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Do Cognitive and Non-Cognitive Factors Predict Responses to Reading Fluency Interventions?

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ABSTRACT

We investigated whether emotional and motivational factors had predictive effects beyond those of cognitive factors on responses to two reading fluency interventions. Eighty-two dysfluent readers (Grades 3–5) participated in a 12-week school-based fluency intervention, either combined with or without self-efficacy support. Response to the intervention was determined by the fluency gain score and the Reliable Change Index. In the skill-focused intervention, cognitive predictors contributed to the response, and reading-related anxiety and self-efficacy had effects beyond the cognitive predictors. Weaker initial reading skills and older age predicted response in the combined intervention. Thus, children's personal characteristics may have a greater influence on their responses in a skills-focused intervention than in an intervention that also considers emotional and motivational aspects.

KEYWORDS

Cognitive predictors; non-cognitive predictors; reading fluency intervention; response to intervention

In orthographically transparent languages, such as Finnish, Italian, or Spanish, the majority of children develop an accurate decoding skill during their first grade in school (Seymour et al., 2003), and reading fluency becomes a primary challenge around the second grade for those with delayed development. Accordingly, reading disability is mainly manifested as a problem in acquiring an efficient and fluent decoding skill (Aro & Wimmer, 2003). As reading fluency is subsequently needed for reading comprehension (Pikulski & Chard, 2005), effective interventions for children struggling to become fluent readers are of utmost importance.

Although reading fluency interventions have been shown as moderately effective at the group level (e.g., Maki & Hammerschmidt-Snidarich, 2022), there is considerable variability in participants' responses to interventions (e.g., Al Otaiba & Fuchs, 2006). Relatively little effort has been invested in understanding this variability, although a better understanding would help in developing effective interventions for a variety of students. Furthermore, existing studies on intervention responses have focused on cognitive predictors. For example, Fuchs et al. (2021) found that participants with weaker pretreatment phonological awareness showed stronger intervention effects. However, cognitive predictors have been found insufficient in explaining individual variations in responses to fluency interventions (e.g., Stuebing et al., 2015) and there has been an emerging recognition of the importance of the "non-cognitive" factors of school learning, such as motivation, emotions, and beliefs (Farrington et al., 2012). Still, there is a scarcity of intervention

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research targeting these factors as predictors of response to intervention. Thus, in this study, we studied whether emotional and motivational factors had effects—beyond the effects of cognitive factors—on children's responses to two reading fluency interventions. In a broad sense, reading fluency can be defined as the ability to read accurately and rapidly, with appropriate expression (Kuhn et al., 2010). In this study, we operationalized reading fluency as the ability to read accurately and with speed.

The present study is based on our earlier study reporting reading fluency and reading fluency related self-efficacy (SE) outcomes of elementary school children who participated in two partly different reading fluency interventions (Aro et al., 2018). The first intervention was a traditional reading fluency skill-training intervention including repeated reading in a group and individual computer-based training. The second intervention used a combined approach, embedding reading SE support (e.g., visualization and verbalization of progress, mastery experiences, verbal persuasions, and discussing emotions) in a similar reading fluency skill-training as the other group received. In this previous study, we examined the mean-level effects of the interventions using three reading fluency measures and one reading SE measure as indicators of the outcome (i.e., gain score indicating difference between pre- and post-intervention assessments). The results revealed that the two intervention groups had similar improvements in reading fluency in mean level which concords with findings of McBreen and Savage (2022) who found no significant differences in reading fluency between groups receiving either cognitive-only or cognitive plus motivational reading intervention. Furthermore, there were large variances of the gain scores and both groups had children demonstrating clinically reliable changes and those not showing such changes. These mean-level analyses did not provide understanding on factors contributing to intervention response, on the contrary, they indicated the need for closer inspection from the perspective of predictive factors. Thus, in the present study, we wanted to gain a more in-depth understanding of the participant-related factors assessed before the interventions influencing the variance in their responses in these two interventions.

As previous research on intervention response has targeted mainly cognitive factors, we wanted to understand the extent to which both reading-related cognitive predictive factors and reading-related emotional and motivational predictive factors explained the participants' responses; more specifically, we studied whether the emotional and motivational factors had effects beyond those of the cognitive ones. Based on the rationales explained in the following sections, we investigated the effects of phonological skills and rapid automatized naming (RAN) as cognitive factors and the effects of reading-related anxiety and reading-related self-efficacy as emotional and motivational factors using two operationalizations of the intervention response.

Cognitive predictors of response

The pre-intervention reading skill level has often been included as one of the predictors of responses to fluency interventions. In general, the predictive effects have been found to be rather small, with varying directions of the effects (for a meta-analysis, see Scholin & Burns, 2012). In some studies, the students with lower skill levels have benefited the most, whereas in others, the students with better skills or milder difficulties have gained the greatest advantages (Scholin & Burns, 2012).

The essential role of phonological processing skills in reading development has often been presented in English speaking languages (e.g., Snowling, 2001). Recent evidence from different orthographies (English, French, German, Dutch, and Greek) showed that especially RAN predicts reading fluency across orthographies (Landerl et al., 2019) corroborating earlier evidence and theorization (e.g., Wolf & Bowers, 1999; Kirby et al., 2010). Despite phonological skills and RAN are

suggested to be the core predictors of reading skill, their role in predicting response to intervention is less known.

Studies on responses to reading fluency interventions have shown both significant and non-significant effects associated with phonological skills and RAN. For example, among English-speaking children, phonological awareness was associated with improvement in fluency after an intervention including fluency training (e.g., Barth et al., 2010; Fuchs et al., 2021; Fletcher et al., 2011), while a variety of phonological processing skills did not predict Dutch children's responses to fluency intervention (Scheltinga et al., 2010). Similarly, other studies have shown that performance in RAN predicts responses to an intervention targeting reading fluency (Scheltinga et al., 2010) and to an intervention including fluency training as a component (e.g., Barth et al., 2010). However, not all intervention studies on reading fluency have found a significant predictive effect associated with RAN. Field et al. (2019) found that RAN did not have a significant predictive role in students' response to fluency intervention, particularly among those with significant fluency deficits. As phonological skills and RAN have been suggested to predict reading skill development, and their role in explaining intervention outcome is not clear, in this study, we included them (in addition to initial reading skills) to our analyses to obtain more evidence of their predictive roles in fluency intervention outcomes.

Emotional and motivational predictors of response

It has been known that anxiety symptoms are common among students with learning disabilities (meta-analysis: Nelson & Harwood, 2011), and accordingly, higher anxiety has also been shown to be associated with reading difficulties (Francis et al., 2019; Grills et al., 2022; Grills-Taquechel et al., 2013). Although majority of the studies have focus on other forms of anxiety than reading-related anxiety, some research has shown that anxiety more focally related to reading is also associated with reading achievement (Mohammadpur & Ghafournia, 2015) and that students with reading difficulties may experience anxiety specifically related to reading (Ramirez et al., 2019) or to academic situations (Elgendi et al., 2021). These findings may be due to anxiety's relations with poorer working memory performance (Moran, 2016) which may hamper learning. Based on the interference model (for test anxiety see Tobias, 1985) anxious students may experience interference with their concentration, memory functioning, and/or information processing leading to deficient learning. Beside anxiety, also self-beliefs, such as self-concept and SE, have been found to be associated with reading motivation and better reading fluency development (Nevo et al., 2020), but the association between reading self-concept and reading fluency has also been shown to be reciprocal (Quirk et al., 2009). Recent studies have shown that lower reading fluency related SE is associated with poorer word reading (Carroll & Fox, 2016) and with poorer reading fluency development (Peura et al., 2019). In the present study, our focus is on reading-related SE which is an element of reading motivation and assumed to influence on child's thoughts and feelings in the task situation and thereby on effort and persistence invested in the task, and finally on achievement (e.g., Schunk & Mullen, 2012). Thereby, it may also be a factor influencing response to intervention.

Despite the shown associations between reading skill and reading-related anxiety and SE, their relevance for intervention response is less well understood. Recently, Ronimus et al. (2020) found that high SE was associated with better reading fluency development after playing the GraphoGame program, and Vaughn et al. (2022) showed a moderating effect of students' reading anxiety on their reading fluency outcome after an intervention targeting multiple components of reading; higher anxiety was associated lower intervention effect. In contrast, Grills et al. (2014) reported that anxiety did not predict intervention response in an intervention study targeting several reading components. Due to the paucity of research, we lack knowledge on reading-related anxiety and reading-related SE as predictors of responses to fluency interventions.

Combined interventions

The growing awareness of the relevance of other than cognitive factors for reading development has resulted in an increase of studies combining such components with reading interventions. In these combined interventions, mostly motivation/self-belief (Lovett et al., 2021; McBreen & Savage, 2022; Toste et al., 2017, 2019; Zentall & Lee, 2012) or anxiety regulation (Francis et al., 2021; Vaughn et al., 2022) has been embedded in reading instruction. These studies have found positive effects on the non-cognitive aspects trained, such as anxiety, reading competence, and success attributions (e.g., Francis et al., 2021; Lovett et al., 2021; Toste et al., 2017) as well as on reading skills, primarily on comprehension (McBreen & Savage, 2022), but also on fluency (Lovett et al., 2021; Toste et al., 2017). For example, Toste et al. (2017) reported that after the intervention, the participants of the intervention including support for motivation were more likely than those in the business-as-usual group to attribute success to internal causes (e.g., effort) than to external causes (e.g., luck).

However, despite the above intervention studies having shown positive emotional and motivational mean-level effects of combined interventions, we lack knowledge on who benefit from combined intervention, what kind of individual pre-intervention characteristics explain response to combined intervention and to what extent the same characteristics predict response to solely skill-focused reading fluency intervention. Despite not being the main aim of the study, Vaughn et al. (2022) showed that initial reading anxiety moderated the reading fluency outcome of the intervention targeting both reading and anxiety but not that of the business-as-usual intervention (i.e., no researcher provided treatment). This finding suggests that different pre-intervention characteristics may influence the responses to combined interventions and to interventions comprising purely skill training.

Defining response to intervention and using continuous and dichotomic predictors

As it has been shown that various definitions of intervention response may result in different findings (e.g., Hughes & Dexter, 2011), both continuous and categorical operationalizations of response were used in the present study. First, by using a continuous reading fluency gain score (i.e., difference between pre- and post-intervention scores) as a measure of response to intervention, we searched for linear relations between the predictors and the responses across the whole distribution. This allowed the participants with the lowest performance levels to demonstrate growth, which could have been obfuscated by using a criterion and/or a norm-referenced cutoff score.

Second, we designated the participants as either responders or non-responders (cf. responder status) based on the Reliable Change Index (RCI; Jacobson & Truax, 1991), to provide information on the present sample instead of comparing participants to peers or normative samples. This allowed us to explore individual participants' likelihood of benefiting from the interventions and to map the characteristics that were prevalent among responders and non-responders (i.e., according to their responder status).

As previous studies have suggested, the association between cognitive precursors (i.e., RAN) and academic skill are not necessarily linear (Koponen et al., 2013) and that small to moderate amounts of anxiety can have a motivating role, while excessive amounts of anxiety can result in decreased skill development (see Grills-Taquechel et al., 2012), we wanted to study whether high reading-related anxiety or low reading-related SE, or low performance in RAN or in phonological test affected intervention outcomes. Therefore, beside using continuous pre-intervention predictive variables, we also predicted responses to the interventions with dichotomic variables. To do this, we first divided the participants based on their pre-intervention scores into those showing and those not showing a clear problem in the specific measure. We then studied the association

between their responder status and the presence of clear problems and between their responder status and accumulation of these clear problems.

Aim of the present study

The previous research findings indicate the potential of providing emotional and/or motivation support together with fluency training, thus backing the stance that combined intervention approaches constitute a significant second step when aiming to tackle the complex concerns related to reading difficulties (Grills et al., 2022). However, more research is needed, especially on whether emotional or motivation factors have predictive effects beyond those of the identified cognitive predictors of intervention outcomes and whether the same factors predict the responses to skill-focused and combined interventions. Thus, the aim of the present study was to analyze to what extent the participants' pre-intervention cognitive and emotion and motivation related characteristics explain variance in the responses to the two reading fluency interventions, one providing traditional skill-training (FLUENCY) and the other using a combined approach, embedding reading SE support in skill-training (FLUENCY + SE). Our research questions (RQs) were:

1. To what extent was the variance in the reading fluency gain score explained by pre-intervention phonological skills and RAN (a) FLUENCY-intervention and (b) FLUENCY + SE-intervention? Did the pre-intervention reading-related anxiety and reading-related SE have effects beyond those of the cognitive predictors in (a) FLUENCY-intervention and (b) FLUENCY + SE-intervention?
2. (a) Were cognitive or emotion and motivation related problems, that is, weak pre-intervention performance in the phonological test or in RAN or high scores in anxiety or low score in SE, associated with the responder status defined by RCI in the two intervention groups? (b) Was the accumulation of these problems associated with the responder status in the two intervention groups?

Method

Procedure and participants

This study was part of the Self-Efficacy and Learning Disabilities Intervention (SELDI) study focusing on reading and math fluency interventions in elementary schools. In this article, we report the analyses concerning reading interventions carried out in the school context, applying a quasi-experimental design. The 12-week intervention programs started in January 2014. The individual pre-intervention assessments of the cognitive skills were conducted from November to December after the participant screening and selection. The pre-intervention reading fluency and the reading-related anxiety and reading-related SE were assessed in January. The post-intervention reading fluency assessment was conducted in May. The Ethical Committee of the University of Jyväskylä has approved the study.

Participant recruitment

The data was collected in four municipalities in central and eastern Finland, where all interested teachers teaching mainstream students in Grades 2–5 were invited to join the study. In total, 20 schools from rural, suburban, or urban areas participated. These schools had 27 special education teachers. They invited the classroom teachers to participate in the study. Seventy-five classroom teachers joined, and they asked permission from their students' guardians to let the children participate in the study. Participation was voluntary, and informed consents were received from the guardians. Of the 20 participating schools, 14 were selected to provide either FLUENCY + SE-intervention or FLUENCY-intervention (7 schools each) for reading fluency in Grades 3–5; the

Table 1. Descriptive information of the sample.

	Group			
	FLUENCY		FLUENCY + SE	
n[a]	40–42		38–40	
Girls/Boys[b]	15/27		12/28	
Grade 3/4/5[c]	15/14/13		14/10/16	
	M	*SD*	*M*	*SD*
RCPM (raw score)	29.05	4.63	29.64	4.75
Lukilasse (stand. score)	3.90	1.83	4.61	1.76
RAN (z-score)	−.88	1.11	−1.53	1.45
Phonology (stand. score)	6.78	2.61	7.02	3.34
Anxiety (z-score)	.79	1.17	.17	1.06
SE (z-score)	−.78	1.17	−.54	1.03
	% (*n*)		% (*n*)	
Mother's education[b]				
Comprehensive school	7.9 (3)		11.1. (3)	
High school/vocat. school	57.9 (22)		48.1 (12)	
College/polytechnic/bachelor	34.2 (13)		40.7. (11)	
Master's degree	0 (0)		11.1 (3)	
Finnish as the main home-language[b]	92.3 (36)		88.9 (24)	
Diagnoses (e.g., asthma, migraine, DLD)[b]	2.6 (1)		11.1 (3)	

[a]Due to missing data (absence from school during the assessment) number of children varied.
[b]38–39 participants of the FLUENCY-group and 26–27 of the FLUENCY + SE-group had data on mother's education, home language, and diagnoses.
[c]Two children had missing data on gender. RCPM = Raven's Colored Progressive Matrices (Raven et al., 1990). Lukilasse = Lukilasse Reading subtest (Häyrinen et al., 1999) conducted prior to intervention. DLD = Developmental Language Disorder.

reaming six schools provided only math intervention. The two interventions were not provided in the same school to avoid "contamination." There were 3–5 students in each intervention group.

To select the participants, first, two time-limited group tests of reading fluency (Allu and Luksu tests; see below Measures) and an individually administered reading-aloud test (Text Reading Fluency, see below Measures) was administered. The latter was also used as a measure of the intervention response in this study. Second, all children who performed below the 20th percentile in the group-level tests were further assessed with an individually administered Lukilasse test (see below Measures) to verify the group-assessment results concerning reading problems. Thus, the final inclusion criterion for the intervention study was performance of < 7 at a scale-score in the Lukilasse test. The FLUENCY- and the FLUENCY + SE-groups were matched according to the Lukilasse test results. Altogether, 1,098 children (446 from Grade 3, 360 from Grade 4, and 292 from Grade 5) participated in the group assessments. The whole dataset was used to standardize the questionnaire's sum scores in this study.

Of the total number of participants (1,098), 1,016 were not assigned the interventions (52% male), 42 were assigned to the FLUENCY-intervention (64.3% male), and 40 were assigned the FLUENCY + SE-intervention (70% male). The median grade level was 4 in all groups (max 9). No differences between the groups emerged in the Raven's Colored Progressive Matrices test (Raven et al., 1990) administered in a group in the classroom. See Table 1 for the scores of the intervention groups; the scores of the reference group were $M = 30.70$ and *standard deviation* [*SD*] = 3.90. The demographic information about the intervention groups is also presented in Table 1.

Measures

Reading

Measures for participant selection. Two group-assessments tests (Allu and Luksu) and one individually administered test (Lukilasse) were used in the participant selection process. In Allu, the

children read silently and separate the words with a vertical line. According to the manual, the Allu test assesses word reading and has a high scale reliability (Cronbach's alpha = 0.97; Lindeman, 1998); it consists of words written in 2–4-word clusters, with no spaces between them (78 clusters in total). The Luksu test is a Finnish adaptation of the Woodcock-Johnson Reading Fluency Test (Woodcock et al., 2001) assessing sentence-level reading. It consists of 70 short and easy statements (e.g., "Strawberries are red."). Both the scale reliability and the split-half reliability have been reported to be to be good in the normative sample (Cronbach's alpha = 0.94 and split-half = 0.97; Eklund et al., 2013). In the present data ($n = 1{,}075$), the Allu and Luksu scores highly correlated, $r = 0.78$.

The Lukilasse test was used for verifying the group-assessment performances and to match the intervention groups. In the Lukilasse the children read aloud a list of words of increasing complexity and length. According to the manual and the normative data, the test has shown good scale reliability for all grades (Cronbach's alpha range = 0.94–0.98; Häyrinen et al., 1999). In the present data ($n = 81$), test-retest (pre- and post-intervention assessment) correlation was $r = 0.84$ (the test was done only for the intervention participants).

Measure of pre-intervention reading level and intervention gain. A reading-aloud text-reading test (Text Reading Fluency, Salmi et al., 2011) was administered individually in pre- and post-intervention assessments. In the test, each child reads aloud a 120-word text. The score is the number of correctly read words within 1.5 min. In the present data ($n = 81$), the text-reading score's correlation with the Lukilasse test was 0.87, and test-retest (pre- and post-intervention assessment) correlation was $r = 0.86$. The gain score used in this study was the discrepancy between the pre- and the post-intervention text-reading scores.

Cognitive and emotion and motivation related predictors

Rapid automatized naming (RAN). RAN was assessed with the alpha-numerical subtests of the Test of Rapid Serial Naming (Finnish version) (Ahonen et al., 1999). The mean of the times taken to name the letter and the digits was used as the score. For the Finnish version a good split-half reliability coefficient (0.80) has been reported (e.g., Torppa et al., 2017). As RAN is a time limited test, counting Cronbach's alpha separately either for letters or for digits is not meaningful. However, their correlation in the present data ($n = 81$) was 0.84 indicating good reliability.

Phonological skills. Two phonological processing tasks in the Phonological Awareness subtest of Nepsy-II (Korkman et al., 2007) were used. In the Word Segment Recognition task, the child is asked to identify words from word segments. The Phonological Segmentation is a test of elision. The child is asked to repeat a word and then to create a new word by omitting a syllable or a phoneme or by substituting one phoneme in a word with another. In the manual, the reliability coefficient has been reported to be very high (0.96; Korkman et al., 2008). As the items-level data was not available for the present sample, Cronbach's alpha could not be counted.

Reading-related anxiety. Reading-related anxiety was assessed with three statements on anxiety or tension arousal in situations involving reading: "I become anxious when I know I have to read aloud," "I become anxious when I start reading," and "I feel tension in my body when I have to read.". The items were adopted from a subscale initially designed for measuring affective and physical state sources of self-efficacy, which was based closely on the ideas of Usher and Pajares (2009; see Bandura, 1997). The factor structure of the reading anxiety measure has been shown to be satisfactory (high factor loadings) and the structure to be invariant across grade levels (see Peura et al., 2021). In this study we used a sum score of the three reading anxiety items. The instructions and the items were read aloud one by one to ensure that all children could answer

them, irrespective of the children's reading skills. The children rated their beliefs using a 7-point scale, ranging from "not true" (1) to "true" (7). Cronbach's alpha for the anxiety questionnaire was 0.84 in the whole available data of the present study.

Reading-related self-efficacy (SE). The group-administered questionnaire targeting reading SE was constructed on the basis of the guidelines outlined by Bandura (2006). The questionnaire was filled out by the children before the reading assessment. The instructions and questionnaire items were read aloud to ensure that every child could answer them, irrespective of the reading skill. Two practice items familiarized the children with the tasks and scales. The children rated the strength of their confidence using a 7-point scale, ranging from (1) "I'm totally certain I can't …" to (7) "I'm totally certain I can …". The questionnaire had 14 items; 3 of them covered SE related to developing better reading skills, 3 targeted daily reading activities requiring fluency, and 8 items measured children's confidence in specific reading fluency tasks (for details, see Aro et al., 2018). The mean of all items was used in the present study. Cronbach's alpha for the SE questionnaire was 0.91 in the whole available data of the present study.

Pre-interventions problems

Problems in pre-intervention measures. To analyze the associations between the intervention response (responder status defined by RCI, see below) and weak performances in pre-intervention cognitive tests or low/high scores (i.e., problems) in pre-intervention questionnaires, we designated the children as having problems versus not having them, separately for each of the predictive factors. Those participants whose score exceeded the set cutoff score used to indicate a weak performance or a low/high score were designated as having problems. For the cognitive factors, we utilized the score of 1 SD or more below the age-equivalent norm mean as the cutoff point—that is, a child was designated as having a problem if the standardized score was < 7. The problems in the reading-related anxiety and reading-related SE were defined based on the child belonging to the lowest (SE) or the highest (anxiety) 16th percentile using the grade-equivalent scores of the whole data as references. Similar cutoffs have previously been used in both cognitive tests (e.g., MoCA, see Borland et al., 2017) and in anxiety assessments (Vaughn et al., 2022).

Accumulation of clear problems. We also studied whether the accumulations of clear problems were associated with responder status and intervention grouping. The variable for the accumulation of problems was computed as a sum score of the individual dichotomous predictors (problem vs. no problem), separately for the cognitive and the emotion and motivation related problems and then for the total number of problems. As our sample size was small, we wanted to avoid extremely small groups. Therefore, to compute the total accumulation score, we merged the participants with a score of 0 or 1 in the lowest scoring group, while the participants with a score of 3 or 4 formed the highest scoring group.

The problems in the predictors were mainly equally common in the groups. However, 19 (47%) participants had high anxiety scores in the FLUENCY group. This was more than expected by chance as there were only eight such participants (21%) in the FLUENCY + SE group ($\chi^2(1) = 6.02$; $p = .014$, *Adj. Res.* $= 2.5$).

Definitions of intervention response

First, the intervention response was operationalized as a child's gain score in the text-reading task, that is, the difference between the pre- and the post-intervention text-reading scores. Second, the participants were designated as responders or non-responders based on their RCI scores (Jacobson & Truax, 1991) in the text-reading task. The RCI determines if a change in the text-reading score over the course of the intervention for each participant can be attributed to the

intervention rather than to chance or a measurement error at the probability level of $p < .05$, corresponding to the value of 1.96 standardized normal distribution. The SDs of both the FLUENCY and FLUENCY + SE groups were used for computing the SD applied to calculate the RCI. The RCI was used to classify the participants into those who did not show a reliable change ($|\text{RCI score}| \leq 1.96$; non-responders) and those who showed a reliable change ($|\text{RCI score}| > 1.96$; responders).

Interventions

The interventions lasted for 12 wk and were provided by the special education teachers (see Aro et al., 2018). They comprised 1 weekly group session (45 min) and 3 weekly computer-based individual practice sessions (10–15 min) with 2 individually adaptive computer programs that were alternated every second week: the GraphoGame fluency program (Richardson & Lyytinen, 2014) and the Reading Acceleration Program (Breznitz & Bloch, 2010; Snellings et al., 2009). The children participating in the interventions did not receive other reading support during the interventions.

The difference between the two interventions' group sessions was that the FLUENCY + SE-intervention included support for all four sources of SE defined by Bandura (1997): mastery experiences (e.g., positive, explicit, and concrete feedback on improvement, effort, and practice), verbal persuasion (e.g., teachers discussed the children's practice, effort, and improvement), vicarious experiences (e.g., encouragement to observe and share the improvements of the children's peers), and discussions of learning-related emotions and difficulties (e.g., encouragement to share observations on their emotions and practice).

The FLUENCY + SE-intervention included repeated reading with exercises, which allowed following improvements and providing feedback. Repeated reading was chosen as it is known to be effective (Hudson et al., 2020). The log data recorded by the computer programs were used for providing feedback on the students' development and amount of practice only in the FLUENCY + SE intervention group. The children also wrote down their mastery experiences during the computer training sessions (e.g., "I noticed when I succeeded.").

The FLUENCY-intervention group sessions focused solely on reading fluency training, with tasks including speeded and non-speeded reading and general and repeated reading. The computer-based practice sessions were equal for the groups. As the group intervention sessions were equally long in both intervention programs and the FLUENCY-intervention did not contain SE components, FLUENCY + SE-intervention group spent less time on fluency exercises than the FLUENCY-intervention group (see Aro et al., 2018).

The intervention providers participated in a 6-h training on the implementation of the programs. They were provided with detailed session-by-session manuals, including the intervention principles and theory on reading fluency, descriptions of each intervention session, the exercises to be carried out in each session, and the needed materials. The FLUENCY + SE-intervention manual additionally included the SE theory and the training, and the manual focused on ensuring intervention providers' understanding of the implementation of the elements intended to support SE. After the third intervention session, each teacher was called to confirm that the intervention manuals were followed and that the principles of the programs were well understood.

The fidelity to the implementation was ensured with the training, session-by-session manuals and materials, meetings of the intervention providers, and telephone conversations with the researchers. These were used to monitor adherence to protocols. Moreover, the teachers used individual checklists of the feedback given to each child regarding one's improvement, amount of work done, effort, and persistence during the practice. The Questionnaire on Students' Intervention Experiences (see Aro et al., 2018) was also used to check how their experiences corresponded to the supposed content. The FLUENCY-group and the FLUENCY + SE-group

differed in all scales concerning SE-specific content, indicating that the teachers had followed the manuals (for details, see Aro et al., 2018).

Statistical analyses

In RQ1, we predicted the gain score in text reading, with continuous pre-intervention cognitive and emotion and motivation related variables and controlled for grade and initial reading skill levels using hierarchical regression analyses. Separate models were built for the FLUENCY-group and the FLUENCY + SE-group. In both models, grade and pre-intervention text reading levels were entered in step 1 of the analyses, the phonology and RAN were added in step 2, and the reading-related anxiety and reading-related SE were added in step 3 to analyze whether they had predictive effects beyond those of the cognitive factors. In addition to the standardized regression coefficients and R^2 for each step, we report the semi-partial correlation (i.e., the correlation between the dependent variable and the unique effect of a predictor, independent from all the other predictors) as a variable-specific effect size. The size of the semi-partial correlation is interpreted according to Cohen's (1988) cutoffs: $r \geq 0.10$, $r \geq 0.30$, and $r \geq 0.50$ indicating weak, moderate, and strong associations, respectively.

We utilized cross-tabulation and the χ^2 test to scrutinize whether the responder status was related to problems in the cognitive and the emotion and motivation related predictors in the two intervention groups (RQ2a). Moreover, we examined whether the accumulation of problems was associated with the responder status in the intervention groups (RQ2b). Cramer's V is reported as an effect size.

Results

Preliminary analyses

The correlations between the predictive factors and the gain score in text reading varied between the intervention groups (Table 2). In the FLUENCY-group, initial reading, RAN, and phonology were positively correlated with the gain score, indicating that better pre-intervention performance was associated with more gain. In the FLUENCY + SE-group, initial reading and the gain score were negatively correlated. The correlations between the reading-related anxiety and reading-related SE and the gain score were small and non-significant, except for the correlation between the gain score and SE in the FLUENCY-group, indicating that higher SE was associated with higher gain. The correlations between the predictors were small, except for the correlation between the initial skill level and SE in both groups. We also counted the correlation between pre- and post-assessment text reading scores separately for the FLUENCY-group and the FLUENCY + SE-group, they were $r = 0.88$ and $r = 0.85$, correspondingly.

Table 2. Correlations between the gain-score, initial reading skill, and the predictive factors in two intervention groups.

	Gain	Initial Reading	RAN	Phonology	Anxiety	SE
Gain		.258	.266	.292	−.186	.332*
Initial Reading	−.232		−.024	.217	.167	.518***
RAN	.089	−.053		−.142	.017	.195
Phonology	−.217	.302	−.007		.090	.042
Anxiety	.036	−.190	.309	−.066		−.212
SE	−.003	.433**	.246	.041	−.100	

Note. Correlations of the FLUENCY-group are right and above the diagonal and the correlations of the FLUENCY + SE-group are left and below the diagonal.

Predictors of the reading fluency gain score

The results of hierarchical regression analyses on the predictors of the text reading gain score are shown in Table 3. The predictors explained 45.3% of the variance in the gain score for the FLUENCY-group, and the final model was statistically significant ($F(6; 34) = 3.862$; $p = .006$). The first step, with the initial reading skills and grade, made a statistically significant contribution to R^2, explaining 21.1% of the variance in the gain score. The second step, with phonology and RAN, increased R^2 by 11.6%, but the contribution was only marginally significant ($F(2; 30) = 2.589$; $p = .092$). Similarly, the last step, with the reading-related anxiety and reading-related SE, increased R^2 with 12.5% beyond the variance explained by the previous steps, which was marginally significant ($F(2; 28) = 3.190$; $p = .057$).

In the final model, initial reading skills and phonology had significant effects, and the semi-partial correlations were moderate, indicating the unique variances explained by the total gain score. Better initial reading skills and better initial phonology predicted a better response to FLUENCY-intervention. Although anxiety only had a marginally significant effect in the final model, it suggests that in the FLUENCY-group, those with more reading-related anxiety benefited somewhat less from the intervention.

In the FLUENCY + SE-group, the predictors explained 20.1% of the variance in the text reading gain score (Table 3). Despite the rather high R^2, the final model was not statistically significant ($F(6; 34) = 1.171$; $p = .350$). The step-by-step examinations revealed the reason. The first step, with the initial reading skills and grade, made a statistically significant contribution ($F(2; 32) = 3.427$; $p = .045$), explaining 17.6% of the gain-score variance. The effect of initial reading skills made a significant contribution to R^2, but the effect was opposite to that in the FLUENCY-group, indicating that lower initial skills were associated with a greater gain in the FLUENCY + SE-group. In steps 2 and 3, none of the added factors predicted the gain, and their contributions to R^2 were also minor (1.3% and 1.1%, respectively). The contribution of initial reading skills was no more significant, perhaps due to the correlation between initial reading skills and phonology in the FLUENCY + SE-group (see Table 2). Although the effect of initial

Table 3. Standardized estimates, standard errors, and semi-partial correlations of hierarchical regression analyses predicting reading fluency gain-scores with grade, initial reading, RAN, phonology, anxiety, and self-efficacy.

FLUENCY-group		*B* (*SE*)	β	r_{sp}	*p* value
Step1	Grade	−.20 (1.81)	−.20	−.19	.228
	Initial Reading	.40 (1.90)	.48	.46	.006
Step 2	Grade	−.06 (1.95)	−.06	−.05	.747
	Initial Reading	.37 (2.00)	.37	.32	.040
	RAN	.10 (1.95)	.10	.09	.564
	Phonology	.36 (1.56)	.36	.34	.031
Step 3	Grade	−.08 (1.86)	−.08	−.06	.655
	Initial Reading	.42 (2.27)	.42	.30	.043
	RAN	−.01 (1.90)	−.01	−.01	.941
	Phonology	.39 (1.46)	.39	.36	.015
	Anxiety	.32 (1.56)	−.32	−.27	.063
	Self-efficacy	.13 (1.61)	.13	.10	.493
FLUENCY + SE-group		*B* (*SE*)	β	r_{sp}	*p* value
Step1	Grade	.39 (2.00)	.39	.36	.031
	Initial Reading	−.34 (1.58)	−.34	−.32	.053
Step 2	Grade	.39 (2.15)	.39	.35	.044
	Initial Reading	−.31 (1.78)	−.31	−.27	.115
	RAN	.11 (1.50)	.11	.11	.520
	Phonology	−.06 (1.56)	−.06	−.05	.746
Step 3	Grade	.42 (2.32)	.42	.35	.046
	Initial Reading	−.37 (2.15)	−.37	−.27	.124
	RAN	−14 (1.72)	.14	.12	.486
	Phonology	−.06 (1.62)	−.06	−.05	.770
	Anxiety	−.11 (2.01)	−.11	−.10	.579
	Self-efficacy	.04 (2.11)	.04	.04	.837

reading skills was not significant for the FLUENCY + SE-group, the semi-partial correlations were rather similar in both groups but in the opposite direction. Grade made a statistically significant contribution in the FLUENCY + SE-group in all steps, showing that a higher grade level was related to larger gain in text reading.

Problems, problem accumulations, and responder status

In RQ2, we examined the association of the problems in phonology and RAN and in reading-related anxiety and reading-related SE and the responder status. Table 4 shows the number of participants with or without problems being designated as responders or non-responders in the intervention groups. The percentages of responders and non-responders were similar in the two intervention groups. The gain in the responder and the non-responder groups differed supporting the grouping. The mean of the text reading gain score for the responders was 16.93 ($SD = 4.82$; FLUENCY-group: $M = 17.40$, $SD = 5.55$; FLUENCY + SE-group: $M = 16.37$, $SD = 3.89$). For the non-responders, the mean was 2.07, which is clearly lower ($SD = 6.43$; FLUENCY-group: $M = 3.15$, $SD = 4.79$; FLUENCY + SE-group: $M = 1.08$, $SD = 7.61$).

In the FLUENCY-group, two statistically significant associations were found between responder status and problems in the predictors. Those with problems in either phonology or SE were more likely to belong to the non-responder group than to the responder group. In contrast, the responders more likely had no problems in phonology and/or SE.

Regarding the accumulation of cognitive problems, a statistically significant association was found between responder status and number of cognitive problems in the FLUENCY-group. The residuals revealed that the participants without problems in their cognitive performances were more likely responders, whereas those showing one problem were less likely to be responders (Table 4). No such effect was found in the FLUENCY + SE-group. Similar trend and effect sizes were found for the accumulation of anxiety and SE problems in the FLUENCY-group, but the χ^2-test result was only marginally significant. The participants with two problems were less likely to be responders. In the FLUENCY + SE-group, the non-responders did not differ in the number of problems in the reading-related anxiety and reading-related SE.

Finally, the results for the total sum of problems showed a statistically significant association only in the FLUENCY-group. In this group, the participants with a total sum ≤ 1 were more likely responders, while those whose total sum was 2 were more likely to be non-responders. As shown in Figure 1, the mean numbers of problems in cognitive, emotion and motivation related predictors, and in both types of predictors were higher among the non-responders than the responders in the FLUENCY-group, but no such difference was observed in the FLUENCY + SE-group.

Discussion

We aimed to understand the participant-related factors contributing to elementary students' responses to reading fluency interventions. We analyzed both cognitive and emotion and motivation related predictive factors associated with the responses in two interventions, one targeting solely reading fluency (FLUENCY) and the other combining fluency training with SE support (FLUENCY + SE) using both continuous and categorical operationalizations of the intervention response. More specifically, we first studied whether the reading-related anxiety and reading-related SE had effects beyond those of the phonological skills and RAN and the control variables (initial reading skills and grade), and then analyzed whether clear pre-intervention problems or the number of these problems were associated with the responder status.

Table 4. Crosstabulation and number of participants with and without problems as designated to responder and non-responder groups in the two intervention groups.

	FLUENCY $n = 40–42$				FLUENCY + SE $n = 38–40$						
	No Problems		Problems		No Problems		Problems				
Predictor	Resp. *n* (%)	Non-Resp. *n* (%)	Resp. *n* (%)	Non-Resp. n (%)	Resp. *n* (%)	Non-Resp. *n* (%)	Resp. *n* (%)	Non-Resp. *n* (%)	$\chi^2(1)$/Cramer V	sig.	Adj. Res.
Phonology	15 (58)[a]	11(42)	4 (27)	11 (73)[a]	6 (30)	14 (70)	10 (50)	10 (50)	3.68/.300	.055	1.9[a]
RAN	13 (54)	11 (46)	6 (35)	11 (65)	9 (45)	11 (55)	7 (35)	13 (65)			
Anxiety	12 (57)	9 (43)	7 (37)	12 (63)	12 (40)	18 (60)	3 (37)	5 (63)			
SE	15 (62)[a]	9 (38)	4 (25)	12 (75)[a]	9 (38)	15 (62)	6 (40)	9 (60)	5.41/.368	.022	2.3[a]
Accumulation of Problems	Responders $n = 19$ (46%) *n* (%)		Non-Responders $n = 22$ (54%) *n* (%)		Responders $n = 16$ (40%) *n* (%)		Non-Responders $n = 24$ (60%) *n* (%)		$\chi^2(2)$/Cramer V	sig.	Adj. Res.
Phonology & RAN									6.95/.41	.031	
0 prob.	11 (73)[a]		4 (27)[a]		4 (44)		5 (56)			2.6[a]	
1 prob.	6 (30)[a]		14 (70)[a]		7 (32)		15 (68)			−2.0[a]	
2 prob.	2 (33)		4 (67)		5 (56)		4 (44)				
Anxiety & SE									5.45/.37	.066	
0 prob.	10 (63)		6 (37)		7 (39)		11 (61)				
1 prob.	7 (54)		6 (46)		7 (37)		12 (63)				
2 prob.	2 (18)[a]		9 (82)[a]		1 (50)		1 (50)			−2.3[a]	
Total									8.90/.47	.012	
0–1 prob.	14 (70)[a]		6 (30)[a]		8 (38)		13 (62)			3.0[a]	
2 prob.	2 (20)[a]		8 (80)[a]		5 (42)		7 (58)			−1.9[a]	
3–4 prob.	3 (27)		8 (73)		3 (43)		4 (57)				

Note. Non-Resp. = Children with no reliable change; Resp. = Children with reliable change: Prob. = Problems in pre-intervention measures.

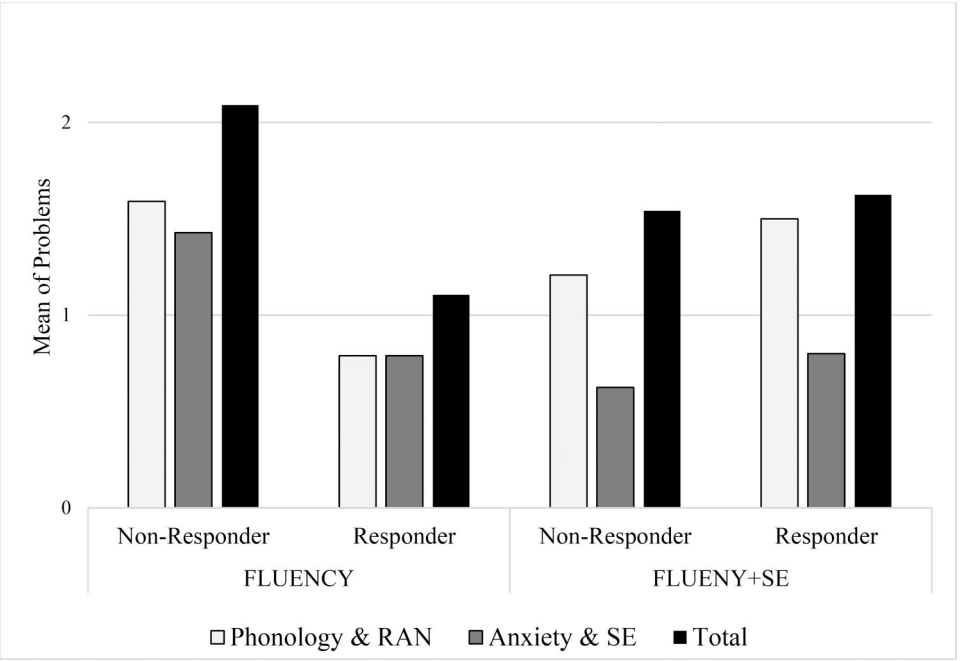

Figure 1. Mean of problems in phonology and/or RAN, in anxiety and/or SE, and total problems in the non-responder and responder groups in the two intervention groups.

Factors associated with the gains score

Our first main finding was that the pre-intervention predictors jointly explained a greater variance in the text-reading gain score (45%) of the FLUENCY-group than that of the FLUENCY + SE-group (20%). Although the contributions were only marginally significant, both the phonology and RAN as well as the reading-related anxiety and SE contributed considerably more to the gain score (both around 12%) in the FLUENCY-group compared to the FLUENCY + SE-group (both around 1%). This suggests that the cognitive predictors only contribute to the response in the FLUENCY-group; similarly, the reading-related anxiety and SE have effects beyond the variance explained by the cognitive predictors only in the FLUENCY-group.

A more detailed examination of the results showed that the pre-intervention reading had an opposite effect on the responses in the two intervention groups and that phonological skills contributed to the gain only in the FLUENCY-intervention. Specifically, weak initial reading skills and lower phonology scores predicted a minor response in the FLUENCY-group. This implies that children with weaker basic skills do not benefit from an intervention targeting solely their skills. Furthermore, grade contributed to the gain only in the FLUENCY + SE-intervention, which, together with the contribution of the poor initial reading skills, indicated that the older the children and the poorer their initial reading skills, the greater their gain. It can be tentatively surmised that students who continued to struggle with reading fluency over a long time benefited from an intervention that also targeted their emotions and self-beliefs. This finding needs to be verified with other samples since previous studies on combined interventions have not analyzed the effects of grade (Lovett et al., 2021; McBreen & Savage, 2022; Toste et al., 2017; Vaughn et al., 2022) and previous research on fluency interventions has not found grade effects nor observed that early intervention is effective (Maki & Hammerschmidt-Snidarich, 2022).

Reading anxiety slightly contributed to the gain in the FLUENCY-group. Furthermore, although there was no significant contribution to the variance in the reading fluency gain score,

the correlations indicated that reading-related SE was also associated with the gain in the FLUENCY-group only. This further suggests that in addition to the children's cognitive characteristics, their reading-related anxiety and SE may contribute to their responses differently, depending on the content of the intervention, highlighting the need for further research on emotional and motivational factors and different types of interventions.

It should be noted that despite the rather high variance explained by the predictors in the FLUENCY-group, much of the variance remained unexplained. Our tentative results urge for more research that aims to understand the contributions of cognitive and emotions and motivation to intervention outcomes. Ideally, in future research, in addition to these factors, also environmental and interactional factors (see Bazen et al., 2023), as well as participants' engagement and involvement in activity, should be considered in the design. However, such a study requires a much larger sample than the present one.

Pre-intervention problems and the response status

Our second main finding was that problems in the predictors, especially poor phonology skills and low SE, were associated with belonging to the non-responders in the FLUENCY-group. This was not the case in the FLUENCY + SE-group. The effects of cognitive and emotion and motivation related problems accumulated, so that having several problems in pre-intervention measures increased the probability of being a non-responder only in the FLUENCY-group. In the FLUENCY + SE-group, these problems were equally common among the responders and the non-responders. Thus, corresponding to the first main finding, this suggests that having clear problems in pre-intervention measures is associated with not showing response to an intervention targeting solely reading fluency. In the FLUENCY + SE-intervention, the students received encouraging and concrete feedback and emotional support. It might be that such support helped them better overcome both cognitive and emotion/motivation-related barriers.

The findings obtained using a categorical operationalization of the intervention response are in line with those obtained using a continuous gain score as an indication of the response. Hughes and Dexter (2011) have cautioned researchers that different definitions of intervention response may result in various findings and conclusions. In the present study, both continuous and categorical approaches indicated that pre-intervention characteristics were associated with the response to the skill-focused intervention. However, although the use of cutoff score is always arbitrary to some extent, if we had used solely the continuous approach, we would not have detected the finding suggesting the association between the accumulation of rather clear problems and the weaker response to the skill-focused intervention.

Limitations

We recognize that these results are preliminary, and that further research is needed to substantiate them with larger samples, enabling a larger statistical power. Although our sample accurately mirrors characteristics of the Finnish school-aged population with difficulties in gaining fluent reading skill, to achieve better statistical generalization, future studies using larger as well as culturally and orthographically diverse samples are needed. Not using a randomized controlled design can be perceived as a limitation, although our choice of a quasi-experimental design was driven by our aim to achieve high ecological validity, with interventions provided as part of the school routines. Thus, our justifiable claim that these findings are generalizable to the everyday school context and special educational practices in Finland can be regarded as a strength, even if the requirements of an ideal intervention design were not met. Being unable to match the groups in terms of the predictive variables also hindered our interpretation of some findings, such as the influence of reading-related anxiety. To verify that the response to skill-focused training is more

sensitive to participants' emotional characteristics compared to an intervention combined with emotional/SE support, future studies that will also match participants according to other than reading-related factors are needed.

Conclusions

Despite the shortcomings, some conclusions can be drawn for both future research and pedagogical practices. Based on the result indicating that the overall variance in the responses explained by the predictors was larger in the intervention targeting solely reading fluency, it can be cautiously concluded that in such an intervention, children's personal characteristics may have a greater impact on their responses than in an intervention that also considers their emotions and motivation-related beliefs. However, more research is needed to corroborate the finding. Furthermore, it can be concluded—with caution—that in a skill-focused intervention, high anxiety and low SE are relevant predictors of the intervention response. However, non-linear associations require further research, but it is plausible that some factors may become relevant only when clear problems occur, that is, after a certain threshold is met, preventing, or precluding, learning.

Our findings have two main implications. First, research should not ignore the significance of emotions and motivational factors for the intervention response; thus, they deserve explicit attention in intervention research on reading fluency problems. Second, the pedagogical implications of our findings are that children with several cognitive and possible emotional and motivational problems should be offered an intervention that (in addition to targeting reading skills) considers their emotions and motivation-related beliefs, for instance, by giving them systematic feedback and encouragement, as well as recognizing the emotions and beliefs related to learning difficulties and practicing the exercises to hone the required skills.

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