007)	Intervention	4 (2)	36-52	?	?		
	Control (DS)	4 (2)	36-52	?	?		
	Control (TD)	4 (2)	14-16	?	?		
Transcriptions of children's language and gestures							
Sanz Aparicio (1989)	Intervention 1	4 (?)	4 (?)	0-2	?	64-68	DQ for language
	Intervention 2	4 (?)		0-2	?	64-68	
	Intervention 1	4 (?)		3-5	?	61-64	
	Intervention 2	4 (?)		3-5	?	61-64	
	Intervention 1	4 (?)		6-8	?	54-59	
	Intervention 2	4 (?)		6-8	?	54-59	
	Intervention 1	4 (?)		9-11	?	54-56	
	Intervention 2	4 (?)		9-11	?	54-56	
	Intervention 1	4 (?)		12-17	?	53-55	
	Intervention 2	4 (?)		12-17	?	53-55	
	Intervention 1	4(?)		18-23	?	48-51	
	Intervention 2			18-23	?	48-51	
	Brunet-Lezine's First Childhood Scale						
Sanz Aparicio & Balana (2002)	Intervention 1	12 (4)	0-1	?	?		
	Intervention 2	12 (5)	3-4	?	?		
	Intervention 3	12 (7)	6-7	?	?		
Brunet-Lezine's First Childhood Scale							
Sanz Aparicio & Balana (2003)	Intervention 1	10(?)	0-2	?	?		
	Intervention 2	10(?)	0-2	?	?		
Language subtest of Brunet-Lezine							

				Brunet- Lezine's First Childhood Scale	
Bidder et al., (1975)	Intervention	8 (6)	12-33	9.5-22, mean 16.6	?
	Control	8 (6)	12-33	9.5-22, mean 14.8	?
				Griffiths test	Speech subscale
Girolametto et al. (1998)	Intervention	6 (5)	39.2	73.2	16.5mos
	Control	6 (5)	37.2	57.8	16.8mos
				Developmental Profile II	CDI vocab age
Karaaslan & Mahoney (2013)	Intervention	7 (2)	55.1	20.4	18.6mos
	Control	8 (3)	44.1	19.8	17.1mos
				DD	ADSI
Sanz et al., (2011)	Intervention 1	10 (?)	5-8	78-85 DQ	?
	Intervention 2	10 (?)	5-8	78-85 DQ	?
				Brunet- Lezine's First Childhood Scale	Language subtest of Brunet- Lezine
Weller & Mahoney (1983)	Intervention 1-oral group	7 (3)	18-36	54.71 (standard score)	14.14 mos ELA, 14.29 RLA, 9.14 words spoken
	Intervention 2- total com	8 (5)	18-36	67.75 (standard score)	0 words signed 15.38 mos ELA, 17.25 RLA, 14.63 words spoken, 0 words signed
Yoder et al. (2014)	Intervention	8 (?)	21*	14	7.5
	Control	9 (?)	22*	14	7
				BSID	CDI (median words)
Yoder & Warren (2002)	Intervention	16 (?)	22.5	12.7	1.37
	Control	19 (?)	21.6	12.1	0.94
				BSID	CDI (mean words)

Key: *median reported; ? - missing/not reported

Note: Abbreviations- mos-months; DS – Down syndrome; TD – typically developing children; BSID - Bayley Scale of Infant Development; DD - Denver Developmental Screening test-II; ADSI - Ankara Developmental Screening Test-II; ELA - Expressive Language Age; RLA – Receptive Language Age; EPBV- Environmental Pre-language Battery – verbal; CDI Communicative Development Inventories; total com-total communication, DQ- Developmental Quotient

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Table 2: Study design and outcomes

Study	Design	Intervention/ Control	Durati on (week s)	Frequency	Length (minute s)	Measures	Child outcomes	Parent outcomes
Andrade & Limongi (2007)	Quasi- Experimental	Dialectic-didactic intervention Treatment as usual	40	Weekly (child) ? by researcher		Number of different words or signs	No significant differences between the DS groups for oral, gestural, or simultaneous oral/gestural communication	n/a
Sanz Aparicio (1989)	Quasi- Experimental	6 intervention groups (0, 3, 6, 9, 100 12, 18 mos), each group allocated to either modelled or written instructions	26- 78	Twice weekly by clinician + 60 mins weekly at home by mothers	180	Language: Brunet- Lezine Scale	The children in all age groups whose parents had received modelled training scored better than those whose parents got only written instructions	n/a
Sanz Aparicio & Balana (2002)	Quasi- Experimental	3 intervention groups: Age 0 mos, Age 3 mos, Age 6 mos	52- 78	? by clinician + 30mins weekly at home	150	Language: Brunet- Lezine	The children who started intervention at birth had better language scores than those who started later	n/a
Sanz Aparicio & Balana, 2003	Quasi- Experimental	2 intervention groups: Intervention 1 (modelled instruc tions) Intervention 2 (w	70- 78	Twice weekly by clinician + 30mins weekly at home	150	Social development: Brunet-Lezine	The children whose parents received visual instructions (modelled) had significantly higher social	n/a

		ritten instructions)				developmental quotie nts	
Sanz et al., (2011)	Quasi- Experime ntal	Intervention 1 (social reward 1) Intervention 2 (social reward 2)	43	?	?	Language: Brunet- Lezine	Children who received n/a both verbal approval+a gest ure (e.g applause) did not significantly differ from those who received verbal approval only
Bidder et al., (1975)	Quasi- Experime ntal	Behaviour modifi cation intervention Control	26	4 sessions weekly+4 sessions fortnightly+4 sessions monthly for mothers; 10 mins daily twice+ for children	135 (par ent training) 10 (childre n)	Language: Griffiths Scale	The intervention group's language had advanced significantly more than the control group's Mothers were asked for feedback but no formal assessment
Girolametto et al. (1998)	RCT	HPP Treatment as usual	13	Weekly (paren ts trained)	150 (par ent training) 20	Child Vocab. CDI	HPP group used significantly more target words and more words overall than control. No significant difference for semi- structured interaction with clinician Mothers in control group used fewer utterances than intervention group. Parents in the intervention used more target words
Karaaslan & Mahoney (2013)	RCT	RT Treatment as usual	24	Weekly	90-120	Language (DD-II) Language- cognitive scale (ADSI) CBRS	Significant improvements across all development subscales (including language) than control group Mothers in intervention showed more responsiveness and positiv e affect than control group (MBRS)

							Children in the intervention had higher attention and initiation than controls	
Weller & Mahoney, 1983	Quasi-Experimental	Intervention 1(oral language); Intervention 2 (total communication)	20	Weekly (for 4 weeks) for mothers + daily for children	60-120 (parents) 30 (children)	Receptive and expressive language, expressive and receptive vocabulary + signs (REEL, EPB)	No significant differences between the groups	n/a
Yoder & Warren (2002)	RCT	RE/PMT Treatment as usual	24	3-4 weekly (PMT) for children; Up to 12 RE for parents	20	Intentional pre-linguistic communication (commenting and requesting) Child Vocab (transcription)	DS children in control group had steeper growth curves. DS children in intervention group had de-accelerated growth in requests	Parent's responses to their child's communication
Yoder et al., (2014)	RCT	High dose (MCT) Low dose (MCT)	36	5 sessions/week PMT (high dose) Weekly PMT (low dose) 9 RE	60	Child Vocab CDI	Significantly more spoken words on CDI for those in higher dose group	n/a

1 Note: ? - information missing or unclear; HPP- Hanen Parent Programme; DD II- Denver Developmental Screening test-II; ADSI - Ankara
2 Developmental Screening Test-II; CDI - Communicative Development Inventories; REEL – Receptive Expressive Emergent Language Scale; EPB
3 – Environmental Pre-language Battery; RE – Responsive Education; PMT – Prelinguistic Milieu Teaching; Vocab – vocabulary; CBRS
4 – Child Behaviour Rating Scale; MBRS – Maternal Behaviour Rating Scale; DS – Down syndrome; TD – typically developing children; mos -
5 months

1 *Description of interventions*

2 The interventions targeted both verbal and non-verbal communication in children with
3 Down syndrome. Interventions were either designed for, or adapted to be used with children with
4 Down syndrome.

5 *Communication training, responsive teaching, behaviour modification (including*
6 *Hanen) (n=6)*

7 A number of studies focused on training parents/caregivers to be more attuned to the child's
8 communication needs and to respond in a way that is going to optimise the child's
9 communication gains and the child's verbal or non-verbal communication.

10 Four studies (Girolametto et al. 1998, Karaaslan and Mahoney 2013, Yoder and Warren
11 2002, Yoder et al. 2014) used *communication training and responsive teaching* as the
12 intervention method. This approach involves training parents/primary caregivers to enhance
13 children's communication using one or more of the following techniques: Responsive Teaching
14 (RT), Responsive Education (RE), Pre-linguistic Milieu Training (PMT) or Milieu Teaching
15 (MT). Girolametto et al. (1998) trained parents with a view to increasing their children's
16 expressive vocabulary, based on the principles of the Hanen Parent Programme (HPP; Manolson,
17 1992), a recognised intervention for children with developmental delays which aims to teach
18 parents to better understand and recognise their child's communication attempts, to follow their
19 child's lead and to respond appropriately to their child's actions (Fong et al. 2012). These have in
20 common the fact that they aim to teach the child specific gestures, eye gaze and vocalisations.
21 They focus on intentional communication (not necessarily words) and encourage the child to use

1 pointing to initiate or request an object/action or to respond to bids for joint attention.

2 Responsive education is often combined with child treatment such as Pre-linguistic Milieu

3 Training or Milieu Language Teaching (MLT). MLT aims to increase the frequency and

4 complexity of verbal communication through modelling, mand-modelling time delay and

5 incidental teaching (Fey et al. 2013). PMT targets children's non-verbal communication,

6 focusing on child-centred play by adjusting the environment, following the child's lead and the

7 use of prompts with a view to improving later speech and language production (Fey et al. 2013).

8 Responsive Teaching (RT) encourages parents to increase their levels of responsiveness (e.g.,

9 turn-taking, joint attention), model developmentally appropriate communication, and discourages

10 the use of directives. In the HPP programme, mothers were supported by being shown how to

11 follow their child's lead, observe and listen, be face to face, wait, take turns etc with a view to

12 maximising the modelling of target words, and how to use signs to accompany the words. A

13 similar approach, called *behaviour modification*, was used in Bidder et al. (1975). The mothers

14 were trained how to change their behaviour and modify their daily routines to support verbal

15 communication with their child and how to involve other family members in the treatment plan.

16 The training programme included mothers observing video tapes and demonstrations through an

17 observation mirror. The programme was individually tailored for each child and emphasised the

18 importance of early language development, activities which involve object manipulation,

19 especially construction, developing the child's independence through self-feeding, toilet training,

20 self-dressing etc. Weller and Mahoney (1983) used the *environmental language training*

21 *programme*, a parent assisted programme which incorporates aspects of behaviour modification,

22 Piagetian theory, concepts from the language acquisition literature and theories of

23 communication development. The mothers were trained how to model language, record

1 behaviour changes, adapt teaching techniques based on the child's abilities. The mothers
2 administered daily sessions to their children which included training in language comprehension,
3 imitation, conversation, structured play, and generalization training.

4 *Dialectic-didactic method (n=1)*

5 Andrade and Limongi (2007) used the dialectic-didactic method, which is based on the
6 clinical method proposed by Jean Piaget and focused on the building of knowledge through
7 problem solving. The intervention was done by a researcher and materials included
8 developmentally appropriate toys with the aim to improve the child's communication by
9 prompting the child to use verbal communication through object and action naming.

10 *Early Stimulation Programme (n=4)*

11 Four studies conducted in Spain (Sanz Aparicio 1989, Sanz Aparicio and Balana 2002,
12 Sanz Aparicio and Balana 2003, Sanz et al. 2011) state that they used an early stimulation
13 programme aimed at infants with Down syndrome (from birth to 18 months). The papers
14 mention using the following as intervention materials: Intervention programme for Down
15 syndrome children (Hanson, 1979), the Early Stimulation Programme (UNICEF 1982) and the
16 Bayley Child Development Scale (Bayley 1959). The papers do not provide any information as
17 to how these materials (especially a standardised assessment such as the Bayley Scale) were
18 used, or how the different intervention programmes were combined. The UNISEF (1982)
19 programme does not seem to be available in English, and the reference to Hanson (1979) was
20 unattainable. In the Sanz et al. (2011) paper, the early stimulation programme is described as
21 targeting four main developmental areas: language, fine motor, gross motor, and social

1 development skills. Parents were also trained either by observing the clinician (modelled
2 instruction), or by being given written instructions so that they could implement stimulation
3 techniques at home.

4 *Intervention procedures*

5 *Duration, intensity, and intervention implementer*

6 The number of sessions per intervention varied and sessions sometimes only included
7 parent training, sometimes only direct work with the children, and sometimes a combination of
8 both. The total number of sessions ranged from 13 in Girolametto et al. (1998), all of which were
9 parent training sessions, and up to 100 sessions in Sanz Aparicio (1989), all of which were
10 sessions done directly with the child. The child focused session duration ranged from 10 mins
11 each at least twice a day (Bidder et al. 1975), 20 minutes (Yoder and Warren 2002), 60 minutes
12 in Yoder et al. (2014) to 90-120 in Karaaslan and Mahoney (2013). See Table 3 for further
13 details.

14 The intervention duration ranged between 13 weeks (Girolametto et al. 1998) and 100
15 weeks in some of the *Early Stimulation Studies* (Sanz Aparicio 1989, Sanz Aparicio and Balana
16 2002, 2003), depending on when the children started their intervention. The intensity ranged
17 between once per week (Girolametto et al. 1998, Karaaslan and Mahoney 2013, Yoder et al.
18 2014 - low intensity group) to 3-4 times per week (Yoder and Warren 2002), 5 times per week in
19 the high intensity group in Yoder et al. (2014), to twice daily (Bidder et al. 1975).

20 Two interventions were delivered by the parent after receiving training from a clinician
21 or researcher (Bidder et al. 1975, Girolametto et al. 1998), one while a researcher worked with

1 the parent to help them use responsive intervention strategies (Karaaslan and Mahoney 2013)
2 and one where the parents had training first and then direct support from a language trainer
3 (Weller and Mahoney 1983). In Girolametto et al. (1998)'s study, a clinician delivered the Hanen
4 Parent Programme to mothers in group sessions using discussions, video tapes, role play and
5 coaching during home visits. In Bidder et al. (1975), the mothers had 12 sessions where they
6 were taught behaviour modification techniques. In addition, there were also sessions for fathers
7 and child minders. In Karaaslan and Mahoney's (2013) study, the trainer first explained how
8 behaviour was linked to child development before describing strategies designed to elicit such
9 behaviours (e.g., following the child's lead, responding positively and promptly to the child).
10 Mothers were coached when trying to implement such strategies and integrate these into their
11 daily routines. In Weller and Mahoney's study, mothers first received individualised instruction
12 on how to implement the programme, and then received weekly instruction and assistance with
13 delivering sessions, and feedback regarding their teaching performance during their daily lessons
14 at home with their child.

15 In only one study, the researcher exclusively implemented the intervention without the
16 parents getting involved (Andrade and Limongi 2007). In the remaining six interventions (Sanz
17 Aparicio 1989, Sanz Aparicio and Balana 2002, 2003, Sanz et al. 2011, Yoder and Warren 2002,
18 Yoder et al. 2014) the sessions were delivered by a clinician or researcher, in addition to the
19 parent-delivered sessions at home. In the Yoder and Warren (2002) study, the parents were
20 trained in responsive education (i.e., HPP), in small groups and 1:1 format. During the same six
21 months, clinicians delivered Pre-linguistic Milieu Teaching directly to the children, three to four
22 times per week. Clinicians aimed to promote play routines and the opportunities for children to

1 make requests for objects or actions. In the Yoder et al. (2014) study, parents completed nine 1-
2 hour Responsive Education sessions at home and read the Hanen Parent Program book: *It Takes*
3 *Two to Talk* (Pepper and Weitzman, 2004) in the first three months of intervention. Children
4 received either Pre-linguistic Milieu Training or Milieu Teaching, depending on the number of
5 spoken words at the baseline assessment. Children in the lower dose frequency received one 1-
6 hour session each week and those in the higher dose frequency received five 1-hour sessions
7 each week. In Sanz Aparicio (1989), Sanz Aparicio and Balana, (2002, 2003), the parents
8 attended two group sessions, in which early stimulation was explained and then parents were
9 given either written instructions or modelled instructions where they observed the clinicians
10 working with their child in the clinic (Sanz Aparicio, 1989). As this earlier study showed that
11 there was more improvement with modelled instructions compared to written instructions, in the
12 remaining three studies parents observed the clinician working with their child and then
13 implemented the programme at home (Sanz Aparicio and Balana 2002, 2003, Sanz et al. 2011).

14 *Control Condition*

15 Four studies used treatment as usual as the control group (Bidder et al. 1975, Girolametto et al.
16 1998, Karaaslan and Mahoney 2013, Yoder and Warren 2002). In the Bidder et al. (1975) study,
17 the control group continued to receive usual care from health visitors and their general
18 practitioner. In the Girolametto et al. (1998) study families in the control condition continued
19 with their existing language interventions, which involved monthly consultations with a
20 clinician, or liaison between the clinician and teachers and families. Parents in the control
21 condition were not given the list of target words that were provided for the intervention group. In
22 Karaaslan and Mahoney (2013), both the control and intervention groups continued to receive

1 early intervention services at their local special education centre. This took the form of group
2 and/or individual education and teaching social skills using the Picture Exchange System
3 (PECS). Both children in the intervention and control group in the study by Yoder and Warren
4 (2002) continued with early intervention services from community providers.

5 The remaining studies used an active control. Yoder et al. (2014) compared the effects of
6 dose frequency (i.e., lower, and higher dose frequency). Sanz Aparicio (1989) compared the
7 effect of age when children started intervention, and whether the parents had observed the
8 clinician on how to deliver the intervention or whether they had only received written
9 instructions. In Sanz Aparicio and Balana (2002), the age at which children entered the
10 intervention was compared, and Sanz Aparicio and Balana (2003) compared the effects of how
11 training was provided for the parents (modelled versus written instruction). Sanz et al. (2011)
12 compared the effect of different type of social reinforcement (verbal versus physical). Weller and
13 Mahoney (1983) compared the effect of oral versus total communication. Andrade and Limongi
14 (2007) reported that the control group had an intervention with different theoretical and
15 methodological approach to the intervention group, but no details were given.

16 *Treatment Fidelity*

17 Karaaslan and Mahoney (2013) reported 100% adherence to content and procedure for all
18 sessions. Furthermore, all clinicians delivering the intervention were professionals educated to a
19 doctoral level and completed 5 months of training on the intervention. Girolametto et al. (1998)
20 evaluated the fidelity of parent implementation of the intervention, in terms of attendance and
21 clinician ratings of parental adherence to the intervention. They reported that all mothers
22 attended at least seven out of the nine sessions and completed all home visits. Clinicians

1 confirmed the mothers' use of target words and focused labelling during home visits. Yoder et al.
2 (2014) reported intra-class correlation coefficients of .91 to .98 for absolute agreement on the
3 number of correctly implemented teaching episodes, across both the higher and lower dose
4 frequency groups. However, they did report that children in the lower dose frequency group
5 experienced fewer cumulative teaching episodes than the higher dose group. Yoder and Warren
6 (2002) reported no difference in the frequency and proportion of correct teaching between the
7 lower and the higher dose frequency groups. The intervention lasted 9 months for both groups.
8 Slightly more sessions were completed by the lower dose frequency group, but Fey et al. (2013)
9 reported that the completed sessions were high for both groups and did not affect the analyses.

10 The remaining studies do not report any information on treatment fidelity.

11 *Children's speech language and communication outcomes*

12 Girolametto et al. (1998) used a parent-report measure of language, i.e., Mervis's adaptation
13 of the Communicative Development Inventories (CDI) (Fenson et al. 1993). A direct assessment
14 of language, i.e., Sequenced Inventory of Communication Development (SICD) (Hedrick et al.
15 1984) was completed at baseline but post intervention results were not reported. The use of target
16 words was assessed during a free-play mother-child interaction.

17 Karaaslan and Mahoney (2013) used two developmental assessments to measure language:
18 The Turkish version of the Denver Developmental Screening Test-II (Denver-II: Anlar and
19 Yalaz, 1996) which covers four developmental domains: language, gross motor, fine motor and
20 personal-social. It is unclear whether both expressive and receptive language were assessed. The
21 second measure was the Ankara Developmental Screening Inventory (ADSI) (Savaşır et al.,

1 2005) which examines cognitive-language development, fine motor, gross motor, and
2 social/emotional functioning, which is completed by parents or primary caregivers. It is also
3 unclear if ADSI assesses expressive or receptive language, or both. A child behaviour rating
4 scale (CBRS; Mahoney and Wheeden 1998) was used to assess children's interactive behaviour
5 with their mothers in terms of attention and initiation.

6 The language/social subtest of the Brunet-Lezine First Childhood Scale (1971) was used in
7 four studies (Sanz Aparicio 1989, Sanz Aparicio and Balana 2002, 2003, Sanz et al. 2011). It is
8 unclear, however, which aspects of language are assessed.

9 Weller and Mahoney (1983) used several language outcome measures: Receptive Expressive
10 Emergent Language Scale (REEL), the Environmental Prelanguage Battery (verbal subtests),
11 parental report of number of spoken and signed, or only signed words.

12 Andrade and Limongi (2007) used spontaneous communication of oral language and coded
13 linguistic concepts and gestural communication.

14 Bidder et al. (1975) used the language subtest of the Griffiths Scale (1954) and it is not
15 specified which aspects of language were assessed. The authors refer to the subscale both as
16 speech in one instance and language in another.

17 Yoder and Warren (2002) used transcriptions and observations to evaluate child language
18 outcomes. Specifically, the Communication and Symbolic Behaviour Scales (CSBS: Wetherby et
19 al. 1989), the Experimenter-Child Play Session (ECX: Yoder and Warren 1998) and the Parent-
20 Child Session (PCX: Yoder and Warren 1998). Both the CSBS (specifically the Communication
21 temptations and Book sharing sections) and the ECX measured child communication and lexical

1 density by adapting the environment to encourage child-initiated requests. The PCX measured
2 child requests and comments through a series of three sections (structured play session, snack,
3 and free play). All observations were transcribed and analysed using the Systematic Analysis of
4 Language Transcripts (SALT) (Miller and Chapman 1993) to record the frequency of child-
5 initiated comments, child-initiated requests, and lexical density.

6 Finally, Yoder et al. (2014) used the MacArthur-Bates Communication Development
7 Inventories (MB-CDI: Fenson et al. 2003) which is a parental questionnaire, to measure
8 expressive language (vocabulary).

9 *Parental language, communication and response outcomes*

10 In three of the 11 studies, parental outcomes were measured as well. Girolametto et al. (1998)
11 examined maternal behaviour during a free play interaction, which was transcribed and analysed
12 using the Systematic Analysis of Language Transcripts (SALT; Miller and Chapman 1993). The
13 frequency of maternal utterances, complexity of the language (i.e., mean length of utterance) and
14 the use of labelling (signed and spoken target words) was measured.

15 Karaaslan and Mahoney (2013) assessed maternal interaction behaviour through a mother-
16 child free play interaction. The Maternal Behaviour Rating Scale (MBRS: Mahoney 1999)
17 examined maternal responsiveness, affect, and achievement/directedness.

18 Yoder and Warren (2002) measured parental responsiveness during the parent-child
19 interaction by counting the number and proportion of optimal parental responses to the children's
20 communication acts. Optimal responses included complying with the child's communicative act,

1 immediate imitation of child vocalization and responding to the child's nonverbal
2 communication (e.g., labelling an object the child points to).

3 *Effect of interventions for the speech and language outcomes for children with Down*
4 *syndrome*

5 All 11 studies reported tests of statistical significance on at least one measure of
6 language, verbal, or social communication post intervention. Post-intervention measures were
7 administered at the end of the intervention with some studies reporting further follow ups (Sanz
8 Aparicio 1989, Sanz Aparicio and Balana 2002, 2003). Two studies (Girolametto et al. 1998,
9 Sanz et al. 2011) used non-parametric statistics. It was not clear whether parametric or non-
10 parametric statistics was used in Bidder et al. (1975). The other eight studies used parametric
11 statistics. Effect sizes were reported in three studies and were small to medium. Cohen's d effect
12 sizes could not be computed for seven studies because they did not provide adequate descriptive
13 statistics (Andrade and Limongi 2007, Bidder et al. 1975, Sanz Aparicio 1989, Sanz Aparicio
14 and Balana 2002, 2003, Sanz et al. 2011, Yoder and Warren 2002)

15 Based on the p values and effect sizes reported (when provided) by the authors, seven
16 studies showed significant positive effects (Bidder et al. 1975, Girolametto et al. 1998, Karaaslan
17 and Mahoney 2013, Sanz Aparicio 1989, Sanz Aparicio and Balana 2002, 2003, Yoder et al.
18 2014). Bidder et al. (1975) reported that children in the intervention group obtained significantly
19 higher language scores on the Griffiths Mental Development Scales by advancing their language
20 skills at a mean rate of 6.56 months in comparison to the control group ($p < 0.01$). Girolametto et
21 al. (1998) reported that children in the intervention group produced significantly higher number
22 of target words than the control group post intervention both in parental report ($U = 7,0$, $p < 0.05$),

1 and in free play ($U=6.0$, $p<0.05$), although only the intervention group had targeted words in
2 their intervention. However, there were no statistically significant between group differences in
3 vocabulary size as measured by the CDI, nor in the number of target words used by the two
4 groups assessed by a clinician-administered semi-structured interview. Karaaslan and Mahoney
5 (2013) reported a statistically significant difference between the treatment and control groups in
6 post-test language quotient scores as measured by the Denver-II, in favour of the treatment group
7 ($F=6.50$, $p<0.05$) with a small effect size (Hedge's $g=0.42$). Yoder et al. (2014) found that
8 children with Down Syndrome in the higher frequency dose group showed significantly bigger
9 growth in expressive vocabulary (as measured by the CDI) than those children in the lower
10 frequency dose group ($t=2.926$, $p<0.01$) with a medium effect size (Hedge's $g=0.55$). Sanz
11 Aparicio (1989), Sanz Aparicio and Balana (2002) reported that the earlier the children started
12 intervention, the better their language outcomes on the Brunet-Lezine's First Childhood Scale
13 ($p<0.001$, for both studies). The social development quotient was significantly higher for the
14 children whose parents had visual training (i.e., they learnt how to stimulate their child by having
15 directly observed the clinician as opposed having received only written instructions).

16 In the Yoder and Warren (2002) study, the children with Down syndrome who had
17 received the intervention had a significantly lower growth curve in requesting behaviours (t for
18 product term on slope = -2.18 ; $p = .04$; $b = -.044$) compared to the control group as measured
19 during parent-child sessions, experimenter-child sessions and Communication and Symbolic
20 Behaviour Scales (Wetherby and Prizant 1993).

21 No differences between intervention and control groups were reported in Andrade and
22 Limongi (2007). Also, there were no differences in language outcomes between the two groups

1 (physical versus verbal reinforcement) in Sanz et al. (2011), nor were there any significant
2 differences between the two intervention groups (oral versus total communication) in Weller and
3 Mahoney (1983).

4 *Effectiveness of intervention on parental/maternal language, or responsivity*

5 Most studies included parent training, however, only three studies reported outcomes for
6 parental responsiveness/communication/behaviour. Girolametto et al. (1998) reported significant
7 differences between maternal utterances during mother-child interaction post-intervention,
8 however, further investigation found that mothers in the control group showed a reduction in the
9 number of utterances, whereas the mothers in the intervention group maintained their baseline
10 level of utterances. Mothers in the intervention group also used more target labels than mothers
11 in the control group, although there were no differences in linguistic complexity of maternal
12 utterances. However, it is important to note that only mothers in the intervention group were
13 aware of the target words.

14 Karaaslan and Mahoney (2013) found that mothers in the intervention group
15 demonstrated significantly greater improvements in responsiveness, affect and
16 achievement/directiveness as measured by the MBRS. Yoder and Warren (2002) reported that
17 parents in the intervention group demonstrated a higher frequency and a higher proportion of
18 responsiveness to child communicative acts as observed during the parent-child interaction
19 compared to the parents of the children in the control group.

20 **Risk of Bias- PEDro-P Appraisal**

1 The risk of bias of the 11 included studies as assessed with the Pedro-P tool and is
2 presented in Table 3.

3 Insert Table 3 about here

4

5 As shown in Table 3, out of the 11 included studies, only four demonstrated an adequate level of
6 quality according to the PEDro-P criteria (Girolametto et al. 1998, Karaaslan and Mahoney 2013,
7 Yoder and Warren 2002, and Yoder et al. 2014). By adequate level, we mean a score of 6 or
8 above, in line with other reviews (Maher et al. 2003, Wren et al. 2018). The other seven studies
9 lacked information about most of the following: clearly specified eligibility criteria; random
10 allocation of participants and allocation concealment; blinding of participants and assessors;
11 control groups being similar at baseline regarding key outcome measures; point measures and
12 measures of variability for at least one outcome variable provided; all participants for whom
13 outcome measures were available received the treatment or control condition as allocated. None
14 of the studies reported any method of allocation concealment, hence they are at high risk of
15 concealment bias. Only three studies reported a computer randomisation of participants. None of
16 the studies provided any details of any methods to blind parents or personnel, hence they are all
17 deemed at high risk of performance bias. It should be noted that, due to the nature of the
18 interventions (where parents needed to be trained and assisted by clinicians), it would have been
19 hard, if not impossible, for parents and clinicians to be blind.

1 The seven studies which scored lower than 6 did not provide usable outcome data
2 because it was not possible to see the range of performance for speech/language/communication
3 outcome measures across individuals in the groups.

4 **Discussion**

5 The aim of the systematic review was to investigate early speech and language interventions
6 for children with Down Syndrome aged 0 to 6 specifically focusing on which interventions exist
7 and whether they are effective for children with Down Syndrome. Eleven studies, four of which
8 were randomised controlled studies, were identified as fulfilling the inclusion criteria and
9 included in the review. It was not appropriate to complete a meta-analysis study due to the
10 heterogeneity of outcomes and measures used, and information missing which did not allow to
11 compute effect sizes for most of the studies. The results from the systematic review showed that
12 the most common type of interventions are those which are based on social-interactionist
13 theories of language acquisition, and suggest that children with Down syndrome under the age of
14 6 years at the start of the intervention can benefit from early intervention. There were also
15 positive outcomes for the parents (where parent outcomes were measured), in that they increased
16 their responsiveness, affect and non-directiveness in their interactions with their children. All
17 studies had moderate to high risk of bias and any conclusions drawn are very preliminary and
18 should be treated with caution given that no meta-analysis was performed, and results are based
19 on individual RCTs and group comparison studies of small sample sizes, with effect size
20 reported that have no power calculations.

21 Our first question asked which early interventions exist for children with Down Syndrome
22 and the focus of these interventions. Broadly speaking, three different types of intervention were

1 identified in this review, and these will be discussed in turn. Communication training, response
2 teaching and behaviour modification interventions were described in much more detail in the
3 original studies than the other two types of intervention.

4 *Communication training, response teaching and behaviour modification* focused on training
5 the parents (usually mothers) to adapt their communication style and the way they respond to
6 their child in order to increase responsivity to their children's communication bids. Parental
7 responsiveness is one of the most important social environmental factors which can influence
8 children's language and general cognitive development both in typically developing children and
9 in children with developmental disabilities (Landry et al. 2001). Parents in all six studies were
10 given training on how to promote language learning, either via strengthening pre-linguistic
11 precursors to language by encouraging joint attention, responding to their children's
12 communication bids and promoting social communication skills, or via direct verbal
13 communication training. Two studies specifically targeted children's expressive vocabulary
14 (Girolametto et al. 1998, Yoder et al. 2014), which is often relatively weaker than receptive
15 vocabulary in children with Down syndrome (Mason-Apps et al. 2020) by situating vocabulary
16 learning within an interactionist, naturalistic context. In both studies there were positive
17 outcomes in vocabulary growth following intervention (or in the case of Yoder et al., following a
18 higher dosage), suggesting that it is possible, through early intervention, to accelerate lexical
19 acquisition of children with Down syndrome. However, a flaw in the Girolametto et al. (1998) is
20 the fact that only the parents in the intervention group knew what the target words were. The
21 Karaaslan and Mahoney (2013) study did not specifically target vocabulary but used a
22 relationship focused intervention which combines elements from the Hanen Parent Programme

1 with interaction strategies to train parents to promote the development of children’s cognitive,
2 communication and social emotional skills by encouraging contingent responding, reciprocity,
3 joint attention, interaction for fun and non-directiveness (i.e., following the child’s lead). Positive
4 outcomes were reported in several aspects of the children’s general development, including
5 general language skills.

6 Yoder and Warren’s (2002) study focused on developing children’s prelinguistic
7 communication (requesting and commenting) because these may elicit more language input from
8 parents, and it is known that optimal parental responses mediate the association between
9 intentional prelinguistic communication and later language (Yoder and Warren 1999) which in
10 turn facilitates word learning. Also, they were interested in children’s lexical density, which is
11 the number of different symbols (i.e., sign and spoken words) children use to express different
12 meanings. The children with Down Syndrome in this study decreased the number of requests
13 they used following the intervention. The authors suggested this result may have been found due
14 to the passive nature of children with Down Syndrome and their levels of hypotonicity as
15 requesting requires gross motor skill development. The children with Down Syndrome tended to
16 actively resist prompts to request during the training sessions. It should be noted that the children
17 with Down syndrome were part of a larger group of children with intellectual disabilities and the
18 intervention was targeting specific behaviours rather than specifically children with Down
19 Syndrome. This highlights the importance of having interventions which are tailored to children
20 with Down Syndrome, which are suitable to their behaviour phenotype and can be adapted to the
21 capabilities and strengths of the child, so that we see accelerating rather than deaccelerating of
22 abilities (Neil and Jones 2018).

1 Behaviour modification and environmental language training were used in two studies, both
2 of which targeted verbal communication. The results were mixed, in that one study reported
3 language gains for the intervention group (Bidder et al. 1975), where the other one (Weller and
4 Mahoney 1983) reported no difference between an oral communication and the total
5 communication groups, although there was an effect of time for both groups, indicating that both
6 groups had made significant gains in language over 5 months. However, as there was no control
7 group, it not possible to conclude that any language gains were due to the intervention.

8 *Early Stimulation Programme:* A cluster of studies (Sanz Aparicio 1989, Sanz Aparicio and
9 Balana 2002, 2003, Sanz et al. 2011) refer to stimulation programmes and materials which are
10 hardly described at all. These stimulation programmes targeted children’s general development,
11 including fine and gross motor skills, general cognitive skills, and language, but there is no
12 explanation of what exactly the ingredients of the interventions were. The lack of details and
13 information provided about the intervention programmes used severely limits replication of the
14 studies and makes evaluation of the interventions very difficult.

15 *Dialectic-didactic intervention* was used in one study (Andrade and Limongi 2007) and
16 focused on developing children’s problem-solving abilities through play and promoting verbal
17 communication, however details or examples of targets of the intervention are not provided. The
18 reference for the intervention is a conference presentation and it is not available in English. The
19 intervention did not seem to improve language or communication skills in the intervention group,
20 however, the intervention group only had four participants. Also, it was stated that the
21 participants in the control group were receiving intervention which had a different

1 methodological/theoretical focus, and it is not clear how this intervention would have affected
2 the outcomes for the control group.

3 The evidence for positive parent outcomes following early intervention is more consistent.
4 All studies which measured parent behaviour and responsiveness reported positive parent
5 outcomes following the early intervention. Both Karaaslan and Mahoney (2013) and Yoder and
6 Warren (2002) found parents becoming more responsive to child communications acts.
7 Furthermore, Karaaslan and Mahoney (2013), also found improvements to maternal affect and
8 decrease of directedness. Girolametto et al. (1998) reported that mothers in the intervention used
9 labels more frequently although their language complexity did not change.

10 The implementers of the interventions varied and included speech and language therapists,
11 highly trained researchers and parents or some combination of these (parents and researchers, or
12 parents and clinicians). Parents were involved in delivering the intervention in all but one study.
13 The results indicate that all of these can be successful in implementing an intervention and it is
14 not possible to conclude that trained specialists may be more successful than non-specialist
15 trainers such as parents or researchers.

16 There was large variability between studies with regard to dosage, hence it is not possible to
17 derive common characteristics with regard to duration and frequency/intensity. It should be
18 noted, however, that intensity was found to be important in Yoder et al. (2014) in that the
19 children in the high intensity group who were receiving intervention 5 times a week had better
20 vocabulary outcomes than those in the active control group who were receiving intervention
21 once a week. It can thus be suggested that high frequency intervention may potentially lead to
22 better outcomes.

1 **Implications for future research**

2 **Quality of the evidence, limitations, and implications for future research**

3 There is not sufficient evidence to suggest any particular early intervention. Although 11
4 studies were included in the review, seven of these did not meet the minimum criteria for quality
5 using the PEDro-P appraisal tool. The collective evidence from the literature is underdeveloped
6 and not sufficiently homogeneous for a meta-analysis. None of the studies addressed the issue of
7 power. The sample sizes were generally small with some studies having only four children with
8 Down Syndrome per group (Andrade and Limongi 2007). Even the studies which had a
9 relatively large number of participants (Sanz Aparicio 1989, Sanz Aparicio and Balana 2002)
10 and potentially more power suffered from severe limitations, such as inadequate information
11 about the intervention methods, little or no description of the outcome measures, no treatment
12 fidelity, no control groups which had the same baseline assessments as the intervention groups,
13 and results were reported by only providing means without any standard deviations or ranges.
14 The consequences of these severe limitations are such that they do not allow replication nor
15 application in the field of clinical practice and hence the field of intervention research does not
16 move forward.

17 The studies which scored the highest during quality appraisal were all randomised control
18 trials and all used a similar intervention approach which is responsive education/focused
19 stimulation. Interventions based on responsive education/focused stimulation techniques and the
20 Hanen programme embedded within a social context and everyday activities have the potential to
21 result in positive outcomes for children's language and communication. However, caution is
22 needed, as one study reported a decrease in children's social communication skills following this

1 kind of intervention (Yoder and Warren 2002), and it was hypothesised that this was due to the
2 fact the intervention was not tailored to the communication needs of children with Down
3 syndrome. At this point in time, it is not possible to say whether one intervention is preferred
4 over another. Future research should consider the longer-term effects of parental
5 responsivity/communication style on child speech/language/communication outcomes.

6 Another potential limitation is that some studies used a language outcome measure based on
7 parent report measures. Very young children often find it difficult to cooperate when formal
8 assessments are administered, or if they need to interact with strangers, which may lead to the
9 assessment being stopped and data not to be collected. Hence parental reports of language, such
10 as the Mac Arthur-Bates Communicative Development Inventory (CDI) (Fenson et al. 2003) are
11 widely used because parents have extensive experience with their children in a variety of
12 naturalistic settings (Feldman et al. 2005). The CDI has a reasonable predictive and concurrent
13 validity. For example, children's scores on the CDI at ages 2 and 3 correlate significantly
14 positively with standardised receptive language measures (Feldman et al. 2005). The concurrent
15 validity of the CDI was established for children with Down syndrome in a study by Miller et al.
16 (1995). The measures of children's language obtained on the CDI and laboratory (standardised)
17 measures of language correlated strongly (between 0.70 and 0.82). However, due to the possible
18 inherent bias in parent report, especially when parents were also administering the intervention,
19 it may be more scientifically reliable if children were assessed using a combination of
20 standardised assessments with well-established parental questionnaires. A combination of
21 measures will allow for more reliable information to be gathered and should give a more
22 accurate view of the child's development and relative changes.

1 It is also very important that when language/communication measures are reported, it is made
2 clear whether expressive or receptive language is being assessed. Key statistics, such as the mean
3 and standard deviation should also be reported to allow for meta-analysis to be completed.
4 Sometimes language/communication measures used are poorly described, which makes it
5 difficult to combine in a meta-analysis. Furthermore, if a measure was taken at baseline, it needs
6 to be reported post-intervention as well. For example, Girolametto et al. (1998) administered the
7 SICD at baseline but did not report the results post-intervention.

8 Although positive outcomes have been reported up to 18 months post intervention in a few
9 studies (Sanz Aparicio 1989, Sanz Aparicio and Balana 2002), and there was some evidence that
10 the earlier a child started an intervention the better their language outcomes, none of the studies
11 included longitudinal (over several years) follow up assessments. The follow up was only up to
12 the age of 24 months. Hence it is unclear whether any benefits of the interventions are
13 maintained longer term. Future research should endeavour to include longitudinal follow up
14 assessments to consider the long-term impact of early intervention.

15 Dosage and duration of interventions varied, and some studies did not report frequency or
16 length of intervention sessions. The number of sessions varied hugely from 13 to over 100
17 sessions where an intervention lasted for 18 months. Only one study compared high versus low
18 dosage and found evidence in favour of high dosage (Yoder et al. 2014). Due to the lack of other
19 relevant data in the remaining studies, it is not possible to draw conclusions about optimum
20 dosage and frequency.

21 **Conclusions**

1 The common component of all but one of the interventions was parental training and an
2 expectation for parents to implement parts or the whole of the intervention at home by teaching
3 their child, responding contingently, adapting their behaviour to match the child's
4 communication level and needs. Three studies also reported positive changes in parental input
5 and responsivity. Eight studies reported positive language outcomes for the children following
6 intervention. In two out of the 11 studies, the intervention did not seem to improve children's
7 language/communication outcomes, and in one study the children with Down syndrome
8 deaccelerated their social communication skills post-intervention, possibly because the
9 intervention was not specifically tailored for children with Down syndrome. Seven of the 11
10 studies were low in quality which makes it impossible to replicate these and to fully appraise.
11 Although we can tentatively conclude that early interventions for children with Down syndrome
12 may have positive outcomes, this review highlights the need for higher quality studies.

13

14 **Declaration of interest:** The authors report no conflicts of interest.

15 **Data availability statement**

16 Data sharing is not applicable to this article as no new data were created or analyzed in this
17 study. The data come from published articles which are all listed in the Reference list below.

18

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