Translational Science: A Roadmap for the Science of Reading

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Abstract

Despite scientific advances that have informed our understanding of reading acquisition and development, a profound gap exists between empirical findings and the implementation of evidence-based practices in the assessment and instruction of reading in school settings. The debate regarding the practical implications of the science of reading (SOR), and its implementation in authentic school settings is palpable. As researchers, practitioners, policymakers, parents, and other educational stakeholders engage in this latest version of the debate on how best to teach children to read, a familiar, almost cyclical, narrative has emerged. As an interdisciplinary group of researchers, who study diverse facets of reading development, assessment, and instruction, it is troubling how little the current and past debates have focused on processes that could ensure that the instructional experience students receive in classrooms is informed by existing science. Specifically, we contend that the persistent gap between SOR and its school-based implementation exists because the field has yet to invest in the appropriate methodologies and processes to develop an effective model of translational science. We argue not only that much can be learned from previous iterations of this debate but also that advances in translational science provide a framework for how to address the debate on SOR differently and more productively in the current climate. Thus, we propose a roadmap for translational science for SOR, acknowledging the breadth of work done in translational science in other fields and recognizing and describing the added complexities in the emerging field of translational science in educational settings.

Many articles in this special issue highlight the challenges with terminology, interpretation of findings, and how to best use the existing evidence base that supports the science of reading (SOR). These important topics are useful to clarify and situate the current status of empirical findings and their use in authentic classroom settings. We contend that we must also bring attention to an understudied aspect of reading and literacy research: the translation of research findings from multiple fields of study to applied research studies and implementation in classroom settings. The SOR has a strong foundation in the theoretical building blocks of early reading acquisition, known malleable factors related to individual differences in reading and language, developmental differences due to exogenous and endogenous factors, causal mechanisms to improve reading difficulties and how one is able to precisely measure literacy skills (Cain, Compton, & Parrila, 2017). However, we also acknowledge that reading is a multifaceted process, with particular aspects, such as early reading development and instruction, currently benefiting from a strong evidence base. Recognizing these complexities, we argue that the field has fallen short in communicating what is known about the SOR to educational stakeholders. Communicating aspects of the SOR where a compelling evidence base does exist, and not overstating what we know, is essential. We don't know everything about reading. However, that should not stop the field from moving forward with translating research findings to support aspects of instructional practice that have a solid evidence base so that they can be implemented in classroom settings. Recognizing the bidirectional nature of knowledge development between basic and applied scientists and teachers and other schools personnel, we contend that the field should leverage this ongoing back and forth exchange, acknowledging the unique and critical roles each of these experts play through

interdisciplinary teams. Doing so can push the field forward towards accomplishing our shared goal of improved reading achievement for all learners.

There are several reasons that the evidence base is not adequately implemented in school settings; there are many layers between basic science findings and teacher implementation that must be traversed. Translational difficulties are readily observed in institutions of higher education with lack of communication and collaboration between the basic science disciplines and colleges and schools of education. One example of a bottleneck of the translation of research findings into practices are teacher preparation programs. Although recent years have seen an increase in overall coverage of evidence-based reading instructional practices, this is not true for all teacher preparations programs. Many have been slower to adopt approaches to teaching reading backed by SOR into their reading methods programs (Cunningham, Perry, Stanovich, & Stanovich, 2004; Moats & Foorman, 2003; Lyon & Weiser, 2009). Challenges associated with the disconnect between SOR and teacher preparation have been reported around the world, in particular in English-speaking nations (e.g., Castles, Rastle, & Nation, 2018; Washburn, Binks, & Joshi, 2014) and increasingly in other languages (e.g., Soriano-Ferrer, Echegaray-Bengoa, & Joshi, 2016; Yin, Joshi, & Yan, 2019) and in low- and middle-income nations (e.g., Kim, Hansel, & Zuilkowski, 2020).

Other factors, beyond teacher preparation, also impede evidence based reading instruction, including insufficient dissemination efforts to stakeholders, state and district level policies, curriculum and assessment decisions, and lack of professional development of in-service teachers. Ultimately, classroom teachers and other school practitioners operate in a broad and extensive system with instructional decisions made by actors and policies outside of the classroom setting. As these dynamics play out within and across multiple levels in the

educational system, the process of translating research findings to classroom practice becomes increasingly complex (Durlak & DuPre, 2008; Fixsen et al., 2005), and therefore, cannot be captured adequately by engaging teacher preparation programs alone. While high quality reading research has been and continues to be conducted in tightly controlled settings, the field has been less successful in developing an adequate process by which to translate these findings to classroom practice at scale.

In the health sciences, translation, dissemination, and implementation sciences are widely recognized and advocated for as means to resolve some of the challenges to translating research evidence into everyday practice (for example, see the National Center for Advancing Translational Sciences, NCATS). Implementation, dissemination, and translational sciences are distinct disciplines, but work in tandem with each other and are supported by the National Institutes of Health (NIH) as mechanisms that intersect with primary research activities. These sciences are designed to facilitate better adoption and use of evidence-based interventions as opposed to putting the onus of implementation and use on the stakeholder. In order to successfully translate research findings, scientists and researchers involved in both basic science and applied studies of reading must collaborate and include input from various educational stakeholders. Applied reading scientists play a distinct role in the translation of findings to the field. In a very real way, applied scientists serve as the "agents of change" in the translational process, as their work is to take basic science findings and troubleshoot the implementation of these findings in authentic school settings.

While the health fields provide a template for the translation of findings into practice, it is important to acknowledge that educational science and the health sciences are not the same. There are unique difficulties that may impact the translational process in education. For example,

it is difficult to translate research that has not fully considered the diverse contexts in which learning happens. Schools operate in very different contexts and serve different demographics both within and between districts and states. To date, limited reading research focuses on the how, why and under what conditions research-based instructional practices can be implemented effectively in routine classroom-based settings. Moreover, little is known about how to make these practices applicable to all classroom contexts and student populations, which creates additional difficulties in successfully ensuring that evidence-based instruction reaches classrooms.

The goal of this paper is to leverage advances in translational science to introduce and apply its frameworks to the field of reading research by proposing a roadmap for the translation of SOR to better ensure its use in district and classroom settings. We engage in this process within the context of a few specific assumptions. First, the existing research base supports the science of early reading development, in particular how early word reading develops and effective teaching practices for word level skills. These practices are a direct result of the basic science of early reading acquisition and includes explicit and systematic phonics instruction. While the research in comprehension development and instruction has been steadily growing, we know less about this area of reading relative to decoding. Second, that science in the area of reading, as in every other discipline, is constantly evolving, and continuous scientific discovery in both early word reading and reading comprehension is necessary to move both research and practice forward. Finally, strategic and intentional investment into translational science may not only increase the implementation of the current evidence base in classroom settings, but also support advances in the reading and literacy fields towards novel and innovative solutions in the study and implementation of SOR.

Translational Science Process and Translational Scientists

The term translational research was first introduced in the medical literature nearly 30 years ago and its definition continues to evolve (Rubio et al., 2010). For instance, in 2009, NIH defined translational research along two dimensions: the process of applying basic and laboratory findings to studies and clinical trials in humans and the process of enhancing community-level adoption of the best practices observed through the clinical trials. Stated differently, NIH's definition conveys two important perspectives of translational science. First, applying basic and laboratory findings to clinical trials is concerned with a *translational science process* that seeks to establish levels of evidence in quantity and quality of programs and interventions. Second, the process of enhancing community-adoption of best practices that are established from programs with compelling evidence can facilitated by *translational scientists* who communicate scientific results to both the scientific community and the world at large.

Translational Science Process

The translational science process is represented as a multidirectional, non-linear, and iterative pathway referred to as the translational science spectrum (NCATS, n.d.). Research is categorized by its stage along a continuum that its working together; see Figure 2 where we map these categories to educational/reading research: (a) T0: basic research studies, which define mechanisms and constructs of behaviors, or the malleable factors that may impact reading; (b) T1: preclinical research studies, which test new methods, assessments, and interventions to better understand and address behaviors (reading), or development studies; (c) T2: clinical research studies, which extend T0 and T1 findings to specific populations through controlled studies or efficacy studies; (d) T3: clinical implementation studies, which examine the effectiveness and implementation of efficacious interventions in real-world settings or effectiveness studies; and

(e) T4: public health studies, which examine population-level outcomes in response to wide-spread use of interventions or population studies. This process is well aligned with the former and current Institute of Education Sciences (IES) Structure, which also presents research as a process progressing from basic to applied to implementation studies to build evidence-based solutions to problems of practice at scale.

When applied to the field of reading research, currently, the majority of published research can be categorized as T0-T2, or Exploration, Development and Initial Efficacy studies. In some ways, this makes sense. Federally-funded syntheses of empirical research in reading (e.g., Snow, Burns, & Griffin, 1998; National Reading Panel, 2000) coupled with growing calls for the use of evidence in educational decision-making (Slavin, 2002) prompted the field of reading research to shore up its evidence base through T0-T2 studies. For example, with increased funding and concerted effort from the National Center for Education Research and the National Center for Special Education Research, IES has sponsored over 300 studies examining intervention effects on student outcomes (Schneider, 2018).

While this progress is noteworthy, without T3-T4 studies (currently funded by IES Efficacy and Effectiveness and Replication grants), the generalizability of the findings from this body of research is limited. The first limitation is the lack of replication, as this is an essential part of the accumulation of scientific knowledge (Francis, 2012; Travers, Cook, Therrien, 2016). In reading research, as in many other fields, the confidence of research findings improves as they are replicated. The second limitation of the T0-T2 studies to inform the field broadly is the that they are limited by the representativeness of the samples—many of which lack diversity in learners (e.g., students with moderate and severe disabilities; English learners; students growing up in poverty or who are homeless) and settings (e.g., underperforming and under resourced

schools, rural schools, schools in neighborhoods with concentrated poverty, alternative educational settings like juvenile detention centers or residential facilities). Behavioral research, including studies in reading with diverse learners is increasing; however, relatively little empirical research has been focused on factors specific to the learning and development of these student populations (Cabrera & SRCD Ethnic and Racial Issues Committee, 2013). The field of reading research is not exempt (Lindo, 2006). Thus, it is important to acknowledge that within the current research portfolio are several rigorous reading research studies whose findings may be limited in their generalizability to the vulnerable student populations whose performance is reflected in the achievement gaps this research is often intended to address.

Translational Scientists

Gilliland and colleagues (2019) describe seven fundamental character traits of a translational scientist: 1) Systems Thinker, 2) Skilled Communicator, 3) Rigorous Researcher, 4) Domain Expert, 5) Process Innovator, 6) Team Player, and 7) Boundary Crosser. The ideal translational scientist, according to Gilliland et al. (2019), possesses all seven characteristics in their work and are independent of a scientific discipline. Petscher, Terry, Gaab, & Hart (2020) adapted and expanded this model, applying the traits of an individual translational scientist to a team approach to translational science (see Figure 1). In their model, members of translational science teams can include a: 1) Big Picture Thinker, 2) Skilled Communicator, 3) Methods Maven, 4) Domain Expert, 5) Barriers-Access-Equity (BAE) Innovator, 6) Expert Implementer, 7) Silo Bridger, and 8) Multimodal Disseminator. Complementary to Gilliland's approach, Petscher et al. propose that translational research is facilitated through a team of scientists who each have expertise in some but not all areas of translational science.

Translational Science for the Science of Reading

The nature of scientific research in education has been debated for more than 100 years (National Research Council, 2002). The suggestion that reading (and education) research might benefit from applying models derived in health and medicine is often met with heated debate (e.g., Slavin, 2002; Olson, 2004; Riehl, 2006). While scholars' perspectives on which aspects from health and medical research can be used to benefit education research continue to vary, it is clear that the field of reading research is characterized by a variety of factors that have complicated the translation of SOR to school and classroom practices uniquely.

First, the 'science' on any human phenomenon or behavior is rarely settled. Behavioral science is constantly evolving, which makes it challenging to not only translate evidence-based findings at any given point in time, but also to convince consumers of this knowledge that we, as researchers, can be confident in our findings while also, simultaneously, innovating and testing the effectiveness of new solutions. Both the scientific literature and discourse in the popular press indicate that many teachers lack awareness about what constitutes an evidence-based practice (Schiuchetti, McKenna, & Flower, 2016). Specifically related to early reading instruction, in a recent study, Kretlow & Helf (2013) found that while over half of all teachers surveyed reported instructing students in all five reading components daily, 63.6% reported using an "eclectic" instructional approach for teaching reading, as opposed to the explicit, systematic instructional approach supported by research evidence.

Beyond the debate over what constitutes the evidence-base behind reading instruction, there are clear links missing in the chain between translation of empirical findings and the instructional experiences students receive in classrooms. A myriad of contextual factors, including perceptions of science, weigh into decision-making processes about scientific evidence (National Academies of Science, Engineering, and Medicine (NASEM), 2017). For instance,

school administrators and teachers do not consistently make instructional decisions based solely on evidence, even if they are aware of the relevant research (Penuel, et al., 2016). Often individual actors in an organization have a different take on empirical research and its usefulness in instructional settings. Teachers often want to learn about research findings in ways that are actionable, demonstrate application, and are contextualized for their own needs (Barton & Tindle, 2019). Meanwhile, district and school leaders are often mixed in opinions about whether research provides a framework for structuring improvement efforts or a common language and set of ideas for dialogue with colleagues (Penuel et al., 2016). Leaders use research evidence in different ways than teachers, and often not with an emphasis solely on instruction (Coburn et al., 2009). How teachers collectively value change is related to a multitude of reasonable factors associated with the organizations in which they work, including the task demands, resource availability, situational factors, and school's capacity to expand and sustain the innovation over time (Armenakis, Harris, & Mossholder, 1993; Fixsen et al., 2013; Weiner, 2009).

Another challenge in translating reading research into classrooms involves the indicators being used to measure success. At a broad level, the most desirable outcomes from educational research are positive impacts on more distal outcomes, such as teacher behavior, change in student knowledge, improved performance on state-level tests, and increased graduation rates. However, in general, the findings gleaned from reading research are not designed to improve these more distal indicators of student success (e.g., increased third grade reading score on a state test), but instead focus on more specific proximal measures of reading development (e.g., increased performance on a decoding or comprehension measure). Therefore, the logic model created to measure broad success is very different from the expected outcomes sought in research, and perhaps unrealistic. This issue prompts an important question: should literacy and

reading researchers adjust their work to match these more distal outcomes, should the educational system adjust metrics of success to include proximal measures of reading success, or is there a useful middle ground?

Proposed Translational Science Roadmap

Despite the challenges to applying SOR in a manner that enhances reading achievement and consequently improves school achievement for all students, the field of reading is primed to engage in the translational science process. Although it is clear that more basic and applied research is needed to inform reading assessment and instructional practices, especially for reading comprehension, and vulnerable groups of students, the field has made progress, including an increase in the availability of efficacious instructional programs and interventions, particularly in the early word reading instruction. Importantly, the urge to push researchers to think about how to translate their work, does not exclude new scientific discovery- typically accomplished through T0-T2 studies (or exploration and development). This work is important for continuous scientific discovery.

Education policies at the federal, state, and local levels continue to encourage evidence-based decision-making in schools (e.g., ESSA, IDEA). These advances are beginning to create conditions that allow for a more strategic focus on the factors and processes that support the effective translation of SOR. It remains to be seen if and how translational science can be applied to reading and literacy research and practice in a manner that results in improved science, improved communication, and improved practice.

Thus, we propose a roadmap for integrating the field of transitional science within reading research, practice and policy. We argue that there are four critical intersections to consider for the translation of SOR to everyday practice in classrooms and schools. Figure 2

illustrates the four intersections, described in detail below, as essential ingredients operating across the T0-T4 research framework. A few assumptions inherent in the roadmap are worthy of discussion. First, we have proposed this roadmap because there are limited examples of a reading research program that incorporates all principles of translational science intentionally and strategically, from initial basic research studies through to efficacy, effectiveness, dissemination, and implementation studies. Second,we have placed translational science teams at the core of the framework because we think that these teams are necessary for simultaneous movement along the four intersections and engagement across T0-T4 studies; that is, they may be the key to increased application of principles of translation science in the study of reading. We envision these translational science teams to be diverse and include education stakeholders working in districts and schools. In this way, the collaboration and communication across members of translational science teams facilitates the translational process itself, both to generate new scientific findings and to implement research findings in authentic settings successfully. Third, our intent is not to provide all of the answers to how reading researchers can become translational scientists. Rather, our intent is to stimulate ideas, to provoke innovative approaches, and to encourage people engaged in reading and literacy broadly to think about how to intentionally and meaningfully collaborate with diverse educational stakeholders around a shared goal of improving reading outcomes for all learners.

Balanced Attention across the Translational Science Process

There are important considerations when aiming for balanced attention across the translational science process. First, we acknowledge that there are certain aspects of reading development and instruction that we know more about; these aspects should be considered ready for larger school-based T3-T4 studies. Those that we know less about may begin earlier in the

process (T0-T2). T3 and T4 studies are critical for translating research to practice because educational practices are not likely to change based solely on dissemination of T0-T2 findings through traditional academic means (i.e., journal publications and research conference presentations). The field must increase its capacity to capitalize on its solid evidence-base in reading acquisition that has been captured in T0-T2 studies and expand to include a more strategic focus on the processes that support translation and implementation of effective practices in schools and communities.

We suggest that two important steps for reading researchers to take towards the translation of SOR are applying methodologies used in effectiveness studies and engaging in both dissemination and implementation science. T3-T4 studies rely on methodologies associated with effectiveness studies, which are different than those researchers may have typically used in T0-T2 studies. Effectiveness studies build from efficacy studies to ask if an intervention works in real-world practice, instead of under ideal circumstances (Creemers & Scheerens, 1994; Brown et al., 2017). Education researchers have long been encouraged to use study designs that maximize external validity, including replication studies designed to address the most pressing problems of instruction and policy (National Research Council, 2002; Slavin, 2002). Like T0-T2 studies, T3-T4 studies adhere to rigorous scientific standards and methodological designs that allow valid, reliable, and reproducible results to emerge. However, unlike some T0-T2 studies, most T3-T4 studies involve mixed methods (i.e., both qualitative and quantitative methods), including structured stakeholder interviews, thematic analyses, fidelity measures, and advanced statistical modeling. T3-T4 studies also typically investigate processes and factors at multiple levels, including the patient (e.g., student), the provider (e.g., teacher), the facility (e.g., school), the organization (e.g., LEA), and the broader community (e.g., neighborhood, SEA). A

translational science team, where various training backgrounds and methodological expertise are present, is ideal for T3-T4 studies.

It is important to note that translational science is distinct from but analogous to dissemination science and implementation science. Dissemination research studies examine factors and processes related to the use of evidence-based interventions by specific populations, while implementation research studies examine the factors and processes related to the integration of those interventions into everyday practice in specific settings under specific conditions (Holtrop, Rabin, & Glasgow, 2018). Both use frameworks that reflect processes (e.g., exploration, preparation, implementation, and sustainability) and the dynamic interactions between context, personnel, and the intervention at each stage (Moullin et al., 2019). When applied collectively, translation, dissemination, and implementation sciences allow reading translational science teams to ask new and different questions, like 'what works for whom under what conditions'; 'what implementation strategy is most effective at increasing use of an evidence-based practice'; 'what factors are associated with sustainable use of a practice'; and 'how can we keep conditions in place to promote targeted outcomes when the research study is over?'

Recent methodological advances in how these frameworks can be used concurrently to accelerate the uptake of evidence to practice are important to consider. For example, Curran, Bauer, Mittman, Pyne, and Stetler (2012) described a suite of emerging hybrid study designs, whereby elements of effectiveness and implementation research are combined, with the potential to support more expeditious translation of research to practice. For example, gathering information on aspects of intervention delivery during an effectiveness trial can provide more immediate feedback on the feasibility of implementation in specific settings. Conversely,

gathering information on aspects of effectiveness during an implementation study can provide more immediate feedback on how an intervention might need to be changed or enhanced in understudied conditions or populations. Integrating the field of reading research and practice with translational science will require reading researchers to increase their familiarity and comfort with these frameworks and methodologies to accelerate the adoption and scaling of evidence-based reading practices, programs, and policies in schools. We contend that in order to engage in these types of studies, the most efficient way is to form translational science teams with varied methodological, content, and practical implementation knowledge.

Cultivating translational scientists

One of the most important steps towards translating SOR is to develop and train researchers who have the capacity to be translational scientists and work collaboratively in translational science teams. . Team science approaches to translation may be more readily applied to the immediate translation of SOR, therefore, it is advisable for reading researchers to leverage existing strengths while also building new ones (Petscher et al., 2020). Competency in each attribute of translational science evolves over the course of a scientific career, beginning with graduate study and continuing as researchers gain new knowledge, skills, experiences, and confidence to engage with the public and their communities around research findings. We argue that in order to move the field forward, it is essential for reading researchers to begin by leveraging their current positions to intentionally infuse translational science competencies into aspects of their existing and future work.

Many of the individual characteristics of a translational scientist are inherent to the various disciplines that encompass reading research. Individual scholars whose disciplines engage in reading research all strive to be experts in their domain. However, inter-and-

multidisciplinary teams are better equipped to tackle complex problems, such as reading achievement. The development of scholars who are willing to engage and collaborate with experts outside their primary disciplines is critical to translating SOR into authentic school-based settings. For example, researchers examining components of an intervention might initiate a collaboration with a qualitative researcher to gather information on aspects of implementation that would inform generalizability of the findings (e.g., identifying mechanisms and processes that facilitated or impeded successful implementation of the intervention).

Beyond collaboration, the choice of which competencies to build may also be guided by funding opportunities. For example, researchers may create interdisciplinary teams to compete for funding that specifically promotes translation. Current examples of such funding opportunities are available from IES (e.g., Research Grants Focused on Systematic Replication; Predoctoral Interdisciplinary Research Training Program in the Education Sciences). However, as the field advances towards translational science, increased funding opportunities will be required for original research on the effectiveness and efficacy of existing evidence-based interventions and on the processes and strategies to disseminate and implement these programs effectively in diverse settings and with diverse populations. Such funding should be prioritized by education research agencies (e.g., The Spencer Foundation). Moreover, because education has implicated models of individual and public health (Shi & Stevens, 2010), where funding opportunities are already available for translational science research, funding agencies that support health and public health related research should expand their purview to include translational education research.

Finally, researchers can also actively seek out *and* create opportunities to develop these competencies as they plan for their own new research endeavors and build pathways for others.

Fortunately, such opportunities are already available in a variety of formats. Researchers on editorial boards for education research and practice journals should also encourage the submission of individual manuscripts and special issues focused on translational science issues (e.g., Cook, Kilgus, & Burns, 2018; Douglas, Campbell, & Hinckley, 2015). Finally, researchers who also serve as graduate faculty can include aspects of translational science in coursework, training opportunities, and residency requirements for doctoral students and postdoctoral fellows. For instance, students may apprentice in LEAs and SEAs, take courses on conducting research in applied settings, or design and deliver professional development or workshops for practitioners and parents. More senior researchers can also advocate for the importance of these experiences and their impact on their peers and the field while serving on a variety of boards and committees (e.g., promotion tenure committees in universities, conference planning committees for professional organizations; grant review committees for funding agencies). Integrating the field of reading research and practice with translational science will require reading researchers to take intentional, significant steps throughout their careers to shift the field towards developing and promoting these key competencies from within.

Transactional public engagement

NASEM (2017) suggests that the purpose of formal public engagement is to "facilitate the exchange of information, knowledge, perspectives, and preferences among groups that differ in expertise, power, and values and help them find common ground" (p. 25). In the field of reading research, therefore, effectively translating SOR may require unique and innovative ways to dynamically engage with diverse education stakeholders in mutually beneficial ways to both generate and implement SOR. The field's focus on research within the T0-T2 stages has been accompanied by knowledge dissemination strategies (Southwest Educational Development

Laboratory, 1996) focused relatively more on one-way processes like spread (i.e., proactive distribution of information to potential users) and choice (i.e., reactive distribution of information as requested by potential users) and relatively less on interactive processes like exchange (i.e., multidirectional exchange of information between the developers and potential users) and implementation (e.g., training, coaching, or technical assistance to change knowledge, attitudes, or behaviors). Furthermore, T0-T2 dissemination tends to take place within academic settings, and not with the public and communities. Conversely, T3-T4 reading research studies designed to address P-12 instructional and programmatic decision-making in LEAs and SEAs would be well-suited to more transactional forms of engagement. They would, however, necessitate both new ways to engage stakeholders and new research to study the effectiveness of that engagement.

We suggest that reading researchers begin by using transactional public engagement strategies to disseminate, implement, and generate new knowledge about evidence-based reading instruction in P-12 schools. Effectively engaging diverse educational stakeholders for the purposes of exchange, implementation, and innovation requires acknowledging that various audiences and needs exist and each may interpret and apply SOR differently (NASEM, 2017). Importantly, these audiences include not just teachers, but also policymakers, professional associations, publishers, professional development providers, SEAs, LEAs, schools, and families.

In addition, the disconnect between research findings and instructional practices observed in schools may not be just about the presence or absence of information about SOR, but also about the way in which this information is being communicated and used. Research on scientific communication indicates that two common assumptions about the public's engagement with

evidence are wrong: that people don't act upon evidence because they simply don't know it and, consequently that if science was simply communicated better people would make choices aligned with the evidence (NASEM, 2017). Rather, the research indicates that people rarely make decisions based upon scientific information alone, and instead, are also informed by their goals, needs, values, beliefs, knowledge, and skills. In other words, having knowledge is not a prerequisite for using it.

Therefore, the goals of public engagement should not be just to increase knowledge, but also to influence behavior and decision-making to improve reading achievement for all learners. Transactional strategies might, by design, be better positioned to communicate SOR effectively. Traditionally, interactive engagement activities like coaching, practice-based professional development, and exchanges with end-users have not been typical practice for researchers, despite evidence that these kinds of approaches can increase knowledge and change behavior. For example, in a study using practice-based professional development to implement writing instruction, Harris, Lane, Graham, Discoll, Sandmel, Brindle, and Schatschneider (2012) found improved student outcomes and teacher practice. Meanwhile, an array of "knowledge brokers" have emerged to disseminate research-informed and evidence-based practices to teachers, school administrators, and other education stakeholders (Malin & Brown, 2019). The field lacks both empirical evidence and comprehensive standards on the effectiveness and appropriateness of these providers to disseminate SOR in a manner that produces improved reading achievement. Nonetheless, these providers are increasing in number and in capacity to engage educators in appealing ways, leaving researchers with a very real challenge: how to maintain a productive academic research agenda while also disseminating knowledge gained from that research to end users effectively.

We are encouraged by several innovative models that researchers are using to engage transactionally with education stakeholders. For example, it may be advantageous for the field to consider the use of collaborative and long-term models for engagement, including community-based participatory research models, policy enactment research, sabbaticals in educational settings, community partnerships, collaborative inquiry, and the formation of researcher-practitioner partnerships (Ainscow, Dyson, Goldrick, & West, 2016; Coburn, Penuel, & Geil, 2013; National Research Council, 2003; Benson, Harkavy, & Puckett, 2000; Wallerstein & Duran, 2010). Inherent in these collaborations is an appreciation for the diverse perspectives that drive social change in education, an acknowledgement that how research is often designed (e.g., in laboratory or clinical settings, without input from end-users) can contribute to unintended biases in how knowledge is generated, disseminated, and used, and intentional organizational structures to diminish power dynamics and promote equity (Tseng, Fleischman, & Quintero, 2018; Chicago Beyond, 2019). These endeavors may allow for the collaborative development of feasible models and tailored frames that explain SOR in memorable and useful ways for a variety of stakeholders. They may also lead to solutions, as researchers work alongside practitioners not only to better understand why evidence-based approaches matter to positive student outcomes, but also how barriers and facilitators to successful implementation operate in school-based settings (Race, 2010).

Moreover, researchers may also make use of creative media to engage the public transactionally. It is well accepted that traditional outlets for sharing and applying scientific evidence are not readily accessible to the public for many reasons (e.g., costs of purchasing journal articles or attending conferences; complexity of academic discourse). As researchers increase their capacity and comfort with various attributes of translational scientists, they can

leverage advances in media to disseminate and support the use of research evidence broadly to diverse audiences (Gilliand et al., 2019; Petscher et al., 2020). In addition to presenting at practitioner conferences or writing articles for practitioner journals and magazines, researchers should also explore other platforms of engagement, such as social media (e.g., Twitter, Facebook, Instagram), podcasts (e.g., https://www.seehearspeakpodcast.com/), briefs (e.g., https://improvingliteracy.org/brief), infographics (e.g., https://ies.ed.gov/ncee/edlabs/infographics/), apps (e.g., https://qmi-fcrr.shinyapps.io/ScreeningToolSelector/), OpEds, and popular press interviews.

This kind of engagement also lends itself to T3-T4 reading research studies, which can be designed to examine the more pragmatic issues related to use of evidence-based reading instruction in schools. Studies can also be designed to examine the extent to which engagement strategies and processes were effective at changing knowledge, behaviors, and decision-making related to reading practices in schools. For example, given research findings that teachers and principals access, perceive, and use research evidence to make decisions differently than district leaders and policymakers (Coburn, Toure, & Yamashita, 2009; Finnigan, Daly, & Che, 2013; Penuel, Briggs, Davidson, Herlihy, Sherer, Hill, Farrell, & Allen, A 2017), it would be advantageous to investigate which knowledge dissemination strategies are more or less effective for changing each stakeholder's knowledge related to implementing evidence-based reading interventions in schools. Finally, T3-T4 studies informed by dissemination and implementation science research add value to research across the entire translational science spectrum, as data gathered from education stakeholders in these studies can be used to inform the iterative process of designing more effective practices, program, and policies in diverse settings and for diverse learners (Douglas, Campbell, & Hinkley, 2015). Integrating the field of reading research and

practice with translational science will require reading researchers to engage with the public in innovative and intentional ways to support the uptake of evidence-based reading practices, programs, and policies in schools.

Collective communication about a single shared problem

Researchers from various disciplines contribute diverse knowledge and perspectives on how society engages with the construct we have collectively come to refer to as "reading". The incredible advances in SOR that have emerged thus far are attributable, in part, to diversity within the field. Irrespective of their disciplinary lens, reading scholars share in their concern for the nation's reading crisis and work to deliver solutions to ameliorate the reading achievement gap. Issues of access, equity, and opportunity also play core roles in these gaps, as barriers to reading achievement arise from many factors both inside and outside of schools. We argue that one critical barrier to solving the nation's reading crisis is unified messaging focused on the fundamental problem to be solved.

Depending on one's disciplinary perspective and area of expertise, a reading researcher may insist that the problem is ensuring grade-level reading performance on state-mandated tests, while others may insist that it is ensuring fluent sight word reading or text comprehension or academic language or content knowledge or motivation for reading. Others still may postulate that the problem is preventing reading failure, closing reading achievement gaps, improving reading instruction, or encouraging literacy to ensure an equitable literate citizenry. We argue that solving each of these problems addresses the nation's reading crisis. The diversity of disciplines engaged in SOR all but ensures that many varied solutions will emerge. Hence, agreement upon the message is not the same as agreement upon the methods or the solutions.

Research on science communication indicates that communicating about science-related controversies (e.g., vaccinations, climate change) is particularly difficult because the debate is typically less about scientific knowledge and more about beliefs, values, and interests (NASEM, 2017). In these spaces, public and academic discourse is often clouded by multiple competing voices resulting in what the public perceives as uncertainty. There is limited research evidence on how best to communicate consensus in controversial contexts (NASEM, 2017). Furthermore, applying a translational science lens to the field of reading research will not squelch the ongoing debates about what SOR is or how or if it should be applied in school settings. However, translational science may provide a framework to pivot these conversations towards collective communication about concerted efforts to solve our single, shared problem: the nation's reading crisis.

Thus, our final suggestion for reading researchers is to begin by articulating a single shared problem and our concerted efforts to solve it. Importantly, agreement on the problem does not require agreement on how to solve it. It only reaffirms our shared commitment to finding the solution. Considering the field's diverse perspectives and approaches to building and applying SOR for reading instruction, we propose unified messaging on our concerted efforts to ensure that all P-12 learners are provided with instructional techniques that teach them how to read adequately. Particular aspects of this problem, the lack of translational science. Aspects of this problem are particularly important to specify. First, our work must address the reality of authentic school settings, where the application of SOR may be best realized with most P-12 learners. Second, the problem is focused on P-12 learners, spanning the developmental timespan during which much of SOR can be actualized in policy and practice to improve reading achievement. Third, the problem is inclusive of all P-12 learners, including, and arguably more

importantly for those who may be more vulnerable to reading difficulties. It is this population of student for whom the field requires significant additional information to support towards reading success in school.

The reading and literacy fields would also benefit from unified messaging around our collective efforts. Translational science requires team science—individual scientists from different disciplines with diverse perspectives, skills, and talents who decide to unite their efforts to discover and develop solutions to persistent problems (Gilliand et al., 2019; Petscher et al., 2020). It is imperative that if we are to be successful in communicating both what we know about SOR, and what we still do not know, reading researchers must come together to communicate about their collective efforts to build and apply SOR, demystifying issues upon which there is or is not sufficient scientific evidence, explaining how scientific uncertainty is decreased over time, and engaging the public in the process of discovery. This communication should happen in both academic and non-academic contexts (e.g., special issues of journals; symposia at research and practitioner conferences; webinars and podcasts; Twitter exchanges), reducing the confusion that can arise when science is not shared repeatedly, transparently, and responsibly with the public.

Importantly, researchers with opposing perspectives can come together to conduct research. For example, in adversarial collaboration (Mellers, Hertwig, & Kahneman, 2001), researchers or research teams with conflicting hypotheses collaborate on a research project to resolve the dispute. These joint research efforts have the potential not only to produce more robust and informative research findings but also increase team member's capacity to communicate about their shared goals—a key competency for translational scientists. Integrating the field of reading research and practice with translational science will require reading

researchers to collaborate and communicate collectively about the field's ongoing efforts to solve the nation's reading crisis by ensuring that all P-12 learners are reading and succeeding in school.

Translational Science in Action: Promising Applications within Reading Research

In proposing a roadmap for the translational science of reading, we acknowledge that the recommendations we've suggested are tentative and dependent, in part, upon the field's interest in pursuing research in what may feel like unfamiliar and perhaps uncomfortable ways. It also requires deep and respectful collaboration between stakeholders who have different training, backgrounds, methodological approaches, and roles in the pursuit of scientific inquiry. We have argued that integrating aspects of translational science into reading research will require intentional shifts in the way the field carries out basic and applied research, cultivates and collaborates with scientists, engages with the public, and communicates about its science. We have also provided some examples of how the field is already advancing toward translational science, from increasing numbers of replication studies to authentic research-practice partnerships. We view these examples as models for how scholars can apply aspects of the translational science to reading research to improve reading instruction and student achievement. Importantly, these examples demonstrate that reading researchers need not begin anew; rather, aspects of translational science can be incorporated into existing projects, collaborations, and initiatives.

As a group of interdisciplinary researchers, we too have begun to incorporate aspects of translation into our ongoing work and to consider it as we begin new work. In part, this was the impetus for our collaboration on this roadmap: an exercise in imaging the critical crossroads we might encounter as we travel along in the journey to addressing the nation's reading crisis

together. We expect that, as we and others continue this work, the roadmap will evolve and become more refined for reading and education researchers who translate the science of reading to ensure that all P-12 learners are reading and succeeding in school. We urge the multi-disciplinary scholars that make up the larger body of literacy and reading researchers to more consistently engage in meaningful ways with schools and communities and to coalesce around a research agenda that values and promotes the translation of research findings into authentic school and classroom settings.

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