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Research Article

The effect of rapid automatized naming on reading fluency and academic intrinsic motivation among students with learning disabilities

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Abstract

This study aimed to evaluate the effects of a 10-week rapid automatized naming (RAN) training intervention on reading fluency and academic intrinsic motivation among Egyptian 5th graders with learning disabilities. A quasi-experimental pre-test/post-test design with follow-up was employed. Thirty-two 5th grade students with LD (aged 11-12) participated in the study. Post-intervention analyses revealed significant improvements across all reading fluency measures ($p < .01$), with the largest gains observed in reading rate and prosody. Intrinsic motivation also increased significantly across all AIMS subscales (challenge, curiosity, control, and career outlook; $p < .01$). Importantly, both fluency and motivation gains were maintained at the six-week follow-up assessment, with no significant decline in scores. The findings demonstrate that RAN training can effectively enhance both reading fluency skills and intrinsic motivation in students with LD. The intervention appears to strengthen fundamental rapid serial processing skills while simultaneously boosting students' perceptions of reading competence. These results suggest that integrating RAN training within multi-tiered reading instruction may offer a promising approach for preventing and remediating reading disabilities by jointly supporting skill development and motivation. Future research should examine the long-term sustainability of these gains and the potential for implementing RAN training in group settings.

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Introduction

Over the past 40 years, a large body of research has demonstrated that rapid automatized naming (RAN) is closely connected to reading development and disabilities (Norton & Wolf, 2012). RAN refers to the ability to quickly name familiar with visual stimuli (e.g. letters, numbers, colors, pictures) presented serially (Jones et al., 2016; Keskin et al., 2022). Specifically, poor RAN performance is characteristic of children with dyslexia and other learning disabilities (LD), and RAN measures can even predict later reading difficulties before formal reading instruction begins (Araújo & Faísca, 2019; Katzir et al., 2006; Nagler et al., 2021).

While the exact cognitive mechanisms underlying RAN are still debated, most researchers believe RAN taps into multicomponent skills related to visual processing, attention, memory, lexical access, and articulation (Koponen et al., 2020; Norton & Wolf, 2012; Ozernov-Palchik et al., 2022). Importantly, RAN measures the integration of these

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component skills in a rapid, automatized naming sequence, placing high demands on overall cognitive efficiency and processing speed (Das & Samantaray, 2023). As such, RAN performance has been theoretically and empirically linked to the development of skilled, fluent reading (Huschka et al., 2021).

Reading fluency is considered a hallmark of expertise and skilled reading (Rakhlin et al., 2019). It refers to a construct that includes accuracy, speed, and prosody of text reading (Kim et al., 2021). While beginning readers focus their efforts on decoding words, skilled readers are able to read fluently and direct their attention to comprehension (Nemt-allah & Darwesh, 2024). Thus, reading fluency plays a pivotal role in the development of overall reading proficiency, making it an important target of reading instruction and intervention (Hudson et al. 2020).

A large body of research attests to the reciprocal relationship between RAN and reading fluency. On one hand, slow and dysfluent RAN appears causally implicated in some forms of reading disability characterized by slow, labored reading (McBride, 2019; Wong, 2023). On the other hand, reading fluency interventions involving repeated readings have been found to improve RAN performance as well as transfer effects to novel reading tasks, supporting the notion that RAN and reading fluency rely on shared underlying processes (Katzir et al., 2006; Young et al., 2020).

Given the persistent reading difficulties experienced by many children with LD—difficulties that stem largely from deficits in fluency, RAN emerges as a salient factor connecting LD to problems with reading achievement across the academic lifespan. Unfortunately, persistent academic underachievement often leads to impairments in motivation as well (Borkowski & Thorpe, 2023; Wong, 2023). Motivation is not a unitary construct, however, both quantity and quality of motivation matter. While students with LD often display lower levels of motivation for academic tasks, deficits in the quality of their motivation—specifically lower intrinsic motivation—appear especially predictive of diminished achievement outcomes (Butler & De La Paz, 2021)

Intrinsic motivation refers to the inherent pleasure and satisfaction derived from engaging with a task for its own merits, whereas extrinsic motivation relies on external incentives, pressures, or contingent consequences (Ryan & Deci, 2000a). According to self-determination theory, intrinsic motivation results from satisfaction of the basic psychological needs for autonomy, competence, and relatedness; consequently, it is associated with greater engagement, persistence, creativity and conceptual learning (Ryan & Deci, 2000b). Students perform better, achieve more, and experience greater psychological well-being when intrinsically motivated (Taylor et al., 2014). However, students with LD often feel less competent, autonomous, and related within academic contexts, undermining intrinsic motivation (Daniel & Cooc, 2018).

Importantly, intrinsic motivation has been empirically linked to both RAN and reading fluency, suggesting a motivational pathway connecting RAN deficits to poorer reading outcomes among children with LD. With regards to RAN, Willcutt et al. (2007) found that intrinsic reading motivation fully mediated the relationship between RAN deficits and reading disability symptoms in an adolescent sample. Turning to fluency, several studies have demonstrated increases in reading motivation alongside improved fluency following reading interventions (Guthrie et al., 2013; Quirk & Schwanenflugel, 2004). Taken together, these findings indicate that RAN, fluency and intrinsic reading motivation are intertwined. Enhancing RAN and fluency may foster greater intrinsic motivation for reading activities among students with LD, initiating a positive motivational spiral supporting further academic growth. Currently, however, research on the relationships between RAN, fluency and academic motivation among students with LD is limited.

Therefore, the overarching objective guiding this study is to investigate the effect of RAN training on both reading fluency outcomes and intrinsic academic motivation among elementary school students with LD. The rapid serial exposure inherent in RAN training may help automatize component reading skills while simultaneously boosting self-perceptions of competence and self-efficacy for reading, enhancing intrinsic motivation. Four specific research questions will structure the investigation:

RQ1: Does RAN training improve reading fluency for students with LD?

RQ2: Does RAN training increase intrinsic academic motivation for students with LD?

RQ3: Are post-intervention gains in reading fluency and intrinsic motivation sustained at follow-up for students with LD?

Method

Research Design

The present study employed a single-group quasi-experimental design with repeated measures to examine the effects of RAN training on reading fluency and academic intrinsic motivation. This design was selected due to the specialized nature of the participant population (students with LD) and ethical considerations regarding withholding potentially beneficial intervention from control group participants.

Participants

The participants were 32 students (18 males, 14 females) in 5th grade identified with LD in reading. They were recruited from one public elementary school located in a large metropolitan area in Egypt. The mean age of the sample was 11.6 years (SD = 0.12 years). Students were screened and identified as having a learning disability in reading based on standardized scores at or below the 15th percentile on the Raven's Progressive Matrices, a nonverbal measure of general intellectual ability. They also scored above the 50th percentile on the Neurological Exam for Children with LD, indicating no evidence of neurological impairment. Additional inclusion criteria per school records were normal vision and hearing, no diagnoses of intellectual disability or emotional/behavioral disorders, and Arabic as the primary language spoken at home. Prior to the study, all students received special education services for reading under the category of learning disability.

Measures

Reading Fluency

Researchers-designed Reading Fluency Scale was used to assess key components of oral reading fluency. The scale was developed specifically for this study based on a review of research on assessing reading fluency in students with reading disabilities (e.g., Miller & Schwanenflugel, 2008; Hasbrouck & Tindal, 2006) and consideration of students' instructional reading level. It contains 10 narrative reading passages ranging from 100-120 words each at the participants' instructional reading level.

Students were administered the scale individually. They were asked to read each passage aloud while being audio recorded. After reading each passage, students responded verbally to five researchers-developed literal comprehension questions about the passage. The recordings were used to score reading accuracy, rate, and prosody. Comprehension was scored based on percentage correct on the comprehension questions.

Specifically, reading accuracy was calculated as the percentage of words read correctly out of the total number of words in the passage. Words omitted, substituted, and hesitations of more than 3 seconds were counted as errors. Reading rate was calculated as the total number of correct words per minute.

Prosody was scored on a 3-point rubric assessing expression and volume, phrasing, and smoothness. Expression and volume evaluated variation in volume and expression to convey meaning. Phrasing assessed pausing at commas, stopping at periods, and appropriate phrase groupings. Smoothness reflected fluid reading with minimal hesitations. A score of 0 meant the element was completely lacking, 1 meant it was evident less than 50% of the time, and 2 meant it was present more than 50% of the time. The three scores were summed to create a total prosody score ranging from 0 to 6 for each passage.

Comprehension was scored as the percentage of comprehension questions answered correctly. Students received a score of 1 for each correct response and 0 for each incorrect response. Scores on the reading accuracy, rate, prosody, and comprehension measures were averaged across the three passages to create a total reading fluency scale score.

The Reading Fluency Scale demonstrated strong psychometric properties through comprehensive validity and reliability analyses when administered to 142 Egyptian students with LD. Content validity was established through

expert review of the scale components and alignment with established research on reading fluency assessment (Miller & Schwanenflugel, 2008; Hasbrouck & Tindal, 2006). The scale's construct validity was evidenced by its multidimensional approach to measuring the key theoretical components of reading fluency - accuracy, rate, prosody, and comprehension. Criterion-related validity was supported through significant correlations with established reading measures, including strong correlations with the Woodcock Johnson Reading Fluency Test ($r = .83$, $p < .001$) and moderate to strong correlations with standardized comprehension measures ($r = .76$, $p < .001$).

The reliability of the Reading Fluency Scale was demonstrated through multiple measures. Inter-rater reliability for the prosody scoring rubric showed strong agreement between raters (ICC = .91 for expression and volume, .89 for phrasing, and .90 for smoothness). Internal consistency reliability was excellent, with Cronbach's alpha of .92 for the overall scale and ranging from .85 to .93 for individual components. Test-retest reliability analyses conducted with a subset of participants ($n = 45$) over a two-week interval indicated strong stability in scores across administrations ($r = .88$, $p < .001$). The use of multiple passages (10 in total) and the averaging of scores across passages helped enhance the reliability of the overall measure by reducing the impact of passage-specific effects, with parallel forms reliability coefficients ranging from .74 to .91 across different passage pairs.

Academic Intrinsic Motivation

Students' academic intrinsic motivation was assessed using the adapted 25-item Academic Intrinsic Motivation Scale (AIMS). This scale was originally developed by Lepper and Hodell (1989) to assess college students' motivation toward academic activities. The adapted version has updated wording suitable for high school students but retains the same four subscales representing key aspects of intrinsic motivation from self-determination theory: Challenge, Control, Curiosity, and Career Outlook.

The AIMS uses a 5-point Likert scale response format ranging from 1 (strongly disagree) to 5 (strongly agree). Students respond based on their level of agreement with each statement as it applies to them personally. Item responses are summed to create a total score ranging from 25 to 125, with higher scores representing greater intrinsic motivation. The adapted AIMS has shown good reliability and validity evidence with high school students (Vo et al., 2021).

The AIMS demonstrated strong psychometric properties when administered to 142 Egyptian students with LD. Internal consistency reliability was excellent for the total scale ($\alpha = .91$, $\omega = .93$) and strong for all subscales: Challenge/Control ($\alpha = .89$), Curiosity ($\alpha = .87$), and Career Outlook ($\alpha = .85$). Test-retest reliability over a two-week interval with 45 participants showed strong temporal stability for both the total score ($r = .88$, $p < .001$) and subscales ($rs = .82$-$.86$, $p < .001$). Internal structure was supported through exploratory factor analysis, which revealed a three-factor solution accounting for 68.4% of the total variance, with factor loadings ranging from .45 to .82.

Evidence for validity was established through multiple sources. Content validity was confirmed by expert review (CVI = .89), while construct validity was demonstrated through confirmatory factor analysis showing good model fit (CFI = .93, RMSEA = .059). Convergent validity was supported by significant correlations with academic self-efficacy ($r = .65$, $p < .001$), school engagement ($r = .58$, $p < .001$), and GPA ($r = .42$, $p < .001$). Criterion-related validity was evidenced through correlations with teacher ratings of student motivation ($r = .56$, $p < .001$) and classroom participation ($r = .49$, $p < .001$), while predictive validity was supported by significant correlations with end-of-year academic achievement ($r = .45$, $p < .001$). The scale also successfully differentiated between students with high and low academic performance ($t(140) = 4.86$, $p < .001$, $d = 0.82$), providing additional evidence of construct validity.

Procedure

An informational letter was sent home to parents of potential participants, followed by obtaining written parental consent and student assent. Students were tested individually in a quiet room at the school over two sessions scheduled about one week apart. The first session lasted approximately 30 minutes and involved administering the Raven's Progressive Matrices, Neurological Exam for Children with LD, and the first five reading passages of the reading fluency scale.

Following pretesting, students participated in a 10-week RAN training program consisting of four sequential modules. Each module built upon skills developed in previous modules, with progression contingent upon achieving specified accuracy and speed criteria. The training was conducted individually for 30 minutes, three times per week, in a quiet classroom setting.

Table 1. Structure and requirements of the 10-weeks RAN training program

Module	Weeks	Focus Areas	Activities
1st Module: Basic Naming Speed	1-2	Single-category stimuli	Week 1: Letter naming uppercase/lowercase), number naming (forward/backward Week 2: Mixed letter-number combinations
2nd Module: Complex Naming Speed	3-4	Additional stimulus categories	Week 3: Color naming and object naming Week 4: Alternating patterns of colors and objects
3rd Module: Mixed Category Integration	5-6	Multiple stimulus integration	Week 5: Structured combinations (letters, numbers, colors, objects) Week 6: Semi-random combinations with consistent groupings
4th Module: Advanced Integration and Automaticity	7-10	Automaticity and generalization	Weeks 7-8: Random combinations without patterns Weeks 9-10: Complex mixed arrays with increased density

Each training session maintained a consistent 30-minute structure designed to maximize learning and engagement. Sessions began with a five-minute warm-up period dedicated to reviewing previous achievements and setting goals for the current session. This was followed by five minutes of explicit instruction, during which new patterns or combinations were introduced. The core of each session consisted of ten minutes of guided practice, incorporating modeling and corrective feedback, followed by five minutes of independent practice through timed trials with self-monitoring. Sessions concluded with five minutes of progress monitoring, during which students received performance feedback and goals were adjusted as needed.

The program implemented a comprehensive progress monitoring system to ensure student success and maintain implementation fidelity. Daily progress was meticulously recorded using standardized recording sheets, with advancement to subsequent modules contingent upon meeting specified success criteria. Students who did not meet these criteria received additional practice within their current module, ensuring mastery before progression. Visual progress charts provided continuous performance feedback, and weekly progress reports were shared with special education teachers to maintain communication and support.

Implementation fidelity was maintained through several rigorous measures. All sessions were conducted by trained researchers who followed a detailed protocol. To ensure consistency and quality, 20% of sessions were randomly selected for fidelity checks using a standardized observation form. These checks demonstrated high reliability, with inter-observer agreement exceeding 95%. Any deviations from the protocol were thoroughly documented and addressed during weekly team meetings, allowing for prompt resolution of any implementation concerns.

After completing the 10-week training program, students were scheduled individually for post-testing. To maintain objectivity, post-testing was conducted by a research assistant who was blinded to the purpose of the intervention program. The reading fluency scale and AIMS motivation scale were re-administered following the same protocol used during pretesting. All post-testing was completed within one week of program completion to ensure accurate measurement of intervention effects.

The modular structure of this intervention proved effective in supporting systematic skill development while maintaining student engagement through clearly defined, achievable challenges. The program's design allowed for clear

progression benchmarks while providing the flexibility necessary to accommodate individual learning rates. This balanced approach ensured that students could advance through the program at an appropriate pace while maintaining high standards of achievement at each level.

Results

Research Question 1 asked whether RAN training improves reading fluency for students with LD. To evaluate this, students' performance on the researchers-designed Reading Fluency Scale was compared before and after the 10-week RAN training intervention. The scale assessed reading accuracy, rate, prosody, and comprehension across narrative passages at students' instructional reading level .

Paired samples t-tests were conducted to compare students' pretest and posttest scores on each of the reading fluency measures as well as the total reading fluency scale.

Table 2. Pretest and posttest comparisons for reading fluency and motivation measures

Variable	Pretest		Posttest		*T*-value	*df*
	M	*SD*	*M*	*SD*		
Reading accuracy	57.97	12.060	62.56	9.675	3.654**	31
Rate	15.09	3.286	20.88	3.867	5.903**	31
Prosody	2.75	0.984	3.69	0.821	5.073**	31
Comprehension	2.13	0.833	2.94	0.801	4.463**	31
Reading fluency	75.81	12.212	87.13	11.628	7.868**	31
Challenge	12.78	2.859	17.00	2.688	7.191**	31
Control	14.94	2.828	19.84	3.811	5.780**	31
Curiosity	13.34	2.598	18.50	4.258	6.389**	31
Career outlook	10.97	2.978	14.25	2.794	3.968**	31
Total AIM	52.03	4.575	69.59	6.370	11.590**	31

Note. N = 32. AIM= Academic Intrinsic Motivation; **p < .01.

As shown in Table 2, students demonstrated significant improvement from pretest to posttest on reading accuracy, t = 3.654, p < .01, rate, t = 5.903, p < .01, prosody, t = 5.073, p < .01, and comprehension, t = 4.463, p < .01. Additionally, the overall reading fluency scale score increased significantly following the RAN intervention, t = 7.868, p < .01 .

These results provide clear affirmative evidence for Research Question 1 - the RAN training program produced substantial gains in reading fluency skills for students with LD. On average, students read subsequent to the intervention with greater accuracy, faster rate, better prosody, and stronger comprehension versus their pre-intervention performance. The magnitude of change was largest for reading rate, followed by prosody, overall fluency, comprehension, and finally accuracy. This pattern suggests the RAN training proved most effective at increasing reading speed and automaticity. Nonetheless, significant growth emerged across all fluency dimensions measured.

Research Question 2 examined whether RAN training increased intrinsic academic motivation for students with LD. The AIMS assessed students' motivation on the subscales of challenge, curiosity, control, and career outlook before and after the intervention. As shown in Table 1, paired samples t-tests revealed significantly higher motivation scores from pretest to posttest across all AIMS subscales: challenge, t(31) = 7.191, p < .01; control, t(31) = 5.780, p < .01; curiosity, t(31) = 6.389, p < .01; and career outlook, t(31) = 3.968, p < .01. Most notably, the AIMS total intrinsic motivation score increased substantially following the 10-week training program, t (31) = 11.590, p < .01.

These results provide an affirmative answer to Research Question 2 - RAN training increased intrinsic academic motivation as well as reading fluency for students with LD. Across motivational subdomains, students reported greater enjoyment of challenge, feelings of self-determination, curiosity to learn, and internal driven academic interests after completing the intervention versus at pretest. This suggests the RAN training helped strengthen adaptive motivational beliefs supportive of ongoing reading progress.

Research Question 3 examined whether post-intervention gains in reading fluency and intrinsic motivation following the RAN training were sustained at a 6-week follow-up assessment. Paired samples t-tests compared students' posttest scores immediately after finishing the intervention and follow-up scores 6-weeks later on the reading fluency scale and AIMS motivation measure .

Table 3. Posttest and follow-up comparisons for reading fluency and motivation measures

Variable	Posttest		Follow-up test		*T*-value	*df*
	M	*SD*	*M*	*SD*		
Reading accuracy	62.56	9.675	62.34	9.276	1.184	31
Rate	20.88	3.867	20.91	3.256	0.114	31
Prosody	3.69	0.821	3.81	0.693	1.161	31
Comprehension	2.94	0.801	3.00	0.718	1.438	31
Reading fluency	87.13	11.628	86.97	10.724	0.482	31
Challenge	17.00	2.688	17.13	2.485	1.438	31
Control	19.84	3.811	20.03	3.188	0.797	31
Curiosity	18.50	4.258	18.44	3.369	0.138	31
Career outlook	14.25	2.794	14.34	2.266	0.475	31
Total AIM	69.59	6.370	69.94	4.826	0.604	31

As shown in Table 3, no significant differences emerged between posttest and follow-up on any reading fluency or intrinsic motivation variables. Reading accuracy, rate, prosody, and comprehension remained stable from post testing to the 6-week follow-up, $t < 1.184$, $p > .05$. Similarly, intrinsic motivation scores on the challenge, control, curiosity, career outlook, and total AIMS subscales did not differ significantly between posttest and follow-up, $t < 1.438$, $p > .05$.

Discussion

This study investigated the effects of a 10-week RAN training intervention on reading fluency skills and intrinsic academic motivation in elementary students with LD. Results indicated RAN training yielded significant improvements in reading accuracy, rate, prosody, comprehension, and overall fluency. Additionally, students reported heightened intrinsic motivation following training across domains of challenge, curiosity, control, and career outlook. Improvements were maintained at a 6-week follow-up with no fading of posttest gains. These findings hold meaningful theoretical and practical implications.

The fluency improvements demonstrated align with and extend previous research on RAN, fluency and LD. First, substantial evidence already links RAN deficits to the hallmark reading fluency difficulties and dyslexia characteristic of LD (Araújo et al., 2021; Norton & Wolf, 2012; Robinson & Meisinger, 2022). The present findings bolster claims of a causal role for naming speed in fluent reading by showing that directly training RAN transfers to sizable fluency gains. This fits with the hypothesized importance of rapid serial processing inherent in RAN for coordinating the visual, phonological, orthographic, semantic and articulatory components underlying automaticity and skilled reading (Georgiou et al., 2012; Norton & Wolf, 2012).

Furthermore, prior training studies demonstrate RAN interventions can improve discrete reading skills for students with dyslexia, including letter sound knowledge, decoding, and sight word recognition (Kairaluoma et al., 2007; Vander Stappen et al., 2020). The current results build on this by documenting significant gains on an authentic, curriculum-based measure of oral reading fluency using narrative passages. This ecological validity helps substantiate the practical value of RAN training for enabling not just isolated reading competencies but meaningful improvements in actual reading tasks.

At the same time, the largest fluency gains occurred for rate and prosody, aligning with RAN's theorized role as a time-constrained measure of efficient serial processing. Reading rate showed the greatest pre-post increase, followed by prosody and overall fluency. Accuracy improved as well, but less dramatically. Thus, RAN training appeared most apt

at honing the speeded sequential processing critical for automaticity gains. This pattern supports emphasizing the distinctive rapid naming demands inherent in RAN when utilizing training programs. Discrete rapid naming of isolated stimuli likely engages component skills less holistically than continuous serial naming required on RAN measures (Norton & Wolf, 2012).

Reading comprehension also improved significantly following the RAN training, though to a lesser degree. Comprehension relies on broader language abilities and world knowledge beyond word recognition automaticity (Cain et al., 2004). Hence, RAN training would be expected to exert a smaller proximal impact on comprehension versus direct fluency skills, since the intervention did not target language comprehension directly. Still, by freeing attention from laborious word decoding, gains in naming speed and reading rate allow more cognitive resources to be directed to meaning making, thereby facilitating comprehension (Samuels, 2006). Improving RAN and reading fluency removes a bottleneck for students with LD, bringing comprehension within closer reach.

For intrinsic reading motivation, students in the current RAN training displayed enhanced motivation on all AIMS subscales: challenge, curiosity, control and career outlook. This reinforces the hypothesized motivational pathway connecting RAN, fluency and motivation whereby RAN deficits undermine early motivation, while fluency gains renew motivation to read (Quirk & Schwanenflugel, 2004; Willcutt et al., 2007). Experiencing success on fluency outcomes following the RAN training may bolster students' perceived competence and self-efficacy for reading. In turn, heightened self-perceptions restore intrinsic incentives to persist, fueled by mastery and inherent interest.

Significantly, motivation increased across multiple facets assessed by the AIMS. Beyond competence valuation, students also endorsed greater curiosity and inclination toward challenge. This suggests renewed motivation stemming from gains in fluency were robust, permeating diverse aspects of intrinsic motivation aligned with self-determination theory (Ryan & Deci, 2000b). Students did not merely feel more capable, but rediscovered curiosity and willingness to take on difficulty - hallmarks of adaptive motivation.

Sustained motivation also remained evident at follow-up without fading. Preserving motivation over time is essential for consolidating intervention benefits (Quirk & Schwanenflugel, 2004). Students avoided motivational backsliding into disengagement. Enhanced interest and perceived fluency competence persisted, implying genuine reshaping of motivational beliefs occurred. RAN training accompanied by fluency success created a self-reinforcing cycle where improved automaticity restores motivation to practice reading, further cementing fluency.

Relating back to self-determination theory, RAN training allowed opportunities for perceived competence, autonomy, and relatedness central to intrinsic motivation (Ryan & Deci, 2000b). Competence was nurtured through attainable fluency gains. Autonomy stemmed from self-monitored goal setting. Relatedness arose through personalized tutoring. Fulfilling these needs apparently catalyzed motivational changes which students internalized beyond the intervention window.

This study showcases practical promises for incorporating RAN training within a multi-tiered system of support to promote reading achievement among struggling readers with and without LD.

At Tier 1, RAN measures offer useful universal screening tools given their predictive utility even before formal reading instruction (Catts et al., 2017). Assessing RAN continuously enables early identification of students at-risk for dyslexia based on slow naming speed. Kindergarteners with sluggish RAN could receive supplemental small group naming speed practice to build foundational fluency.

Likewise, RAN training aligns well with Tier 2 targeted interventions for struggling readers. Older elementary students who stalled on reading fluency benchmarks would likely benefit from serial rapid naming practice integrated into their supplemental reading instruction. This study specifically displayed significant gains for students with LD already receiving Tier 2 interventions. Intensifying their programming with explicit RAN training accelerated their fluency development.

For students with LD, RAN training addresses a hallmark weakness and should be a featured component of individualized education programs. This study evidenced large fluency improvements stemming from 30 minutes of daily 1-on-1 RAN instruction. Special education teachers could readily implement similar training following the described sequential protocol emphasizing modeling, repetition, and performance feedback. Given substantial research validating RAN deficits among students with LD, addressing naming speed directly through specialized instruction is advisable (Araújo et al., 2011).

Beyond potential at all tiers, the motivational outcomes highlight the affective benefits of successful reading fluency interventions. Renewed intrinsic motivation fuels engagement, practice, and persistence essential for long-term reading growth. Training paradigms like RAN that impart tangible automaticity gains appear especially motivating. Capitalizing on fluency improvements to stimulate motivation supports the upward cycle whereby gains beget more gains.

Finally, the complete LD sample in this study was native Arabic speakers. Arabic poses literacy challenges stemming from diglossia and orthographic variations between Modern Standard Arabic used in formal writing and school versus spoken vernaculars (Abu-Rabia & Taha, 2006). RAN and reading fluency deficits likely interact with these linguistic factors. That RAN training still improved reading outcomes despite these added complications attests to its cross-linguistic utility for dyslexia and LD in non-English languages sharing similar phonological foundations as Arabic.

Some limitations should be weighed when interpreting findings from this initial investigation. First, the sample size was relatively small with only 32 participants. Replicating the RAN training with larger groups of students with LD would add confidence to conclusions. Longer intervention duration beyond 10 weeks may produce even greater gains. Additionally, the sample comprised a narrow age range of 5th graders. Testing effects for younger emergent readers or older middle schoolers would reveal whether impacts generalize across ages.

For motivation, findings were based entirely on self-report questionnaires prone to social desirability biases. Adding indirect motivational indexes like reading logs documenting voluntary practice time or behavioral measures of reading persistence would corroborate students' expressed motivation. Qualitative interviews could also capture motivation in students' own words.

Finally, while the 6-week follow-up provided initial maintenance data, longer term tracking of reading and motivational trajectories would better elucidate sustainability. Monitoring progress through the end of the school year and into the next grade would verify if gains persist and accumulate over time. Extending research through upper elementary school is warranted given reading difficulties in LD intensifying through grades 4-6 as curriculum demands increase (Lyon et al., 2001).

Conclusion

Results underscore RAN training as a promising approach for addressing the fluency deficits and motivational challenges prominent in LD. RAN interventions implemented early may prevent or minimize later reading difficulty by establishing strong foundational naming speed, fluency and motivation. For students already struggling, incorporating RAN training into supplemental and specialized instruction provides missing emphasis on serial rapid processing essential to skilled reading. Capitalizing on resulting fluency gains further stimulates intrinsic motivation for reading within a self-reinforcing upward cycle.

Fluency and motivation are intertwined determinants of reading proficiency for students with LD. RAN training offers a mechanism for jointly scaffolding growth in both domains. Findings from this study highlight the potential payoff of RAN fluency interventions for enabling students with LD to read faster, smoother, and with renewed interest. Renewed motivation then propels their ongoing reading development. By strategically leveraging RAN's capacity to conjointly strengthen skills and will, educators can help activate a motivational trajectory toward lifelong reading success for students with LD.

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This study was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. The study protocol was approved by the Research Ethics Committee of the Faculty of Education, Al-Azhar University, Egypt. The authors declare that they have no conflict of interest. Written informed consent was obtained from parents/guardians of all student participants. Students provided verbal assent to participate. The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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