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ORIGINAL PAPER

Between the Lines: Integrating the Science of Reading and the Science of Behavior to Improve Reading Outcomes for Australian Children

Karina L. Stocker[1] · **Russell A. Fox**[1] · **Nathaniel R. Swain**[2] · **Erin S. Leif**[1]

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Abstract

Many Australian students fail to meet an acceptable standard of reading proficiency. This can negatively impact their academic progress, social, and emotional well-being, and increase their risk of developing challenging behaviors. These risks and challenges have been found to compound over the lifetime of the learner. Unfortunately, the proportion of Australian students who fail to meet reading proficiency standards increases as they move through their years of schooling, and reading difficulties disproportionately affect historically marginalized groups. This has raised concerns about the effectiveness of instructional approaches used within the Australian education system, particularly in reading, and prompted discussions of reform. The purpose of this review paper was to examine the contributions of the science of reading *and* science of behavior to our collective knowledge regarding reading development and effective reading instruction, and how this knowledge is currently being used in the Australian context. We provide a discussion on the current state of reading instruction and achievement in Australia by considering national trends, inequities, and systemic challenges. Implications and recommendations to address inequities in reading outcomes, using both the science of reading *and* science of behavior, are discussed.

Keywords Science of reading · Behavior science · Evidence-based instructional practices · Multi-tiered systems of support

Learning to read is a vital skill for a successful life in a contemporary, information-based society (Benton & Noyelle, 1992) and is, arguably, the most important goal

✉ Karina L. Stocker
Karina.Stocker@monash.edu

[1] Faculty of Education, Monash University, 19 Ancora Imparo Way, Clayton, Melbourne, VIC 3800, Australia

[2] Faculty of Education, La Trobe University, Melbourne, Australia

of education (Lemov et al., 2016). It is crucial that children become skilled readers early in their educational journey, so they can access and critique new knowledge and build academic success across the curriculum, paving the way for future employment, economic and social success (Graham et al., 2020). In contrast, deficits in reading skills can negatively impact a student's academic progress (Snow, 2016), their social and emotional wellbeing (Francis et al., 2019), and increase their risk of developing challenging behavior (McIntosh et al., 2012). The detrimental effects of reading difficulties can continue into adulthood, with research linking deficits in reading ability to an increased risk of mental health issues (Eloranta et al., 2019), greater likelihood of unemployment (Aro et al., 2019), and increased contact with the justice system (Snow, 2019).

Although reading is one of the most researched areas of human cognition (Rayner et al., 2001; Snow, 2020a), it has been suggested that approximately 30% of Australian school children experience difficulties learning to read (Hempenstall, 2013), and 47% of Australian adults do not have the necessary literacy skills to participate successfully in modern society (Australian Council for Educational Research [ACER], 2013). These figures should be a cause for concern for Australian school systems, especially since, when provided with effective evidence-based reading instruction and early intervention, 95% of children can successfully learn to read (Al Otaiba et al., 2014; Mathes et al., 2005; Torgesen, 2004). However, there currently appears to be a significant "research to practice gap" with respect to the provision of evidence-based reading instruction and intervention in Australian schools (Elliott et al., 2022; Snow, 2020a). Considering the negative life outcomes associated with poor reading skills, ensuring all Australian students have access to effective evidence-based reading instruction and timely intervention at school is a pressing concern.

It has been suggested that children in Australia currently experience marked educational inequities with respect to reading outcomes, and there is ongoing debate about the best available methods for teaching reading to Australian children (Chamberlain & Medina, 2020; Cobbold, 2022). However, research findings from multiple disciplines including cognitive science, neuroscience, behavior science, education, and speech and language pathology provide helpful insights into how to best support all children to become confident and competent readers. Collectively, the application of these findings in the service of effective reading instruction is commonly referred to as the *science of reading*. As with many other scientific disciplines, the science of behavior has made a meaningful contribution to the overall development of the science of reading (see Brosnan et al., 2018; Goldstein, 1983; LaFrance & Tarbox, 2020; Kelley et al., 2015; Lambe et al., 2015; Newsome et al., 2014; Spencer & Peterson, 2020). Despite this, both reading and behavioral scientists may be unaware of the contributions, strengths, methods, and broader findings of their fellow travelers on the reading instructional journey.

The overall purpose of this discussion paper is to identify and describe the contributions of the science of behavior to evidence-based approaches to reading instruction as part of the broader sciences of reading. This is not to simply claim credit for such contributions. Rather, we believe that an exploration of the integration of the science of reading and the science of behavior has the potential to enhance cross-disciplinary knowledge and collaboration (Kirby et al., 2022). Given the

scope and scale of the challenge of improving reading outcomes in the Australian context, practitioners and students alike may benefit from a deeper, more explicit understanding of the existing integration of the science of reading and science of behavior (Kirby et al., 2022). The identification of specific points of integration may also support cross-disciplinary conversations about the practices, research evidence, research methods, and approaches to systems change that are required to improve reading instruction at a scale of social significance.

To achieve the overall purpose, we first discuss current trends related to reading outcomes for students in Australia, which we believe are cause for significant concern. We describe data suggesting that children from historically marginalized groups, including Indigenous students and students from socio-economically disadvantaged backgrounds, may be most at risk for experiencing poorer reading outcomes. We also discuss some of the policies and systemic structures that contribute to disproportionate literacy outcomes for historically marginalized Australian students. Second, we describe how principles and practices derived from both the science of reading and science of behavior have contributed to our collective understanding of reading development and best practice for reading instruction. Finally, we conclude with evidence-informed recommendations for further integrating the science of reading *and* science of behavior to improve reading instruction in Australia, with an emphasis on ways to promote more equitable educational outcomes for *all* Australian children.

Reading Achievement in Australia: National Trends and Cause for Concern

Declining Reading Performance

Despite two decades of policy initiatives and record government funding aimed at improving the reading outcomes of Australian students (Chamberlain & Medina, 2020), data from international and national literacy assessments indicate that many Australian students fail to meet an acceptable standard of reading proficiency (Australian Curriculum and Assessment and Reporting Authority [ACARA], 2023; Thomson et al., 2019). According to the recent Australian Government Productivity Commission (AGPC, 2023) report, the proportion of Australian students that failed to meet reading proficiency standards increased as they moved through their years of schooling. This concerning trend is reflected in 15 years of data from Australia's National Assessment Program - Literacy and Numeracy (NAPLAN; ACARA, 2023), a yearly standardized test conducted in Australian schools to assess the literacy and numeracy skills of students in Years 3, 5, 7, and 9. In 2022, data collected via NAPLAN showed that the proportion of students "at or below" the minimum standard in reading, writing, spelling, grammar, and punctuation increased with each year level tested. For instance, in 2022, approximately 11% of Year 3 students were recorded as "at or below" the minimum standard for reading. However, this percentage increased to 15.4% in Year 7, and around 24% in Year 9 (ACARA, 2023).

Similar trends in reading performance can be seen when looking at data collected via the Organisation for Economic Co-operation and Development's Programme for International Student Assessment (PISA), as well as when looking at Progress in International Reading Literacy Study (PIRLS) assessment data. While the latest PISA results showed that Australian children were performing better than most countries in reading, mathematics, and science, the past 20 years have seen a steady decline in Australia's relative performance in literacy (Thomson et al., 2019). For example, Australia's international rankings on the PISA reading outcomes dropped from fourth position (when the tests were first administered in 2000) to 13th position in 2018. Our nation's absolute reading performance has also declined, with 15-year-old students in 2018 reporting average reading scores almost a year behind their same aged Australian peers who were assessed in 2000 (Thomson et al., 2019). Australian students' reading performance has weakened over this period, with over 40% of 15-year-olds performing below the national minimum standard, compared to less than 35% below the minimum standard in 2006 (Thomson et al., 2019).

The performance of Australian students as measured by the 2016 PIRLS is not as stark, with 19% "at or below" the international benchmark in 2016 (ACER, 2017, as cited in AGPC, 2023). Data collected via PIRLS suggest that Australia's performance is in the middle of the range compared to other participating countries (e.g., England, United States, Denmark, Ireland, Canada) with the average achievement sitting below the intermediate mark. However, this result did not improve between 2011 and 2016, during which time there was record investment in Australian educational funding to improve educational outcomes for all students (AGPC, 2023). Taken together, PIRLS and PISA metrics suggest that the academic reading performance of Australian students may decline between Year 4 and Year 10. This common trend of declining reading performance has raised concerns about the effectiveness of reading instruction across all Australian education systems (AGPC, 2023), and has prompted discussions about the need for a more targeted approach to support those students failing to make sufficient reading progress.

Widening Reading Achievement Gaps

Significant inequity is also evident when it comes to reading achievement within and across Australian schools, with students from different equity groups faring worse on literacy-based assessments. Concerningly, Australia's most recent Productivity Commission Report (2023) found that the reading achievement gaps in Australian schools disproportionately affected students from historically marginalized groups, with achievement gaps noted for learners according to their socio-economic status, Indigenous status, and their state/territory of residence (AGPC, 2023). These achievement gaps between students are noted to be among some of the widest in the world (Organisation for Economic Co-operation and Development, 2019) and suggest that Australia's most vulnerable children are not receiving the support they need. For instance, the 2018 PISA data revealed a 1.5-year gap in reading performance between the highest performing jurisdiction, the Australian Capital Territory, and the lowest performing, Tasmania (Thomson et al., 2019). This same PISA

data also revealed a 2.75-year gap in literacy achievement between the highest and lowest socio-economic quartiles, and a 2.3-year gap between Indigenous and non-Indigenous students (Thomson et al., 2019). Gaps in reading achievement between Indigenous and non-Indigenous students are also reflected in the 2016 PIRLS report (Thomson et al., 2017) and in 15 years of Australian NAPLAN data (ACARA, 2023). In fact, the 2022 NAPLAN figures show that Indigenous students are consistently over-represented in the proportion of children "at or below" the minimum standard for reading in Year 3 (36% of Indigenous students vs. 9.4% of non-Indigenous students), Year 5 (38% vs. 9.2%), Year 7 (45% vs. 13%), and Year 9 (55% vs. 17%; ACARA, 2023). However, it should be noted that current literacy assessments may not be appropriate for measuring the literacy skills of remote and multilingual Aboriginal students (see Freeman et al., 2023). Collectively, these statistics highlight the significant disparities in literacy outcomes between different groups of Australian students and reinforce the need for educational reform to address persistent equity issues and improve literacy outcomes for all Australian students.

Why Do Many Australian Students Struggle to Learn to Read?

Inadequate Reading Instruction in Schools

In 2005, the Australian National Inquiry into the Teaching of Literacy recommended that reading instruction be "grounded in findings from rigorous evidence-based research" (Rowe, 2005, p. 121). Unfortunately, almost two decades on, these recommendations have yet to be successfully translated into Australian education systems. This is evident in the continued and widespread use of Whole Language, and its descendant, Balanced Literacy, approach to reading instruction in Australian schools (Graham et al., 2020; Snow, 2020b), an approach still largely supported by the Australian Literacy Educators' Association (Graham et al., 2020). Whole Language advocates assert that learning to read is as natural as learning to speak, and if you immerse children in written language, they will intuitively acquire these skills (Gough, 1996; Snow, 2016). As a result, Whole Language reading instruction does not emphasize the explicit and systematic teaching of phonological knowledge as it relates to decoding written words, or the explicit and systematic teaching of language comprehension. Instead, the teaching of semantic, syntactic or picture cues when attempting to "read" unfamiliar words is encouraged (Snow, 2020b), and emphasis is placed on children "discovering meaning" through exposure to literacy rich environments (Castles et al., 2018). The Whole Language approach usually necessitates that children memorize banks of sight words and includes a more incidental, analytical approach to teaching phonics (Snow, 2020b). In fact, decoding is "...considered potentially harmful, to be used only as a last resort" (Hempenstall, 2005, p. 24). Considering the empirical evidence regarding the benefits of systematic explicit instruction in phonics and language comprehension, it was not surprising that the National Inquiry into the Teaching of Literacy found that practices inherent

in Whole Language can negatively impact on a child's literacy development (Rowe, 2005) and are "not in the best interests of children, particularly those experiencing reading difficulties" (p. 12).

Alongside these dominant ineffective practices in Australian classrooms is the concern that many Australian teachers have not been sufficiently prepared with knowledge of evidence-based reading instruction (Buckingham & Meeks, 2019; McLean, et al. 2021). This lack of knowledge may impact on a teacher's ability to effectively teach reading and to accurately identify the need for targeted intervention in subcomponent reading skills (Graham et al., 2020; Hammond, 2015; Tetley & Jones, 2014). As such, this gap in knowledge has been termed the "Peter Effect"; a biblical reference meaning "one cannot give what one does not have" (Snow, 2016, p. 223). It has therefore been suggested that a significant proportion of students who fail to make sufficient reading progress in Australian classrooms, are, in fact, *instructional casualties* (Hempenstall, 2013), meaning that reading difficulties could have been avoided had these students received adequate and effective reading instruction.

Inadequate Pre-Service Teacher Education

To help bridge the research to practice gap and build the capacity of teachers, the National Inquiry into the Teaching of Literacy recommended that pre-service teachers be adequately prepared to deliver evidence-based reading instruction and intervention (Rowe, 2005). However, evidence suggests that this recommendation has yet to be translated into initial teacher education courses (NSW Board of Studies Teaching and Educational Standards, 2014; Teacher Education Ministerial Advisory Group, 2014). For instance, a recent national audit of 116 initial teacher education literacy units found that none mentioned the Simple View of Reading as a theoretical foundation to effective reading instruction (Buckingham & Meeks, 2019; Gough & Tunmer, 1986). In fact, only 6% of the literacy units included all five practices recommended by the NITL, and 70% failed to mention any of these practices in their unit outlines (Buckingham & Meeks, 2019). According to Buckingham and Meeks (2019), none of the six most frequently prescribed textbooks in Australian initial teacher education literacy units "contained sufficiently accurate and detailed content that would allow graduate teachers to use effective, evidence-based instruction, and many contained information that was inadequate and/or misleading" (p. vi). Indeed, a recent study by McLean et al. (2021) found that teachers overwhelmingly reported dissatisfaction with their pre-service teacher education courses and the "limited or non-existent focus on evidence-based reading instruction" (p. 11). This lack of effective pre-service teacher training in evidence-based reading instruction leaves the building of teacher capacity in the hands of schools, where knowledge, skills, and resources to achieve this are limited (Hempenstall, 2012). Without system wide changes to the way initial teacher education courses teach reading instruction, Australian schools will continue to face the insurmountable task of retraining their teachers while they are already in the workforce.

Inadequate Access to Effective Early Intervention

The early provision of evidence-based reading intervention is crucial for the prevention of reading failure in schools (Rowe, 2005; Volkmer et al., 2019). However, in Australia, many children miss out on accessing early reading intervention due to resourcing constraints (Serry & Oberklaid, 2015), and schools' failure to systematically screen and identify reading difficulties in the early years (Graham et al., 2020). According to Graham et al. (2020), Australian teachers' ability to identify reading difficulties varies, with most teachers highlighting behavioral concerns (e.g., off-task or disruptive classroom behaviors) before reading difficulties. However, it is well established that students with poor reading skills are more likely to present with anxiety, depression, and challenging externalizing behaviors (Arnold et al., 2005; McIntosh et al., 2012). According to McIntosh and Goodman (2016), this is because students who begin to experience early reading difficulties, and who are not provided with early evidence-based interventions, are increasingly exposed to environments where they are required to use skills they do not yet possess. Unfortunately, for students with the highest risk, intervention becomes significantly less effective the longer it is delayed (Sprague & Walker, 2000). According to Serry and Oberklaid (2015), Australian students who have been able to access intervention are selected "primarily based on age" (p. 26) and have typically received Reading Recovery (i.e., a catch-up program for Year 1 students who have not made sufficient reading progress). However, Reading Recovery fails to meet all elements of an effective reading intervention, as outlined in the 2005 National Inquiry into the Teaching of Literacy (Rowe, 2005; Serry & Oberklaid, 2015), and is "not aligned with evidence-based reading instruction" (de Bruin, 2019, p. 37). In fact, research has shown that Reading Recovery has failed to close the literacy achievement gap of struggling readers, particularly those from vulnerable populations (May et al., 2023; Tunmer et al., 2013). The lack of identification and access to early, effective evidence-based reading intervention in Australian schools means that the gap between those that can read, and those that cannot, will continue to increase (Serry & Oberklaid, 2015). Intervening early, before reading problems become entrenched and harder to remediate, provides the best chance for successful outcomes and prevention of life-long disabilities (Torgesen, 1998).

Inadequate and Disparate Policy Guidance

In 1997, the Australian federal government set ambitious literacy and numeracy goals, specifying that "Every child leaving primary school should be numerate and be able to read, write, and spell at an appropriate level" (Department of Employment, Education, Training and Youth Affairs, 1998). This resulted in two decades of policy initiatives, national inquiries, and curriculum reforms aimed at improving the literacy achievement of all students. For example, the establishment in 2008 of the Australian National Assessment Program in Literacy and Numeracy (NAPLAN), the National Inquiry into the Teaching of Literacy published in 2005, implementation of the

National Curriculum in 2011, Australia's Literacy and Numeracy National Partnership (2008–2009 to 2011–2012), and the literacy targets as set out by the Australian Education Act in 2013. Unfortunately, despite ambitious goals and ongoing national policy initiatives, literacy rates in Australia have continued to decline (Elliott et al., 2022). In addition, inconsistent practices regarding literacy instruction and assessment across jurisdictions remain. For example, inconsistent and limited uptake of the federally funded Year One Phonics Check is evident, with only three states actively mandating any type of phonics screening in schools. There is also inconsistency across state policies and guidance documentation regarding reading instruction and assessment. For example, the Victorian Department of Education still actively promotes assessments, instructional practices, and resources aligned with Balanced Literacy, as part of a "mix" of recommended approaches. Specifically, the use of the three-cueing method, running records, and predictable levelled readers that instruct and assess students' ability to "read" unfamiliar words using contextual cues – practices which were deemed ineffective and damaging in the 2005 NILT report (e.g., Department of Education and Training Victoria, 2022, 2023a, b). In contrast, the Department of Education in New South Wales (NSW) has more consistently aligned its policy and guidance documents, as well as its assessment and instructional resources, to evidence-based reading instruction as set out by the 2005 NILT report (e.g., NSW Education, 2023a, b). Mixed messages in policy guidance documents, regarding effective reading instruction and assessment, between the Australian states and territories, is likely to continue to lead to disparities in reading achievement across jurisdictions. This will only create further inequities and challenges for Australian students.

Toward an Integrated Framework for Improving Reading Outcomes

Science of Reading

The *science of reading* is a vast body of knowledge based upon cross-disciplinary scientific research into "reading and issues related to reading and writing" (The Reading League, 2022). Research in this area highlights the knowledge and foundational reading skills students need to acquire to become skilled readers and lays down a conceptual map for the effective teaching of reading. Four independent national inquiries into the teaching of reading in the US, Canada, UK, and Australia have provided practice recommendations that are consistent with the science of reading (National Reading Panel, 2000; Ontario Human Rights Commission [OHRC], 2022; Rose, 2006; Rowe, 2005). Collectively, the results of these independent national inquires highlight five key elements of effective reading programs; the systematic and explicit teaching of (1) phonemic awareness, (2) phonics, (3) reading fluency, (4) vocabulary knowledge, and (5) comprehension (National Reading Panel, 2000; OHRC, 2022; Rose, 2006; Rowe, 2005). According to Petscher et al. (2020), the science of reading benefits from an ever-expanding evidence-base informed by decades of accrued research across various fields of study about "reading, reading development, and best practices for reading instruction obtained by the use of the

scientific method" (p. 268). From a theoretical perspective, these recommendations are aligned to the Simple View of Reading (Hoover & Gough, 1990). In the Simple View of Reading, reading comprehension is defined as "the product (not the sum) of decoding ability and language comprehension skills" (Snow, 2020b, p. 37). This means that students must acquire proficiency in decoding and its subcomponents (i.e., phonological awareness, alphabetic principle, spelling-sound correspondence, and sight word recognition), *as well as* acquiring proficiency in language comprehension, and its subcomponents (i.e., background knowledge, vocabulary, language structures, verbal reasoning, and literacy knowledge), to become fluent, skilled readers (Scarborough et al., 2009). However, to ensure students' effective and efficient learning in each of these domains, practitioners must have knowledge of, and be able to accurately use, effective and efficient teaching tactics. They must be skilled in monitoring, evaluating, and adjusting the instructional environment to suit learner needs (Ardoin et al., 2016). To do this, practitioners can draw on research from the *science of behavior* that highlights repertoires of instructional practices, tactics, and procedures that support the effective and efficient teaching and assessment of reading.

Science of Behavior

The *science of behavior* maintains that behavior is circumstantial, where the "person is seen as the locus of behavior, not the cause" (Friman, 2021, p. 12). Research and practice conducted from this perspective focuses on the relationship between an individual's behavior – academic or social behavior – and the contexts within which it occurs (Cooper et al., 2020). For the purposes of this paper, the term the *science of behavior* has been used to reflect an approach to behavior and behavioral research that is functional and contextual (i.e., consistent with Applied Behavior Analysis and Contextual Behavior Science). Behavioral research primarily focuses on the systematic experimentation and observation of environmental events that predict and influence valued outcomes. Reading research that is underpinned by a behavioral world view, (a) focuses on methods that define reading behaviors in objective, observable and measurable ways, and (b) systematically evaluates interventions by manipulating environmental variables and directly observing their impact on reading behavior (Dunlap et al., 2001). The aim of experimentation and practice is to demonstrate a reliable relationship between the environmental variables (i.e., instructional practices) and improvements in reading (Cooper et al., 2020). This is typically done using single-case experimental designs, where a participant's pre-intervention reading behavior is systematically observed, in context, to create a baseline or benchmark of current performance from which to evaluate the effects of an intervention (Ledford & Gast, 2018). Reading interventions are then systematically implemented in phases, and changes in performance across phases are assessed for treatment effects (e.g., see Brosnan et al., 2018; Lambe et al., 2015; Newsome et al., 2014; Kelley et al., 2015). Such single-case research methods then allow for systematic and direct replication of experimental effects that allow for the development of principles, practices, and theories of learning and instruction. As such, behavior analytic

research, and the science of behavior more broadly, has contributed significantly to our collective understanding of *how* to effectively teach and assess reading and evaluate reading instruction (Joseph et al., 2016).

Contributions of the Science of Behavior to Reading Instruction

Knowledge derived from the science of behavior is reflected in behaviorally based instructional approaches, where methods of instruction are implemented and assessed in conceptually systematic and explicit ways to support students to acquire, maintain, and generalize reading skills (Cooper et al., 2020; Joseph et al., 2016; Spencer, 2021). Examples include Direct Instruction programs (e.g., Corrective Reading, Spelling Mastery, Reading Mastery, Language for Learning) and curriculum-based measures (e.g., Dynamic Indicators of Basic Early Literacy Skills) where observable and measurable reading behaviors are systematically taught and assessed within a sophisticated instructional design process aligned with the science of behavior (Spencer, 2021). In particular, curriculum-based measures, originally developed by Deno and Mirkin (1977), "involve the direct observation of behavior and use the single case analytical procedures that are characteristic of Applied Behavior Analysis" (as described above; Deno, 2003, p. 190). Specific examples used in Australian schools include, Story Champs, a narrative oral language Direct Instruction program, and CUBED, a suite of curriculum-based measures. These resources have been developed using behavior analytic instructional design principles (see Spencer, 2021) and co-created by a Board-Certified Behavior Analyst (BCBA) and a Speech Language Pathologist (Petersen & Spencer, 2016; Spencer & Petersen, 2012). According to Dunlap et al. (2001), using data from curriculum-based measures to identify and modify interventions to improve academic behavior, has been "one of the most important contributions of Applied Behavior Analysis to the field of education" (p. 132). These instructional and assessment approaches maintain the behavioral assumption that student learning is highly dependent on the quality of the instructional environment (Stockard et al., 2018). A behavioral assumption that is also embodied in the famous quote by the father of Direct Instruction, Siegfried "Zig" Engelmann, who stated: "if the student hasn't learned, the teacher hasn't taught – that's not a slogan, it's an operating principle" (Heward et al., 2021). In other words, rather than blaming poor reading skills on the characteristics of the child, the teacher must instead determine aspects of the instructional environment to adjust to improve student learning outcomes (Ardoin et al., 2016).

On the contrary, non-behaviorally based approaches to reading instruction, such as Whole Language, are underpinned by a developmental or constructivist worldview (Friman, 2021; Stockard et al., 2018). These approaches assume that learning is dependent on student characteristics, such as, their ability to construct or derive knowledge, their current developmental stage, their individual learning style, or their unique ability *to* learn (OHRC, 2022). In essence, developmental/constructivist approaches to reading assume that children will naturally discover how to read when immersed in spoken and written language, and therefore, the teacher does not explicitly direct student responding but instead provides naturalistic opportunities

for student learning to take place (Daly et al., 1996; OHRC, 2022; Rayner et al., 2001). Engelmann argued that developmental approaches to teaching reading tend to focus on student variables out of the teacher's direct control (e.g., developmental "readiness"), whereas behavioral approaches provide teachers with tangible aspects of the environment to manipulate to better support targeted learning (e.g., strategic arrangement of antecedents, instructional prompting procedures, manipulation of stimuli, provision of reinforcement, and error correction; Heward et al., 2021; Spencer, 2021). Notably, reviews of reading research (e.g., NRP, 2000; OHRC, 2022; Rose, 2006; Rowe, 2005) have consistently favored behaviorally based instructional practices over constructivist based approaches, and Direct Instruction has consistently been reported as the most effective instructional approach to reading over other approaches (Barbash, 2021; Gersten et al., 2017; Przychodzin-Havis et al., 2005; Stockard et al., 2018).

On a granular level, Direct Instruction consists of multiple scientifically validated behavior analytic procedures. Most notably, the detailed use of *task analysis,* the *instructional hierarchy,* and strategically arranged *trial* elements to program for efficient transfer of stimulus control (Spencer, 2021). *Task analysis* is the process of breaking down a complex behavior (e.g., reading) into a series of discrete, measurable, and teachable components (Noell et al., 2011). The *instructional hierarchy* identifies the role of teaching tactics (e.g., modeling, prompting, repetition, etc.) to support accurate student responding across a staged and sequenced learning process of knowledge or skill acquisition, development of fluency of use, generalization of use, and adaptation (Daly et al., 1996). A learning *trial* is part of effective instructional design in Direct Instruction programs and consists of specific elements drawn from behavior analytic principles and teaching tactics. Learning *trial* elements include an antecedent (e.g., the instruction, an attention signal, a task stimulus, a stimulus/response prompt), a behavior (e.g., the correct/incorrect student response – anything the student says or does), and a consequence (e.g., feedback that is either contingent reinforcement or error correction; Spencer, 2021). Some specific learning *trial* elements and behavior analytic teaching tactics have been described in more detail in Table 1, along with a practical example of how each element might be used when teaching different aspects of reading. These behavior analytic procedures ensure that reading is taught in conceptually systematic ways, where student responding builds on previously mastered skills, and instructional practices are targeted to the appropriate stage of the instructional hierarchy, together allowing student learning to progress efficiently and effectively (Daly et al., 1996; Dunlap et al., 2001; Spencer, 2021; Stockard et al., 2018).

Multi-tiered Systems of Support Frameworks

At a larger scale, knowledge derived from behavioral research is reflected within multi-tiered systems of support (MTSS) for reading. MTSS frameworks were designed with a three-tiered logic of increasingly individualized and intensive support based on public health models. The framework as a whole – and the practices and interventions across all three tiers – are underpinned by behavior science-based

Table 1 Behavior analytic learning trial elements and teaching tactics for reading instruction

Behavior Analytic Teaching Tactic	Definition	Reading Instruction Example
Response Prompting	The systematic provision of explicit verbal instructions and overt modeling as an antecedent to occasion accurate responding (Ozen et al., 2022).	"(Point to **mēt**). You're going to touch under each sound and say them. Here's what you're going to say. (pause) mmmēēēt. Say that" (Engelmann et al., 1986, p. 47).
Stimulus Prompting	Providing an antecedent environmental cue to draw attention toward the discriminative stimulus to elicit accurate student responding.	Providing visual cues (e.g., lines, dots) to highlight graphemes (i.e., discriminative stimulus) so the student says the correct phoneme when decoding. down boost fruit night
Stimulus Direction	Visual or verbal cue directing students to touch/look at the target stimuli.	(Teacher) "Point to the word Bamboo in part A".
Response Direction	"Discriminative stimulus that communicates to the learner what response will be reinforced" (Spencer, 2021, p.825)	(Teacher) "Bamboo is a type of plant…*Everyone, what is Bamboo?"*
Stimulus Shaping	Altering the physical dimensions of a stimulus gradually over learning trials, so that discrimination is easy at first and then becomes increasingly more difficult, to promote accurate and independent responding (Mosk & Bucher, 1984).	Reducing the size of the final <e> in the word "these" and increasing its size over time or practice opportunities. For example, thēs$_{e}$ thēs$_{e}$ thēse these
Consequence Contingencies	Providing contingent positive reinforcement to strengthen accurate responding or error correction procedures to support future accurate responding.	1) Positive reinforcement for accurate responding. For example, "Good sounding out *mmmaaat"* 2) Error correction for inaccurate responding. For example, "(touch under **s**). This sound is **sss**. You've got to say the sounds I touch. Repeat sounding out" (Engelmann et al., 1986, p. 77).
Systematic Prompt Fading	Planned reduction/slow removal of stimulus prompts from a trial, during guided practice, to support independent responding and generalize reading skills to novel stimuli (e.g., unfamiliar words).	Gradual fading of explicit instruction, modeling, steps in a worked example, sentence stems, as well as colored or bolded font, lines and dots that highlight graphemes, morphemes, syllables, target vocabulary, syntax, or elements of a narrative.
Multiple Exemplar Training	A systematic procedure that provides practice with a variety of response topographies to promote generalization of untrained or novel stimuli and higher order concepts (LeFrance & Tarbox, 2020).	Providing several different story exemplars, with the same grammar elements, to promote story grammar schema (Spencer & Petersen, 2020). "Children quickly learn that story content is not the salient feature, and what is important is the schematic pattern" (Spencer & Petersen, 2020, p. 1086).

Table 1 (continued)

Behavior Analytic Teaching Tactic	Definition	Reading Instruction Example
Frequent Learning Trials/Opportunities to Respond	Providing frequent learning trials to support active student response opportunities, increasing a student's access to reinforcement or error correction (i.e., feedback) to strengthen target reading behaviors.	Reading programs with an explicit instruction approach are designed with high rates of active student responding using a variety of activities (e.g., choral responding, response cards, written/verbal responses, cloze reading, time trials, peer tutoring, etc.; Heward et al., 2021).
Self-monitoring Procedures	A procedure used to teach students to observe, record, and reinforce their own reading behaviors to strengthen accurate and fluent responding (Didion & Toste, 2022; Joseph & Eveleigh, 2011).	Recording words read correctly or fluency rates in a tally, chart, or graph and assessing achievement overtime as positive reinforcement of improved reading behavior.

assumptions and procedures (Ardoin et al., 2016). For example, behavior analytic procedures are used to "determine what aspects of the instructional environment must be manipulated to maximize student reading outcomes" (Ardoin et al., 2016, p. 29). Critically, MTSS for reading is delivered as a school-wide, data driven framework that supports practitioners to select and implement evidence-based reading instruction and intervention to all students. In this way, it may be best conceptualized as an organizing framework for the behavior of those working within a school, as it relates to reading instruction and intervention. It is a preventive framework that emphasizes the critical use of evidence (i.e., data and research-based practices) to actively prevent, identify, and provide needs-based intervention for reading difficulties in schools (Fletcher & Vaughn, 2009). Core components of the MTSS framework include the use of evidence-based core reading curricula informed by the science of reading, evidence-based instructional practices informed by the science of behavior and learning, a sliding scale of increasingly intensive intervention support, universal screening and progress monitoring, data-based decision-making, and an emphasis on teacher professional development in evidence-based instructional practices and assessments (Jimerson et al., 2016; McIntosh & Goodman, 2016).

The tiered logic of MTSS provides universal evidence-based instructional practices for reading at Tier 1. This is with the intention of creating the stimulus conditions for successful responding by arranging an effective learning environment for all students. Specifically, by focusing on the analysis and manipulation of environmental factors (i.e., classroom and instructional variables) and measuring their impact on observable behaviors (i.e., targeted reading behaviors) to improve socially significant outcomes (Cooper et al., 2020; Jimerson et al., 2016). As noted above, this has been informed by the theoretical assumptions and empirically demonstrated principles and tactics of behavior science (Ardoin et al., 2016). In essence, implementation of MTSS for reading requires schools to embody a behavioral worldview and not "blame children for their poor academic performance, but instead determine what aspects of the instructional environment must be manipulated to maximize student achievement" (Ardoin et al., 2016, p. 29). For example, where routine universal screening data indicates that reading behavior is "at risk" or reading instruction is not being provided "as intended," manipulation of the existing environment might include, (1) the implementation of specific interventions to change teacher instructional behavior (i.e., professional learning, coaching, or additional resource provisions for practitioners; McIntosh & Goodman, 2016); (2) changes to curricula materials, teaching tactics, lesson frequency and/or pacing; and (3) providing increasingly intensive interventions for students deemed "at risk" (i.e., increase the duration and/or frequency of instruction by moving to Tier 2 or Tier 3 supports; Jimerson et al., 2016).

Students who have not adequately responded to Tier 1 instruction are provided Tier 2 support where additional evidence-based reading instruction is provided at greater intensity. *Intensity of intervention* is conceptualized as an increase in dosage of instruction (time, frequency, and duration of intervention), a reduction in instructional group size, an increase in the number of opportunities to respond, and frequency of performance feedback, as well as an increased level of skill of the practitioner (Mellard et al., 2010). Tier 2 support includes frequent progress monitoring (Hughes & Dexter, 2011), so that data-based decisions can be made regarding the

need for additional support (i.e., a shift into Tier 3 supports; Fletcher & Vaughn, 2009). Tier 3 interventions are typically provided for a small percentage of students (i.e., 2–5%) who have not responded to previous Tier 1 and Tier 2 supports (Hughes & Dexter, 2011). These Tier 3 supports are provided for as long as necessary and are more intensive and highly individualized (Hughes & Dexter, 2011). Similar to the single-case analytical procedures inherent in behavioral research, intervention effects are then measured using progress monitoring data from curriculum-based measures (Deno, 2003) to assess the impact of the intervention (i.e., above-mentioned environmental modifications) on student reading behaviors (Fletcher & Vaughn, 2009).

The Influence of the Science of Reading Instruction in Australian Education

In Australia, several noteworthy initiatives have been undertaken to better ensure the uptake and provision of approaches aligned with the science of reading in Australian schools. One such program is the "Making Up Lost Time in Literacy," or MultiLit, program (Wheldall & Beaman, 1999). As a program, MultiLit was created to address a lack of research-based intervention programs for older readers experiencing difficulties with literacy. MultiLit incorporates the use of criterion-referenced student assessments to identify specific skills an individual student needs for fluent reading (Wheldall & Beaman, 1999). Systematic instructional methods, such as Direct Instruction, frequent opportunities for students to respond, error correction, and contingent positive reinforcement are then used to teach reading to fluency (Wheldall & Beaman, 1999). Progress data are collected frequently and used to guide the process of data-based decision making (Reynolds et al., 2009). In addition, Wheldall & Beaman (1999) recognized that effective behavior support was a necessary prerequisite for effective classroom teaching and learning. To this end, MultiLit teacher training programs incorporate skill building in a variety of positive and preventive classroom behavior management strategies. For example, arranging the classroom environment to promote student engagement, teaching positive classroom behaviors, and reinforcing positive student behavior (Wheldall et al., 2020). The positive impact of MultiLit programs on student reading outcomes have been clearly demonstrated (Buckingham et al., 2012).

In 2019, MultiLit partnered with Five from Five, an Australian initiative established to promote the uptake of effective, evidence-based reading instruction by providing free resources to parents, teachers, and other stakeholders (Five from Five, 2023). Five from Five focuses on raising awareness about the five essential skills that all children need to become fluent readers: (1) phonemic awareness, (2) phonics, (3) reading fluency, (4) vocabulary, and (5) reading comprehension. In addition to developing resources for educators and parents, Five from Five synthesizes information about effective approaches for teaching reading to advocate for evidence-based policy related to the provision of education in Australia.

In addition, the Australian Association of Specific Learning Disabilities (AUSPELD) have made multiple recommendations and promoted the broad implementation of evidence-based reading across all Australian states and territories. This has taken the form of advocacy and engagement with departments of education across

Australia to bring about systemic change to literacy instruction. Specifically, AUSPELD have recommended that teachers use instructional practices that involve (1) a prescribed sequence of learning targets, (2) breaking reading skills down into small teachable components, (3) providing students with repeated opportunities to practise new skills, and (4) regular review of learnt skills (AUSPELD, 2022). Further, AUSPELD advocates for these practices to be implemented within a Multi-tiered System of Support framework to ensure that all students, including students with learning disabilities, can access high quality evidence-based instruction and intervention in reading.

In 2020, the Australian Education Research Association (AERO) was established with the aim of lifting educational outcomes for all students through the effective use of evidence-based practice. Since its establishment, AERO has developed several practice guides to support professional learning in key evidence-based practices. For example, AERO's Focused Classrooms resource describes the use of modeling, prompting, and reinforcement to teach positive classroom behaviors (AERO, 2021b). Their Explicit Instruction (AERO, 2021a) resource describes instructional practices such as, breaking larger skills down into smaller teachable components, systematically sequencing tasks to build on students' prior learning, providing students with frequent opportunities to practise new skills, and systematically fading prompts as students become more independent (AERO, 2021a). More recently, AERO has developed evidence snapshots and practice guides to directly support schools in their implementation of Multi-tiered Systems of Support (MTSS) for Literacy. These MTSS guidance documents describe instructional practices and interventions aligned with the science of reading (AERO, 2023). Each of the above-mentioned programs and organizations – and their practices and recommendations – have been essential to many students across Australia. However, to this point, they have not proven sufficient to address the scale of change required to improve reading outcomes for Australian students.

Implications and Recommendations

Significant changes to policy, practice, and preparation are required if the inequities and downward trends in Australian reading outcomes are to be ameliorated. As noted above, students from historically marginalized groups (e.g., Aboriginal and Torres Strait Islander students) disproportionately experience the negative effects of the variable reading instruction evident across all Australian school systems. In what follows, suggestions are made as to how the science of behavior and science of reading can be further integrated to improve reading outcomes for Australian students.

Pre-service Preparation to Deliver and Support Evidence-Based Reading Instruction

Currently, many pre-service teachers across Australia are not provided with the necessary knowledge, skills, or experiences to deliver evidence-based reading

instruction as part of their pre-service preparation (McLean et al., 2021; Meeks & Kemp, 2017). To address this, Australian universities should provide pre-service teachers with two critical repertoires of skills (1) the conceptual understanding of reading development drawn from the science of reading, and (2) the repertoires of instructional practices, tactics, and procedures drawn from the science of behavior. Put simply, pre-service teachers need to be aware of *what* to teach and *how* to efficiently and effectively teach their students to read. For this to happen, teachers must be provided with sufficient conceptual knowledge within the domains of phonemic awareness, phonics, fluency, vocabulary, and comprehension (Scarborough et al., 2009). It is important to recognize that while these concepts may be presented or described to teachers within existing Australian pre-service preparation programs, this has not led to confidence to deliver instruction based on this understanding (Horner et al., 2019; Meeks & Kemp, 2017). As such, pre-service teacher preparation programs should focus on developing fluency in the application of this knowledge. For this to occur, pre-service teachers need to be provided with sufficient instruction and modeling, as well as opportunities to practise and receive feedback, on their use of critical instructional practices and tactics derived from the science of behavior. This also needs to be done in a range of settings, to promote the generalizations of teacher instructional skills. For example, pre-service teachers could be engaged in multiple opportunities to practice adjusting the instructional environment in response to learner needs. This could include opportunities to manipulate antecedents, to provide a range of stimulus prompts and to systematically fade those prompts, to provide error corrections, to deliver high rates of opportunities to respond/frequent learning trials and actively engage their students, as well as delivering and monitoring the impact of contingent reinforcement on students' reading behavior. Ideally, pre-service teachers would be instructed and supported to practise these skills to fluency with expert feedback within structured university settings, either with peers or in virtual reality settings. These skills could then be applied in real classrooms as part of teaching practicum experiences. The development of these two repertoires will provide the skills necessary for beginning teachers to deliver on the promise of a science of reading-based understanding of reading instruction within their classrooms.

Pre-service teacher preparation programs in Australia may also provide pre-service teachers with a functional understanding of behavior. As described above, both the science of reading and the science of behavior focus on the impact and importance of the environment as it relates to social and academic behavior. This is likely to support teachers to generalize these skills across contexts and allow teachers to develop a sense of fluency and mastery before engaging in complex and dynamic classroom environments. Furthermore, preparation on a functional understanding of behavior, will likely better prepare beginning teachers to integrate their use of evidence-based instructional *and* evidence-based behavior support practices within a Multitiered System of Support (MTSS).

Finally, there is a need to prepare teachers and practitioners to engage in effective interprofessional collaboration. Given the importance of all staff in the school engaging in effective implementation of the different components of a MTSS for reading, teachers, education support staff, SLPs, behavior analysts, and school

psychologists will be required to engage in effective interprofessional collaboration and cross-disciplinary practice. Challenges to such cross-disciplinary practice have been identified as it relates to teachers, teacher assistants, SLPs, behavior analysts, occupational therapists, and school psychologists (Bolton & Plattner, 2020; Brady & Kim, 2023; Kirby et al., 2022; Jackson et al., 2021; Pfeiffer et al., 2019). Specific challenges appear consistent across disciplines and may relate to disagreements or misunderstanding about roles, a lack of awareness of the challenges of teaching in classroom environments, limited understanding of the knowledge and skills offered by other professionals, limited time and resourcing to meet and work collaboratively, and challenges with cross-disciplinary communication (Bolton & Plattner, 2020; Brady & Kim, 2023; Kirby et al., 2022; Pfeiffer et al., 2019). Providing pre-service practitioners across multiple disciplines with specific training in models of collaborative work, as well as experiences to engage in collaborative models of work, has been suggested as one way to enhance cross-disciplinary practices to support effective intervention in schools (Pfeiffer et al., 2018).

Supporting Successful and Sustained Implementation

When considering the implementation of evidence-based practices such as those described above, Horner et al. (2019) noted that the stark reality facing implementers and system leaders is that many effective interventions are designed, tested, and then not successfully or sustainably implemented. Sadly, a lack of implementation at the classroom level -– and at scale across educational systems – limits the potential positive effects that evidence-based practices may generate for the students with the greatest needs (Cook & Odom, 2013). Australian teachers have reported facing significant workloads, competing priorities, challenging classroom behavioral environments, and a lack of time and knowledge to implement evidence-based practices; all common barriers to successful and sustained implementation of evidence-based practices (Fox et al., 2021; Longmuir et al., 2022; McIntosh & Goodman, 2016). As such, asking teachers to work independently to implement evidence-based reading instruction, in their own classroom, may only add to an already significant workload and level of stress. To address this, school and system leaders should focus on implementing evidence-based reading instruction as part of a whole-school framework such as Multi-tiered Systems of Support (MTSS) for reading. As described above, MTSS is a framework that supports school staff to select, implement, and monitor the effect of evidence-based instructional practices to develop students' reading skills. In this way, a MTSS for reading may allow for the skills of all teachers and practitioners (e.g., school psychologists, behavior analysts, and SLPs) within the school environment to be leveraged to collectively and collaboratively address students' learning and behavioral needs.

However, effectively implementing MTSS for reading in school settings has been found to be challenging (Arden & Benz, 2018; Balu et al., 2015). In contrast, implementation efforts of Positive Behavioral Intervention and Supports (PBIS), a MTSS approach to behavior, has had more success in being implemented at scale both in the U.S. (i.e., implemented in more than 28,000 schools across all 50 U.S. states;

Sugai & Horner, 2020) and internationally (see Poed & Whitefield, 2020). The success of PBIS implementation has been explicitly linked to the focus on the processes, practices, and systems of implementation – the supports required to evoke and sustain adult behavior change – over and above the attention paid to interventions within the framework per se (Horner & Sugai, 2015; Horner et al., 2019). If the potential of the MTSS for reading framework is to be realized across Australian schools, attention must be paid to the successful and sustainable development of school-level implementation support systems. For instance, systems shown to support implementation include staff training programs and systems, ongoing coaching programs and structures, secured resourcing through policy prioritization, school-wide data collection systems that allow for effective data-based decision making, as well as teams to lead and guide the processes of implementation (McIntosh & Goodman, 2016).

As identified earlier, a MTSS can incorporate multi-tiered approaches to reading, mathematics, as well as other social and behavioral frameworks such as PBIS. By implementing MTSS for reading together with PBIS (MTSS for behavior), school leaders can create and leverage consistent structures (e.g., data collection systems and team-driven data-based decision-making) and practices (e.g., high rates of opportunities to respond, error correction, prompting, etc.) to address a range of school improvement needs in a way that minimizes the impact of competing priorities (McIntosh & Goodman, 2016). In this way, effective implementation of PBIS allows for the creation of the pre-conditions necessary for effective academic instruction (Gage et al., 2017), and effective academic instruction reduces the need for behavior supports (McIntosh & Goodman, 2016). As noted earlier, providing pre-service teachers with the specific knowledge and skill to deliver effective reading instruction when combined with a functional understanding of behavior will likely provide an effective platform for graduating teachers to be able to work in schools implementing a MTSS that addresses both academic and behavioral learning. Pleasingly, there has been an increased emphasis on the need to implement MTSS that support evidence-based reading instruction and behavior support within Australian educational settings (AERO, 2021c).

Policy Change and Systems-level Supports

Educational policies focused on reading instruction across Australian school systems must undertake a process of realignment. As noted above, reports have been commissioned, policies have been drafted, and yet the reading outcomes for Australian students continue to decline. Providing a clear overview and definition of socially significant targeted reading outcomes for *all* students is a required first step in aligning policy and practice. For example, where reading outcomes are clear and concretely defined, the task of identifying the practices most likely to elicit these outcomes, *and* the most effective ways to support teachers to implement these practices, becomes clearer. This suggestion aligns with calls made by AUSPELD to define reading skills more clearly within and across curricula (AUSPELD, 2021). Such a move is likely to clarify for teachers and school leaders the reading skills and

knowledge their students need most. This policy and curriculum development within Australia should be informed by knowledge acquired through the science of reading and should focus on theoretically and practically congruent documents that align toward socially significant outcomes. As Horner et al. (2019) noted, policies can have the greatest impact on practice when they prioritize socially significant outcomes, require regular measurement and reporting on progress, as well as record the provision of systems-level resources (e.g., training and coaching supports) required for staff to achieve the intended goals. In this way, public policy shapes behavior at the level of the group by creating contingencies of reinforcement for teachers and school leaders to engage in the necessary implementation behavior, while also reducing the response effort for teachers to effectively implement evidence-based practices (Noell & Gansle, 2009; Todorov & Freitas Lemos, 2020).

To see policies realized in practice in Australian schools, a greater focus on the active provision of implementation support at the district and state-levels is required. For example, Horner et al. (2014) analyzed the state-level variables associated with large-scale, sustained PBIS implementation efforts. They reported that state-level implementation leadership teams and data-based decision making at this same level were important to successful and scaled implementation at the school level. In addition, technical assistance that supports implementers to contextualize efforts, while also developing specific localized expertise (e.g., expertise in the science of reading, the science of behavior, and in implementation science) will be critical to ensuring MTSS implementation efforts can be successful, sustained, and then scaled (Blase et al., 2015; Horner et al., 2014). Critically, Blase et al. (2015) noted that the presence or absence of such implementation and content expertise embedded within the system may be a limiting factor in the long-term success and scalability of implementation efforts. As such, it is essential for education systems to focus on building coaching, consultation, and implementation expertise while also building knowledge and skill in the specific content areas related to the science of reading and science of behavior.

In Conclusion

Significant change is required at the individual, school, and systems-levels if improvements in reading outcomes for Australian students are to be realized. Throughout the current paper, we have discussed how the science of reading and science of behavior are both aligned and necessary to achieving improved reading outcomes. We want to conclude by emphasizing the role of the science of behavior in supporting the necessary changes at the individual, school, and system levels. While many consider the science of behavior to be limited to supporting behavior change at the level of the individual, successful applications at the level of cultures and systems have demonstrated that the science of behavior has the conceptual, theoretical, and practical tools to understand, predict, and influence change beyond the individual (Todorov & Freitas Lemos, 2020). As Horner and Sugai (2015) suggested, organizations and systems do not behave, people within them do. As such, the science of behavior allows for an assessment of implementation behavior – and

the challenges of implementation – with a view to understanding lawful relationships between the environments within which individuals and groups work, and their implementation or reading instruction behaviors (Noell & Gansle, 2009). By underpinning this change with the science of behavior, it is our hope that implementers and system leaders across Australia can focus their efforts on creating the antecedent conditions that support effective reading instruction in Australian schools. That is, preparing pre-service teachers with knowledge from the science of reading and practices from the science of behavior, aligning systems-level policies, providing the necessary training, and creating structures of ongoing support may all serve to set the occasion for the successful and scaled implementation of effective reading instruction across Australian schools. Critically, data must be used to guide decision-making at the school, district, and state levels. Positive outcomes must be celebrated as a way to positively reinforce teacher and school-wide implementation, secure ongoing resources, and ensure that implementation can be sustained. Focusing on these practices and the creation of these supports at the individual and systems levels may allow for the creation of contingencies that encourage, evoke, and reinforce instructional practices that move Australian teachers toward the prized goal of improved student reading outcomes (Cihon & Mattaini, 2020).

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Declarations

Conflicts of Interest The authors declare that they have no conflict of interest.

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