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Effects of a repeated reading intervention on the reading fluency of adolescents with intellectual disability

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Abstract

Although repeated reading (RR) is highly effective in improving reading fluency, it has not been sufficiently studied in students with intellectual disability. This single-case experimental study with multiple baselines across participants examined the effects of an 8-week adapted RR intervention, on reading automaticity [i.e., correct words per minute (CWPM)] and accuracy [i.e., errors per minute (EPM)], in three adolescents with intellectual disability. Visual and statistical analyses revealed a gain in CWPM and drop in EPM on trained texts during the intervention, with moderate to large effect sizes. After the end of the intervention, the gains in reading automaticity (CWPM) were generalized to untrained texts, with large effect sizes. However, drops in accuracy (EPM) were small or not significant. The social validity of the intervention was rated positively by teachers and students. The findings suggest that adapted, evidence-based repeated reading interventions can be beneficial for students with intellectual disability. Implications for future research are discussed.

Keywords Intellectual disability · Reading fluency · Intervention · Repeated reading · Multiple-baseline design

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Introduction

Reading is indisputably powerful in supporting the education and quality of life of individuals with intellectual disability. Good reading skills promote greater independence, enhance social participation, and ensure better employment opportunities (Cree et al., 2022). Due to limitations in cognitive and language skills, and adaptive behaviour (World Health Organization, 2022), students with intellectual disability struggle not only with decoding but also with reading fluency (RF). A study of 3,811 students with intellectual disability illustrated the extent of their difficulties: among Grade 11 students, only 13.9% met the Grade 3 benchmark for word reading, and a mere 2.6% reached the Grade 5 benchmark for passage reading (Lemons et al., 2013).

Unfortunately, their challenges in reading are often compounded by limited access to effective instruction and a lack of evidence-based instructional programs tailored to their needs (Lemons et al., 2016). Research evidence supports that students with intellectual disability have a delayed rather than a different reading profile (Alhwaiti, 2024; Nilsson et al., 2021). Thus, evidence-based reading instructional programs designed for typically developing students are also suitable for them provided they are coupled with explicit modeling, corrective feedback, and increased instructional intensity (Allor et al., 2014; Bakken et al., 2021; Lemons et al., 2016; Sermier Dessemontet et al., 2019). While decoding instruction through phonics is essential, it is not sufficient. To foster fluent reading, studies should also examine effective instructional strategies that support students with intellectual disability in becoming fluent independent readers who can focus on meaning (Stevens et al., 2017). Unfortunately, empirical studies in this field are scarce.

RF is defined as the ability to read a text accurately, at an appropriate speed, and with suitable expression (Fuchs et al., 2001; Kuhn et al., 2010). As one of the "big five" instructional components underlying reading comprehension, RF is undisputably critical for elementary and struggling readers (National Institute of Child Health and Human Development [NICHHD], 2000). Reading comprehension is a higher-level cognitive process that demands significant cognitive resources. The automaticity of word recognition, defined by both accuracy and speed, both key components of RF, is considered essential for reading comprehension because it frees cognitive resources that can be devoted to understanding the text (LaBerge & Samuels, 1974). Nevertheless, the relationship between RF and reading comprehension is not as straightforward as it may seem.

Within the Simple View of Reading (SVR), a framework also applicable to students with intellectual disability (van Wingerden et al., 2017), reading comprehension is conceptualized as the product of two components: word recognition (decoding) and language comprehension (Hoover & Gough, 1990). A substantial body of empirical evidence supports this model, indicating that these two components together account for a substantial proportion (45–96%) of the variance in reading comprehension (Hoover & Gough, 1990; Kim, 2017; Lervåg et al., 2018). Given the importance of RF, researchers have questioned whether RF contributes independently to reading comprehension and should be added as a third component in SVR. However, studies exploring this possibility yielded inconsistent findings. Rather than supporting a direct (Tilstra et al., 2009) or an indirect role (Adlof et al., 2006), Silverman et al.

(2012) argued that RF plays a mediating role, acting as a bridge between decoding and reading comprehension. Building on and extending prominent theoretical models, Kim's (2020) Direct and Indirect Effects model of Reading (DIER), explicitly addresses the role of RF. This model posits that RF not only mediates the relationship of decoding and language comprehension to reading comprehension, but also that this mediation is dynamic, changing over time. As texts become more complex and more demanding in cognitive resources, the contributions of decoding and RF seem to decline and language comprehension emerges as a more powerful contributor to reading comprehension (Ecalle et al., 2020; Stevens et al., 2017). Conversely, for elementary and struggling readers, RF is strongly correlated to reading comprehension (Adlof et al., 2006; Allor et al., 2014; Psyridou et al., 2023) and therefore improving RF is considered to have a positive impact on reading comprehension.

Over the past 20 years, numerous studies have focused on repeated reading (RR), which is widely acknowledged as the most effective intervention for RF, and automaticity in particular (NICHD, 2000). RR consists of reading a short and meaningful text multiple times to improve reading automaticity based on speed and accuracy. Speed is measured by the number of words read per minute (WPM), and accuracy by the number of errors per minute (EPM). Combining the two allows calculating the number of correct words per minute (CWPM = WPM − EPM), an indicator of automaticity. Several meta-analyses and syntheses confirm RR's positive effects on RF and reading comprehension in students with reading disabilities (Lee & Yoon, 2017; Maki & Hammerschmidt-Snidarich, 2022) and learning disabilities (Kim et al., 2016; Therrien, 2004), especially for students in elementary grade levels (Lee & Yoon, 2017).

Beyond the overall effect of RRs on RF, attention must be given to identifying the specific instructional strategies that are most effective for students with different disabilities. Typically, RR interventions in students with disabilities include instructional strategies such as: (a) listening passage preview by a skilled reader, also referred to as teacher modeling (Chard et al., 2002; Wexler et al., 2008) (b) systematic error correction (immediately following or after the student's reading), (c) performance feedback (Chafouleas et al., 2004; NICHD, 2000; Swain et al., 2013; Therrien, 2004) and (d) progress monitoring (Gibb & Wilder, 2002). Therrien's (2004) meta-analysis reported large effects on RF when RR instruction included error correction and performance feedback, whereas Lee and Yoon's (2017) meta-analysis reported that listening passage preview was the most effective additional component for elementary students with learning disabilities. The number of RRs is also a critical variable for memory retrieval (Logan, 1997). When the number of readings increased from two to three or four, the effect of the intervention was 30–50% larger (Lee & Yoon, 2017; Therrien, 2004).

As already mentioned, empirical studies addressing the question of RF and RRs in students with intellectual disability are rare. Up to 2021, meta-analyses and systematic reviews of reading interventions (Alquraini & Rao, 2019; Bakken et al., 2021; Browder et al., 2006) identified only two studies targeting RF, though always embedded within multicomponent reading interventions (Allor et al., 2010; Lundberg & Reichenberg, 2011). Although the specific contribution of RF instruction cannot be addressed in these studies as it was part of a comprehensive instructional program, the study from Allor et al. (2014) highlights the long duration and dosage required for an intervention to produce a meaningful change in reading fluency in this population. To date, only a few single case experimental studies (SCED) have specifically targeted RF through RR in students (Strickland et al., 2020) and young adults with intellectual disability (Hua et al., 2012a, 2012b, 2018). These studies highlight the positive effects of RR with teacher error correction on RF during the intervention (Hua et al., 2012a, 2012b; Strickland et al., 2020). However, once the intervention was withdrawn, most students's RF performance on untrained texts declined or reverted to pre-intervention levels (Hua et al., 2018; Strickland et al., 2020). Hua et al. (2018) suggested that their intervention was likely too short (5 to 14 sessions) for the students to reach RF levels that would generalize to untrained texts. Two of these studies implemented RR with teacher error correction and performance feedback (Hua et al., 2012a, 2012b; Strickland et al., 2020), but none with listening passage preview through teacher modeling, a valuable component of RR with significant effects on RF (Lee & Yoon, 2017). Further experimental studies are necessary to identify effective strategies for implementing RR interventions for students with intellectual disability, ensuring improvements in RF as well as sustained outcomes beyond the intervention.

The aim of our study was to extend the limited knowledge on the effects of RR for students with intellectual disability by assessing the effects of a specifically adapted RR intervention with teacher modeling on RF on trained and untrained texts in adolescents with mild intellectual disability and an elementary reading level. Specifically, the following two questions were addressed: (a) What are the effects of an adapted RR intervention on reading automaticity and accuracy in students with mild intellectual disability on trained texts? (b) To what extent are the effects in reading automaticity and accuracy generalized and maintained on untrained texts after the end of the intervention?

Methods

Design

A multiple-baseline design study across participants was conducted to assess the effects of the RR intervention on the RF skills of three students with mild intellectual disability. Single case experimental studies with multiple-baseline designs across participants, are a robust means of assessing the effectiveness of interventions for persons with low-incidence disabilities, by seeking to establish functional relationships between the independent (intervention) and dependent (outcome) variables (Kratochwill et al., 2010; What Works Clearinghouse [WWC], 2022). They provide valuable insights on the effects and social validity of interventions before testing them with larger samples in randomized control trials (Krasny-Pacini & Evans, 2018). The two dependent variables, CWPM and EPM, were measured repeatedly across three consecutive phases: baseline, intervention, and generalization. To increase internal validity, the design included concurrent data collection across phases and randomly assigning each participant to the study's staggered intervention start points (Kratochwill & Levin, 2010). The random order by which participants entered the intervention was assigned with a manual randomization procedure (person external to the research team drawing lots). Intervention entry was regulated using a response guided design (i.e., the following student entered the intervention only after the preceding student showed a positive effect of the intervention). Specifically, our criterion was a positive change in CWPM and negative change in EPM levels, determined by comparing the first three intervention data points to the last three baseline data points. To ensure external validity, generalization measures were obtained on untrained texts at the end of the intervention (Krasny-Pacini & Evans, 2018).

Participants

Participants were recruited from a small specialized secondary school for students with intellectual and developmental disabilities in a French-speaking region of Switzerland. The school had three classes, each with seven students and aimed to consolidate and further students' academic skills and prepare them for independent living and employement through daily practical activities and workshops. After receiving approval for the study from the principal, a member of the research team presented the study to the school staff. Interested teachers were asked to select a student who met the following inclusion criteria: a confirmed diagnosis of intellectual disability (with or without co-occurring neurodevelopmental disorders); the ability to follow instructions during academic activities ; and no prior experience with RR instruction. Three students were identified. All parents gave their written consent for their child to participate in the study.

Student inclusion in the study was confirmed based on two objective criteria: (a) a WPM score of at least 20, the suggested threshold for RR instruction (Lequette et al., 2014); and (b) a CWPM score of at least 1.28 *SD* below the mean, the commonly accepted threshold for deviation from typical development (Reilly et al., 2014). A research team member administered the standardised test *Evaluation de la Lecture en Fluence* ([Evaluation of Reading Fluency]; E.L.FE, Lequette et al., 2008) to confirm inclusion and to allow selection of probes based on students' pre-test WPM scores. Students were cued to read a text aloud for 1 min. CWPM was calculated based on the following formula: CWPM = WPM − EPM. Based on the test's established norms, raw scores were transformed into z-scores. Table 1 provides the characteristics of the three participants.

Lana and Yassira were in the same classroom and Leonie in a different one. Throughout the study, the two teachers, Lana's and Yassira's teacher and Leonie's teacher, completed logbooks to document the business-as-usual reading instruction

Table 1 Characteristics of the three participants, Lana, Yassira, and Leonie

Student	Age	Gender	Diagnoses	IQ	Reading fluency (E.L.FE)			Instructional reading level[a]
					CWPM	EPM	z-score	
Lana	14	Female	MID, ADD	70	85	4	−2.10	Grade 5–6
Yassira	14	Female	MID, ASD	68	99	5	−1.72	Grade 6
Leonie	15	Female	MID	66	53	5	−3.16	Grade 4–5

MID Mild intellectual disability, *ADD* Attention deficit disorder, *ASD* Autism spectrum disorder

[a]Reflects the instructional reading level reported by the students' teachers

provided to them. The three students received reading instruction either with the entire class or in a small group format, once to twice week. The instruction focused exclusively on training functional reading comprehension skills (e.g., reading recipes and instructions in handbooks, and answering comprehension questions). Reading fluency was never addressed outside of the intervention sessions.

Interventionist

The interventionist, a member of the research team (third author), was a student finishing her Master's degree in Special Education. She had been working part-time for three and a half years in one of the school's classes. Over a 3-month period, she received formal training from experienced researchers, members of the research team. The training covered the methodology of a single-case experimental study, the instructional components of the RR intervention, scoring procedures, procedural fidelity, and data collection methods (approximately 9 h). She delivered the intervention in a one-to-one setting in a separate classroom three times a week during scheduled time slots. Non-participating students remained in their classrooms with their teachers.

Measures and materials

The reading texts were selected from FLUENCE (Lequette et al., 2014; Pourchet & Zorman, 2013), an evidence-based teacher-led instructional French RF program. Probes for all three phases were selected based on the following two criteria: (a) the number of words had to exceed the students' pre-test WPM scores (E.L.FE) by 50% to anticipate progress and (b) the content had to be appropriate for 15-year-olds. Thirteen texts were selected: eight for the baseline and intervention phases (trained texts) and five for the generalization phase (untrained texts). Two members of our research team (first and second author), experts in reading instruction, analyzed all texts, trained and untrained, on the following variables: (a) sentence length; (b) vocabulary difficulty; (c) number of words with consonant clusters (e.g., gl, cl, pl, dr); and (d) number of words with rare phonemes, based on Sprenger-Charolles's (2017) classification. Text complexity analysis revealed no significant differences between trained and untrained texts across all four variables. Table 2 presents the characteristics of the selected probes.

Table 2 Characteristics of the probes used for baseline and intervention, and generalization

Text characteristics	Lana and Yassira				Leonie			
	B–I	G	t (11)	p	B–I	G	t (11)	p
	M (SD)	M (SD)			M (SD)	M (SD)		
Sentence length	14.32 (1.6)	13.06 (1.4)	1.43	.180	12.99 (1.7)	13.50 (4.1)	−0.32	.755
Vocabulary	3.75 (1.8)	3.80 (1.3)	−0.05	.959	3.25 (0.7)	2.80 (0.8)	1.04	.319
Clusters	18.88 (4.1)	16.20 (5.0)	1.05	.314	14.75 (5.2)	11.80 (2.39)	1.18	.262
Rare phonemes	1.7 (1.7)	3.2 (1.6)	−1.53	.154	1.50 (1.1)	0.60 (0.5)	1.73	.112

B Baseline, *I* Intervention, *G* Generalization

Based on their pre-intervention WPM scores (E.L.FE), Lana and Yassira were given the same 13 texts. Eleven of the texts were selected from FLUENCE volume 3 and two texts from the General Education Curriculum (GEC) instructional program targeting RF in our country, as FLUENCE volume 3 did not have enough texts of similar complexity to complete the necessary number of probes. The number of words of the selected probes ranged from 136 to 182. The texts were easy to understand (e.g., no implicit information, no need for inferences); consisted mainly of long or complex sentences; were written in the past (simple past, past continuous, and past perfect); and contained words with clusters (12 to 25) and words rare sounds (0 to 6). For Leonie, all 13 texts were selected from FLUENCE volume 2. The texts ranged from 98 to 141 words; were easy to understand; contained a combination of short and long complex sentences; were mainly written in the present and past continuous tenses; and contained few words with clusters (7 to 16) and few words with rare phonemes (0 to 3).

The texts were copied directly from FLUENCE so their formatting (A5 paper, Arial font, size 14, double spaced) remained unchanged. The texts from the GEC were formatted similarly. The probes did not included any illustrations. At the start of each session, students received a copy of the text. The interventionist had one or three copies of the text, depending on the number of the student's readings. Each copy was annotated with the number of words per line to facilitate word counting and error tracking. Additional materials also included a stopwatch, a voice recorder, and three colored markers to indicate mispronunciation errors after the student's reading (intervention phase).

For each reading serving as a measure, the two target variables, automaticity (CWPM) and accuracy (EPM), were calculated. A 1-min time limit was applied for all student's readings starting with the first word. Words were counted as correct if they were either pronounced correctly or if they were corrected by the student immediately after being mispronounced. Words that were mispronounced were counted as errors. CWPM was calculated as follows: CWPM = WPM − EPM.

Procedure

Baseline

The interventionist presented one of the eight texts to the student and instructed her to read it aloud. Once the 1-min time limit was reached, the student was instructed to stop reading. Each text was read once during baseline (one of the eight selected texts per session). During baseline, the interventionist did not provide any model readings, vocabulary explanations, error correction, or any type of performance feedback. Each session lasted 2–3 min. CWPM and EPM were measured once per probe and session, resulting in eight measures per student. These took place over a 2-week period for Lana, a 3-week period for Yassira, and 4-week period for Leonie.

Intervention

The teacher-led RR intervention designed by our research team, incorporated specific learning strategies for students with intellectual disability: systematic, explicit, and intensive instruction (Maki & Hammerschmidt-Snidarich, 2022); listening passage previews and teacher modeling (Lee & Yoon, 2017); systematic error correction, performance feedback, and progress monitoring (Therrien, 2004); and visual aids, such as highlighting for mispronunciations on students' plasticized copies of the text and images to explain unknown words, aiming to reduce working memory load (Whitbread et al., 2021). Enhancing students' understanding of unknown words and using visual aids to scaffold working memory are essential strategies when providing reading instruction to students with ID (Lemons et al., 2016). An 8-week intervention was provided to each student with increased dosage (three readings per session and three sessions per week).

A scripted lesson was developed for each of the eight texts and was used during three consecutive sessions. During each session, the interventionist followed these steps: (1) stated the lesson's goal; (2) summarized the text orally in Easy-to-Understand language (1st session) or asked the student if she remembered what the text was about (2nd and 3rd sessions); (3) offered a listening passage preview modeling accuracy (4) explained the decoding of difficult words (i.e., clusters and rare graphemes), either indicated by the student or based on the list of the lesson's script; (5) offered a listening passage preview modeling expression; (6) explained the meaning of unknown words, either indicated by the student or based on the script's list; (7) asked the student to read aloud for 1 min; (8) corrected errors of mispronounced words; (9) asked the student to read aloud again for 1 min; (10) corrected errors of mispronounced words; (11) asked the student to read aloud one last time for 1 min; and (12) discussed CWPM and EPM scores (performance feedback) and overall progression between session (progress monitoring). The student's 3rd and final reading of each session served as a probe. We obtained 24 measures of CWPM and EPM during the intervention (1 probe per session × 3 sessions per week × 8 weeks). On average, sessions lasted 15 min for Yassira and Leonie, and 17 min for Lana.

Generalization

Generalization measures were acquired at the end of the intervention phase on five untrained texts. The first three measures were obtained right after the intervention over a period of 1 or 2 weeks. The last two measures were obtained 1 month after the end of the intervention over the same week to assess maintenance of the intervention's effect. Each text was read once and the same procedures as those used for the baseline measures were applied (i.e., no model readings, vocabulary explanations, error correction, or performance feedback). As in baseline, duration of each session did not exceed 3 min (one reading per session).

Reliability and procedural fidelity

Based on audio recordings, the interventionist and the observer (fourth author) coded independently 28.83% (31 out of 111 probes) of students' readings and calculated CWPM. Probes for interobserver agreement (IOA) were randomly selected from each of the three phases. Agreements accounted for words coded the same (i.e., if both coded the word as correct or as error), and disagreements for words coded differently (i.e., if one coded the word as correct and the other as an error or the opposite). The percentage of agreement was calculated as follows (WWC, 2022): (agreements /(agreements + disagreements) × 100. On average, IOA was 99.91% for Lana (*SD* = 0.30), 99.72% for Yassira (*SD* = 0.50), and 99.86% for Leonie (*SD* = 0.45), suggesting overall high reliability in measurement of students' outcomes (Hartmann et al., 2004).

Procedural fidelity was evaluated through in-person observations conducted for 30% (22 out of 72 sessions) of randomly selected sessions from the intervention phase. The observer indicated on a detailed checklist whether each of the 12 intervention steps was implemented accurately. Procedural fidelity was calculated with the following formula (WWC, 2022): (steps implemented as prescribed /total steps) × 100. The mean procedural fidelity was 97.77 for Lana (*SD* = 3.05), 96.95 for Yassira (*SD* = 2.54), and 98.99 (*SD* = 1.57) for Leonie, suggesting overall high adherence to the intervention procedures (Hartmann et al., 2004).

Analyses

Data analysis was conducted on the two dependent variables (CWPM and EPM) according to single-case experimental studies reporting guidelines (Krasny-Pacini & Evans, 2018; Kratochwill et al., 2010; Manolov et al., 2014). Systematic visual analysis of graphed data was conducted within-phases on level, trend, and variability, and between-phases on level change, immediacy of the effect, and overlap. Level was calculated using the mean. Trend (slope and intercept) was estimated using the Theil-Sen regression, a robust nonparametric regression insensitive to outliers. Variability of the data was evaluated based on the trend stability envelope (20% of median). Immediacy was measured by comparing the change in level between the first three intervention data points to the last three baseline data points (3F–3L). Overlap of data was measured based on the calculation of the two-standard deviation baseline bands (mean ± 2 SD). These were projected to the intervention and the maximum consecutive scores above (for CWPM) or below (for EPM) the 2SD bands were counted. Finally, corrected Tau (BC-Tau), a nonparametric assumption-free statistic, was used to calculate the effect size of the intervention (Tarlow, 2017). BC-Tau allows adjusting, if necessary, for baseline trend before calculating the magnitude of the effect based on Kendal's rank correlation order. Values above zero indicate a positive change. Interpretation of BC-Tau effect sizes followed Vannest and Ninci's (2015) guidelines: small (< 0.20), moderate (0.20–0.60), large (0.60–0.80) and large to very large (> 0.80). The visual aids and nonoverlap indices application was used for the visual analysis of the data (https://manolov.shinyapps.io/Overlap/). Data ana lysis was performed (BC-Tau) using the Scan package (Wilbert & Lüke, 2023) and plots were created with the scplot (Wilbert, 2023) and ggplot2 packages (Wickham, 2016) in R.

Social validity

The social validity of the intervention was evaluated at the end of the study through questionnaires completed by the students and their special education teachers. Using a 5-point scale ranging from ‘completely agree’ (1) to ‘completely disagree’ (5), students rated three dimensions, outcome, level of appreciation, and likelihood of recommending the RR lessons to other students. They were also asked to report what they ‘liked’ and ‘disliked’ about the RR lessons. Before asking the students’ teachers to complete the questionnaires, the lessons’ various components, materials, and procedures were presented to them in person by the interventionist. The teachers were required to read one scripted lesson before rating the relevance of the intervention’s goal, students’ outcomes, and feasibility of implementing RR lessons within their school context and real-world classroom conditions. They used the same 5-point scale and each question was followed by space for comments.

Results

Effects of the intervention

Table 3 presents the descriptive within-phase data for baseline, intervention, and generalization, and Table 4 the size effects (BC-Tau). Line graphs were also used to represent data by session for each participant. Two graphs were plotted, one for CWPM

Table 3 Student outcome measures for CWPM and EPM

Student	Phase	CWPM					EPM				
		M	SD	Slope (SE_{xy})	R^2	Variability (%)	M	SD	Slope (SE_{xy})	R^2	Variability (%)
Lana	B	59.75	12.17	3.07 (0.51)	0.47	100.0	7.62	4.21	−1.25 (0.70)	0.53	25
	I	93.25	19.57	2.28 (0.64)	0.60	87.5	2.33	1.63	0.06 (0.67)	0.08	37.5
	G	89.00	16.75	4.50 (0.59)	0.53	80.0	5.40	2.20	0.12 (0.41)	0.15	40
Yassira	B	88.37	12.89	0.25 (0.46)	0.13	75.0	6.62	2.72	−0.58 (0.53)	0.18	75
	I	118.21	18.94	2.09 (0.72)	0.61	95.8	3.46	3.28	0.17 (0.62)	0.24	29.17
	G	123.60	10.31	−5.00 (0.45)	0.12	100	5.60	3.91	−0.67 (0.44)	0.01	40
Leonie	B	38.87	8.03	0.99 (0.97)	0.09	75.0	6.25	3.28	−1.02 (0.65)	0.58	25
	I	89.87	13.08	0.83 (0.66)	0.20	91.7	3.75	2.54	0.22 (0.73)	0.38	25
	G	72.20	9.88	2.25 (0.54)	0.12	100	6.40	3.51	−0.38 (0.45)	0.14	40

Table 4 Effect sizes of the intervention (BC-Tau) for CWPM and EPM

Student phase		CWPM			EPM		
		T_{BC} (SE)	95% CI		T_{BC} (SE)	95% CI	
			Lower	Upper		Lower	Upper
Lana	B–I	0.54*** (0.21)	0.13	0.95	0.58*** (0.20)	0.18	0.98
	B–G	0.68** (0.29)	0.12	1.24	0.19 (0.39)	−0.57	0.94
Yassira	B–I	0.50** (0.22)	0.07	0.92	0.40** (0.23)	−0.04	0.85
	B–G	0.72** (0.27)	0.19	1.25	0.24 (0.38)	−0.50	0.99
Leonie	B–I	0.63*** (0.19)	0.24	1.01	0.32* (0.24)	−0.15	0.78
	B–G	0.72** (0.27)	0.19	1.25	0.00 (0.39)	−0.77	0.77

Note. The significance level for the baseline trend test was set at the default value of 0.05. Since baseline trends were not significantly different from zero, no further adjustments using Theil–Sen regression were applied.

B Baseline, *I* Intervention, *G* Generalization

*$p<.05$; **$p<.01$; ***$p<.001$

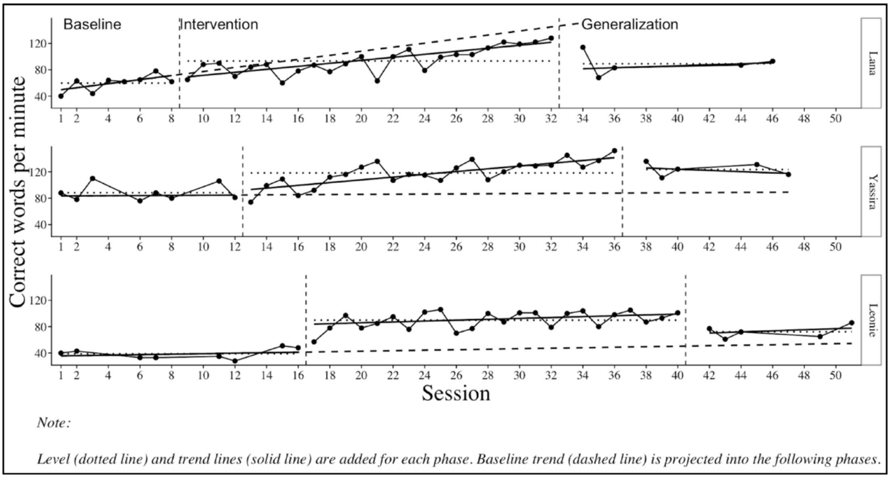

Fig. 1 Correct words per minute (CWPM) for the three students in the three phases

(Fig. 1) and one for EPM (Fig. 2). Scores on the dependent variables were plotted as single data points and connected to subsequent data points across conditions.

Lana

At baseline, Lana showed a stable (100% of the data fell within the trend stability envelope), accelerating trend for CWPM, with scores varying between 40 and 78. She showed a decelerating trend with high variability (25% of data within the trend stability envelope) for EPM, with scores varying between 3 and 16. The onset of the intervention was marked by an immediate loss of 5 CWPM, however, a more gradual change was observed (3F–3L) with Lana progressively reading 12.67 more CWPM and making 4.33 fewer EPM. During the intervention phase, Lana's level improved by 33.5 CWPM (range = 60–128) in a stable accelerating trend although it was slower

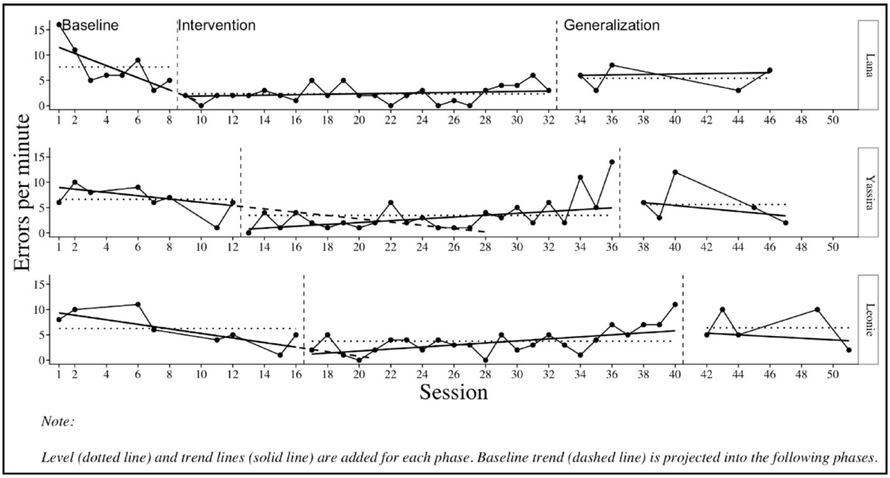

Fig. 2 Errors per minute (EPM) for the three students in the three phases

compared to baseline. She made 5.33 fewer EPM (range = 0–6) in a slightly increasing, variable trend. In terms of overlap, eight consecutive CWPM intervention scores were above the 2SD baseline bands, however no EPM scores fell outside the EPM baseline bands. During generalization, Lana maintained a CWPM level higher than baseline (range = 68–114) with an accelerating stable trend, and an EPM level lower than baseline (range = 3–8), although with an upward, highly variable trend suggesting progressive deterioration.

Yassira

During baseline, Yassira exhibited a flat variable trend (75% of data within the trend stability envelope) for CWPM, with scores varying between 76 and 110, and a decelerating trend (75% of data within the trend stability envelope) for EPM, with scores ranging between 1 and 10. The onset of intervention was marked by a sharp immediate gain of 8.05 CWPM and a gradual change (3F–3L) of 5 CWPM more and 3 EPM less. During the intervention, Yassira's CWPM level increased by 29.83 CWPM (range = 74–152) with an accelerating stable trend and her EPM level decreased by 3.02 EPM (range = 0–14), yet with an upward variable trend indicating progressive deterioration. Eight consecutive intervention scores for CWPM and 0 for EPM were above or below the 2SD baseline bands accordingly. During generalization, Yassira sustained a higher than baseline level on CWPM (range = 111–136) with a deteriorating stable trend. However, her EPM performance declined to slightly lower than baseline levels (range = 2–12) with a deteriorating but variable trend.

Leonie

During baseline, Leonie's performance showed an accelerating variable trend (75% of data within the stability envelope) for CWPM, with scores varying between 28 and 51, and a decelerating variable trend (25% of data within the stability envelope) for EPM, with scores ranging between 1 and 11. Intervention enter was marked by a sharp immediate change of 37 CWPM and a gradual gain of 35 CWPM (3F–3L). For EPM, the immediacy of the effect (3F–3L) was small (one less EPM). Overall during intervention, Leonie improved highly both her CWPM and EPM levels, reading on average 51 CWPM more (range = 57–106) and making 2.5 EPM less (range = 0–11). Her CWPM performance showed an accelerating stable trend indicating improvement, but her EPM performance followed an upward variable trend indicating deterioration. Twenty-four consecutives of her CWPM intervention scores were above the baseline bands, but none of her EPM scores. After withdrawal of the intervention, her performance on untrained texts, was higher than baseline on CWPM (range = 61–86) with un upward trend showing very low variability. However, her EPM level increased slightly above baseline level (range = 2–10), though with a decelerating variable trend.

Social validity of the intervention

The responses of the three students to the RR intervention were mixed. All three acknowledged their progress and stated that they would recommend the intervention to other students. However, Lana was the only one who stated that she enjoyed the lessons. In contrast, Yassira and Leonie said they disliked the lessons, finding them lengthy and tiring. Their teachers recognized the importance of RF instruction and acknowledged their students' gains on RF compared to their pre-intervention skills. Due to the absence of a second special education teacher in their classroom, they noted that the intervention could only be delivered in small groups and not in a one-to-one setting. The teachers expressed their intent to adopt the specific instructional strategies used in the study (i.e., teacher model reading, error correction, etc.) and to recommend the intervention to their colleagues.

Discussion

The purpose of this study was to examine the effects of a RR intervention on automaticity (CWPM) and accuracy (EPM) in three students with intellectual disability. Visual and statistical analyses were conducted (Kratochwill et al., 2010) to assess the effects of the RR intervention on trained (intervention) and untrained texts (generalization). Overall, the RR intervention appeared to have positive effects on CWPM and EPM for trained texts. Visual analysis of the data revealed some consistency in performance patterns among the three students for the two outcomes, CWPM and EPM. During the intervention, all three students exhibited increased levels of CWPM with upward trends and moderate to large effect sizes suggesting significant improvements in automaticity. These effects generalized and were maintained one month after the withdrawal of the intervention to untrained texts, with large effect sizes indicating a possible functional relationship between the intervention and automaticity. All students showed lower levels in EPM during the intervention. However, the upward trends showed that errors progressively increased returning to baseline levels during generalization, in particular for Yassira and Leonie. Effect sizes for EPM were moderate during the intervention and ranged from null to moderate during generalization. This result is consistent with literature suggesting that gains in accuracy are harder to maintain than gains in automaticity (Stevens et al., 2017). Despite the results of the statistical analysis, caution is warranted when interpreting the intervention's effects, given Lana's positive baseline trend in CWPM and the negative baseline trends in EPM for all three students. Regular reading aloud practice, even without the RR intervention, may have contributed to slight automaticity improvements for Lana and accuracy improvements for all students.

Our results align with those of prior studies (Hua et al., 2012a, 2012b; Strickland et al., 2020) regarding the observed effects of RRs on trained texts. However, our results also demonstrate generalization of gains in automaticity to untrained texts, which was not observed in these prior studies. Several possible explanations may account for this outcome. In addition to the systematic error correction and performance feedback used in earlier studies, our intervention included additional instructional components and strategies. Notably, two listening previews of the text, one focusing on automaticity (accuracy and speed) and the other focusing on expression. To our knowledge, this is the first time that a RR intervention targeting this population includes this valuable component (Lee & Yoon, 2017). Compared to no model or peer model reading, adult model reading has been shown to yield higher reading automaticity (Stevens et al., 2017) and greater transfer effect sizes (Therrien, 2004). Exposing students to correct pronunciation through expert-led listening previews and explicit explanations of decoding rules helps set expectations for fluent reading and provides ongoing support for accurate word decoding (Swain et al., 2013). Our intervention also included text summaries and explainations of unknown words to facilitate reading comprehension. These instructional components are present in the FLUENCE program that we adapted for students with intellectual disability. Additionally, we employed visual aids, highlighting of mispronounced words and images to explain unknown words (Quadri et al., 2024), in order to anticipate working memory deficits (van Wingerden et al., 2017) and reduce cognitive load (Lemons et al., 2016).

Another possible explanation for the generalization of automaticity to untrained texts is the increased dosage of our intervention. Unlike previous SCEDs with students with intellectual disability, which included three readings of each text and a maximum of 14 sessions (with a new text proposed in each session), our intervention involved nine readings of each text across three sessions and a total of 24 sessions. However, it is uncertain whether dosage accounts for the generalization and maintenance effects. Meta-analyses in students with learning disabilities suggest that three to four readings increase RF gains, but additional readings do not significantly enhance RF or reading comprehension (Kim et al., 2016; Lee & Yoon, 2017; Stevens et al., 2017). Furthermore, interindividual differences may have contributed as well. While Hua and colleagues focused on young adults, our participants were adolescents aged 14 to 15 years with elementary reading levels and low pre-intervention automaticity scores (−2.32 SD). Their profile aligns more closely with that of Strickland's (2020) study, which included three students aged 11 to 12 years with slightly higher pre-intervention automaticity levels (−1.93 SD). Meta-analyses indicate that RF growth tends to be higher for students with elementary reading levels than for those with secondary levels (Lee & Yoon, 2017). However, initial RF level has minimal impact on overall RF growth when benefiting from a RR intervention (Maki & Hammerschmidt-Snidarich, 2022).

The intervention's effectiveness was evaluated based on the three-factor social validity construct by the students and their teachers (Snodgrass et al., 2018). Similar to Strickland et al. (2020), students rated their outcomes positively but the overall intervention negatively. Teachers rated the intervention's goal, students' outcomes, and intervention's procedures and strategies positively. However, they expressed reservations about implementing the intervention in a one-to-one setting, as was done in the present study. The FLUENCE program, which was adapted for the intervention, was initially designed to be delivered in a small-group format with students at similar RF levels. Therefore, implementing the intervention with small groups (two to three students) would be feasible in real classroom conditions. This may result in fewer readings per student per session (one or two instead of three) to maintain sessions under 20 min, but small-group RR interventions may provide alternative benefits, such as increasing student motivation and enhancing their enjoyment of the RR lessons (Begeny et al., 2009).

Limitations and suggestions for future research

This study adds to the growing body of research suggesting that systematic and explicit RF instruction together with ample opportunities to practice reading aloud through RRs, is an effective approach to help students with intellectual disability become fluent readers (Hua et al., 2012a, 2012b, 2018; Strickland et al., 2020). However, this study has limitations that future research must address. First, the differential effects of the instructional components and strategies included in our intervention (e.g., listening passage preview and teacher modeling, text summaries, explaining of difficult to decode words and unfamiliar vocabulary, and visual supports) cannot be evaluated within the context of our MBD study across participants. Further research is needed to identify whether the effectiveness of RR for students with intellectual disability is linked to the combination of these instructional components or to certain components more than others.

Second, the intervention was implemented when baseline trend appeared to be moving in the same direction of the desired effects of the intervention for Lana (first student) which obviously poses some limitations and imposes caution in the interpetation of the effect of the intervention for her. Since these students had rarely the opportunity to practice reading at school, it is possible that by simply providing the opportunity to read aloud regularly may have induced some improvement for Lana, i.e., a testing effect. Using BC-Tau to measure overlap was an appropriate solution to address this potential issue, as it allows for correction of trending baselines if significant.

Third, the findings should be interpreted with caution in relation to the dosage of our intervention. While it is well established that students with intellectual disability require more intensive practice (Bakken et al., 2021), the optimal dosage needed for long-lasting effects requires further investigation. This is particularly relevant with regard to the feasibility of RR interventions in real classroom conditions and student engagement throughout the process. Fourth, although EPM is widely used in studies (Strickland et al., 2020), we question its validity as an appropriate variable to measure accuracy, due to its relationship to the number of words read. One alternative solution could be to calculate the percentage of accuracy using Rasinki's (2010) formula: (CWPM/WPM) × 100.

Fifth, our intervention was delivered individually to meet the requirements of a single-case experimental study. However, one-to-one interventions are difficult to implement in real classroom conditions. This underscores the need for more studies investigating the implementation of RR interventions in a small-group format and assessing the impact of peer interactions on students' motivation and outcomes (Guthrie & Klauda, 2014). Lastly, the small number of participants in the study limits the generalization of the results.

Implications for practice

The intervention implemented in this study included targeted instructional components and strategies for students with intellectual disability. It was based on evidence-based instructional practices and prior research. Our findings offer practical insights for teachers conducting RR lessons with this population. Consistent with findings in students with learning disabilities (Lee & Yoon, 2017; Therrien, 2004), combining RR with direct instruction, multiple adult model readings, and systematic error correction are essential for improving RF in students with intellectual disability. To support reading comprehension, teachers should provide text summaries and clarify unfamiliar vocabulary. Selection of texts should be carefully considered, as engaging and age-appropriate texts can increase student motivation (Allor et al., 2013). Finally, teachers should ensure sufficient intervention dosage by planning RRs over several consecutive weeks and offering students if possible three opportunities to practice within a single lesson (Maki & Hammerschmidt-Snidarich, 2022).

Conclusion

Overall, this study contributes to the current body of knowledge on the effects of RR interventions for students with intellectual disability. The findings suggest that when RR interventions include teacher modeling and ample guided opportunities to practice and receive feedback, students with intellectual disability can improve in terms of automaticity. To support efficient implementation of RR interventions for this population, a more fine-grained understanding is needed regarding the effects of specific strategies, intervention dosage (number of readings, frequency, and total duration), and small group implementation. More single-case experimental studies and randomized control trials are required before solid conclusions can be drawn about RR's effectiveness for students with intellectual disability. Given that a few single-case studies have shown RR intervention to be promising in improving RF in students with intellectual disability (Hua et al., 2012a, 2012b, 2018; Strickland et al., 2020), conducting randomized controlled studies would be especially valuable.

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Data availability All data supporting the findings of this study have been deposited in Zenodo and are publicly accessible https://zenodo.org/records/15012416.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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