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A two-step sampling weight approach to growth mixture modeling for emergent and developing skills with distributional changes over time☆

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ABSTRACT

Emergent reading skills are crucial to the development of fluency and comprehension, and as such, assessing kindergarten entry skills is critical to inform educational decisions. However, skills that are assessed too early are likely to yield many zero scores, as most students do not yet have the experience or ability to perform the task. Although these floor effects typically lessen across time to show near-normal distributions, growth models cannot accommodate repeated measures with different distributions. The purposes of this paper are to (a) introduce a two-step sampling weight approach to growth mixture modeling that addresses distributions changing over time, and (b) apply the approach to a sample of 1911 kindergarten students universally screened on an emergent reading skill (letter sound fluency) across the year. Results distinguish between students that begin at zero and make meaningful gains and those who begin at zero and do not. We discuss the methodological implications of our approach and the practical implications for growth modeling and early identification.

1. Introduction

Theory indicates, and research supports, that universal screening and early intervention can significantly improve student outcomes if those at risk are identified early (e.g., Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998). Universal screening assessments are generally administered to all students in a classroom, school, or district to identify those at risk of poor learning and/or behavioral problems who could potentially benefit from intervention (National Center for Response to Intervention [NCRTI], 2015a). These assessments are often part of an RTI model, a multi-level, early identification/prevention framework that (often) involves curriculum-based measurement (CBM; Deno, 1985) assessments and intervention to increase student achievement (NCRTI, 2015a). Progress monitoring assessments are used to assess student performance, quantify the rate of improvement (or responsiveness to intervention), adjust the instructional program to match the student's needs, and evaluate the effectiveness of the intervention (NCRTI, 2015a). The success of an applied RTI model hinges on early identification of students at risk for poor learning outcomes.

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1.1. School entry assessment of emergent reading skills for early identification and growth

There is currently an increased interest by policy-makers, administrators, educators, and researchers in assessing school (or kindergarten) entry skills (Stedron & Berger, 2014; U.S. Department of Education, 2011) to understand or identify (a) proficiency upon entry, (b) students at risk for poor learning outcomes, (c) disparities among student groups, (d) specific domains to target, and (e) growth over time.

School entry assessments are administered to children upon entry into the education system to identify the academic, social, and behavioral skills and competencies necessary for school participation (Glover & Albers, 2007; Meisels, 1987). Here, we use the CBM theoretical and research bases to distinguish between two potential school entry assessment types: general outcome measures and mastery monitoring. General outcome measures reflect the overall performance of a student in the curriculum being taught over an extended time, and includes items that both preview and review skills (Tindal, 2013). Assessment development (e.g., content, design, scaling) can account for and eliminate floor and ceiling effects by building a continuum of domain skills. (See Clemens et al. (2015), Table 1 for descriptive statistics and distribution properties of kindergarten mastery monitoring and general outcome measures). In contrast, mastery monitoring measures task-analyze the academic construct outcome (e.g., reading proficiency) into a hierarchy of component skills (e.g., letter names, letter sounds, phoneme segmenting, word fluency) which are explicitly taught in a tractable sequence (Deno, no date; NCRTI, 2015b). Zero scores on entry assessments of mastery skills (e.g., letter sounds) are generally expected because the skills have yet to be explicitly taught to some students; once instruction occurs and learning follows, the score distribution approaches normality. For example, Fig. 1 illustrates distributional change on a Kindergarten letter sounds fluency measure for fall (large proportion of zero scores), winter (bimodal distribution), and spring (approaching normality) measures. (Note that the *y*-axes represent different distributions in order to accommodate the frequency of zeros in fall [entry] as well as better display the distribution shapes in winter [mid-year] and spring [end of year]).

Learning the relations between letters and their corresponding sounds is an integral component of learning to read (e.g., Adams, 1990), and thus integral to school readiness assessment. Emergent component reading skills such as the knowledge of and fluency with letter names (LN), letter sounds (LS), and phoneme segmentation (PS) are generally thought by researchers and educators to develop in concert (Burgess & Lonigan, 1998; Ritchey & Speece, 2006; Wagner, Torgesen, & Rashotte, 1994) and considered to be the foundation of oral reading fluency (ORF) and comprehension. These emergent reading skills have a strong predictive relation and account for meaningful proportions of variance in later reading skills (Foorman, Francis, Novy, & Liberman, 1991; Speece, Mills, Ritchey, & Hillman, 2003; Speece, Ritchey, Cooper, Roth, & Schatschneider, 2004; Wagner et al., 1997), and failure to acquire these skills is an indicator of future reading disabilities (Jenkins & O'Connor, 2002).

The importance of emergent reading skills in future reading proficiency has been repeatedly documented by reading researchers. Kindergarten LN, PS, and LS fluencies were found to explain a significant amount of unique variance in literacy outcomes (Ritchey & Speece, 2006), and LS and PS upon entry into kindergarten predicted nonsense word fluency, word reading, and reading comprehension at the end of the year (Linklater, O'Connor, & Palardy, 2009; Ritchey, 2008; Speece & Ritchey, 2005). Ritchey and Speece (2006) found that LS fluency plays a central role in precursor literacy skills, providing the mechanism that connects emergent reading skills to word reading, making it an ideal measure for early identification of poor learning outcomes. Other studies have documented that (a) Kindergarten LN and LS measures are significant predictors of spring ORF in Grade 1, beyond that of fall Grade 1 ORF (Stage, Sheppard, Davidson, & Browning, 2001); and (b) LN and LS fluencies at the end of kindergarten predicted Grade 1 ORF, and LN fluency predicted Grade 1 ORF growth (Stage et al., 2001).

Moreover, in a study of the growth of reading skills and its correlates, emergent reading skills in kindergarten uniquely predicted letter word identification, word attack, and passage comprehension skills in Grade 3, and was the only unique predictor in letter word identification growth (Speece et al., 2004). Research has shown that initial skill proficiency in LN and PS differentiated students who could read from students who could not read, whereas LS fluency differentiated students in both initial skill and growth (Ritchey & Speece, 2006). That is, LS development was related to proficiency upon entering kindergarten, but LS growth provided meaningful variance independent of initial status. That is, better readers had a fall kindergarten LS score nearly 50% higher than lesser readers and a growth rate about 66% higher. The authors postulated the existence of "three educationally-relevant groups of kindergarten children: those who can already read words, those who learn to read words, and those who still do not read words in kindergarten" (Ritchey & Speece, 2006, p. 323). This finding is consistent with research that showed at risk students continuing to develop LS fluency in the spring of Grade 1 whereas not-at risk students had already acquired and consolidated this knowledge (Speece & Ritchey, 2005).

Table 1
Descriptive statistics and correlations.

							Correlations		
	Mean	*SD*	Min	Max	Skewness	Kurtosis	2. LSF fall	3. LSF winter	4. LSF spring
1. LNF fall	19.00	14.35	0	88	0.63	−0.14	.76	.65	.48
2. LSF fall	5.92	8.35	0	51	1.79	2.98		.62	.42
3. LSF winter	18.79	11.83	0	90	0.58	0.43			.64
4. LSF spring	33.55	12.27	0	96	0.12	0.47			

Note. $n = 1911$ kindergartners. All correlations significant at the $p < 0.01$ level.