RAN Total Time Low-Risk and At-Risk Values for Beginning-of-Year Kindergarten

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Rapid Automatized Naming (RAN) is the "ability to name, as quickly as possible, visually presented familiar symbols, such as digits, letters, colors, and objects" (Georgiou et al., 2013, p. 218). RAN involves both speed and accuracy. That is, not only must a student name items quickly, they must do so without error. As such, the student must be familiar with the items to be named, for the task to be considered a RAN task.

The large research database on RAN suggests that it is typically a good predictor of future reading difficulties. There are various theories as to why this might be the case. For example, Landerl et al. (2019) suggests that "RAN taps into a language-universal cognitive mechanism that is involved in reading alphabetic orthographies" (p. 220). Additionally, however, Landerl et al. has said that "sequential naming mimics the timely integration of visual and verbal skills required during efficient word recognition" (p. 221). According to Wolf and Norton (2012) RAN is a "microcosm" of the reading process. What this means is that RAN mimics or summon the reading circuit by immediately connecting visual and phonological information. RAN essentially provides a peek at the same processes involved in later-developing reading circuitry. For a reader to comprehend while reading, they must integrate a vast circuit within their brain with considerable precision, accuracy, and speed. RAN offers insight into this process, though on a smaller scale.

Despite being a good predictor of future reading problems, difficulties with RAN do not impact reading skills as much as difficulties with phonological awareness (PA) (Georgiou et al., 2011; Pennington et al., 2001). When students have strong PA skills but have difficulties with RAN, the impact on reading skills is typically milder than when students have difficulties with both RAN and PA (see Kilpatrick, 2015). In addition, considerable research support for RAN as a strong predictor of reading skill exists, though variation in the strength of the relation between RAN skill and reading skill is also evident (see Araújo et al., 2015 for discussion). Notably, Kilpatrick (2015) states that at this time, a research-based means to directly improve RAN is not known; however, there is evidence to suggest that meaningful improvement in reading skills is associated with improvements in RAN. Furthermore, as noted by Norton (2021), "despite extensive research, there is no single test or single cut-off score that indicates that RAN is a problem" (p. 27).

Acadience RAN Measures

The Acadience RAN measures are brief assessments that are individually administered. They are based on established procedures for creating and interpreting RAN tasks used in decades of research by multiple researchers (see Araújo et al., 2015). Acadience RAN is composed of three brief measures: RAN Objects, RAN Letters, and RAN Numbers. Students begin with RAN Objects and proceed to RAN Letters. RAN Numbers is only administered to students who discontinue on the RAN Letters task. A Spanish version of Acadience RAN also is available.[1]

[1] Both the English and Spanish versions of RAN are available for free download from www.acadiencelearning.org

Some preliminary research on Acadience RAN has examined the extent to which it provides information for predicting reading skills above and beyond extant measures of reading ability. Some researchers view RAN as a unique piece of information for understanding a child's reading ability (e.g., Norton & Wolf, 2012). On the other hand, there has been some speculation that screening for RAN ability can be adequately accommodated using existing measures of reading skills, specifically Letter Naming Fluency (LNF) (University of Oregon, 2018–2019). Our preliminary research suggests that RAN is not only strongly related to later reading outcomes, but also adds significant variability explained, independent of the Acadience Reading Composite Score (RCS) or LNF (see Gray et al., 2020). However, that initial research did not delimit the sample to include only those schools where RAN was used for universal screening purposes. One goal of this study was to further examine predictive validity and the contribution of RAN to explaining reading outcomes across a broad range of student performance, thus data selected for analysis was from schools in which 90% or more students received a complete and valid RAN screening assessment at the beginning of kindergarten. Another goal of this study is to explore cut points for risk on RAN measures.

Purpose and Research Questions

The purpose of this study was to further examine the role of Acadience RAN measures in predicting reading outcomes and explore possible cut points for risk. The following specific research questions were examined:

1. Does RAN Total contribute to the Reading Composite Score in predicting the middle-of-kindergarten Reading Composite Score?
2. Does RAN Letters contribute to the Reading Composite Score in predicting the middle-of-kindergarten Reading Composite Score?
3. Does RAN Total contribute to Letter Naming Fluency in predicting the middle-of-kindergarten Reading Composite Score?
4. Does RAN Letters contribute to Letter Naming Fluency in predicting the middle-of-kindergarten Reading Composite Score?
5. What values of RAN Total could be used to indicate Low-Risk and At-Risk status on RAN Total at the beginning of kindergarten?
6. What are the instructional implications of risk status on RAN Total at the beginning of kindergarten?

Method

Participants

Students' data were selected for inclusion in this study based upon 4 criteria: (1) a complete and valid measure of RAN Total time at the beginning of kindergarten, (2) an RCS at the beginning of kindergarten, (3) an RCS in the middle of kindergarten, and (4) enrollment in a school where 90% or more students received a complete and valid RAN screening assessment at the beginning of kindergarten. Measures of RAN were required to be valid in the sense that students were highly accurate on the RAN assessment, making no more than 5 errors on any form (90% accuracy). Measures of RAN Total were also required to be complete in the sense that the total time was made up of 2 valid forms, either: (a) RAN Objects time plus RAN Letters time, or (b) RAN Objects time plus RAN Numbers time. The RAN Numbers option was only used if the student made more than 5 errors on RAN Letters or otherwise discontinued. As is clear from the sample sizes for RAN Numbers in Table 1, many assessors administered all three forms, but RAN Numbers was not used to compute

the RAN Total time except in the cases where a valid RAN Letters was not available. Descriptive statistics and intercorrelations of the measures for the 803 students who met selection criteria are reported in Table 1.

Table 1

Intercorrelations and Descriptive Statistics for Students in Schools with 90% Complete and Valid RAN Screening at the Beginning-of-Year Kindergarten Benchmark Assessment

	Acadience Measure						
Acadience Measure	1	2	3	4	5	6	7
1. Objects time (bk)							
2. Letters time (bk)	.60						
3. Numbers time (bk)	.59	.76					
4. Total time (bk)	.87	.92	.79				
5. RCS (bk)	-.47	-.62	-.53	-.60			
6. LNF (bk)	-.46	-.64	-.54	-.61	.92		
7. RCS (mk)	-.42	-.55	-.54	-.55	.71	.66	
N	803	750	684	803	803	803	803
M	81.42	72.80	72.92	155.40	49.47	29.62	154.38
SD	20.24	24.77	25.36	40.59	24.60	16.40	49.44
Percent of students by likely need for support							
Intensive	2%	3%	4%	5%	6%		8%
Strategic	10%	7%	11%	10%	13%		15%
Core	88%	89%	85%	85%	81%		76%

Note. bk indicates the measure was administered at the beginning of kindergarten. mk indicates the measure was administered in the middle of kindergarten. RCS is the Reading Composite Score. For the RCS, likely need for support of intensive, strategic, and core corresponds to Well Below Benchmark, Below Benchmark, and At or Above Benchmark, respectively.

It is clear from these descriptive statistics that the current sample is relatively high performing. For example, on the beginning-of-kindergarten RCS 6% of students performed Well Below Benchmark, 13% were Below Benchmark, and 81% were At or Above Benchmark. By way of comparison, in the 2014–2015 nationally representative normative sample, at the beginning of kindergarten, 22% of students scored Well Below Benchmark, 19% scored Below Benchmark, and 59% scored At or Above Benchmark. A second pattern of note in the intercorrelations is that all measures are moderately to strongly correlated, ranging from -.42 to .76 (excluding subtest–total test correlations).

Results

The contribution of RAN given the beginning-of-kindergarten benchmark assessment was examined in a series of hierarchical regression models fitting a full and reduced model. The full model included the RAN assessment being examined, and the reduced model consisted of the benchmark assessment being controlled. The additional variance explained by RAN over and above the variance accounted for by the benchmark assessment is reported as the delta R^2. The results are reported in Table 2.

Table 2

Multiple Regression Models Examining the Contribution of RAN Total and RAN Letters to the Reading Composite Score and Letter Naming Fluency in Predicting Middle-of-Year Reading Composite Score

Regression models	*N*	R^2	Delta R^2
Contribution of RAN-Total given RCS			
Full Model: RCS (bk) RAN-Total (bk)	803	.530	
Reduced Model: RCS (bk)	803	.505	.025
Contribution of RAN-Letters given RCS			
Full Model: RCS (bk) RAN-Letters (bk)	750	.513	
Reduced Model: RCS (bk)	750	.489	.024
Contribution of RAN-Total given LNF			
Full Model: LNF (bk) RAN-Total (bk)	803	.466	
Reduced Model: LNF (bk)	803	.430	.036
Contribution of RAN-Letters given LNF			
Full Model: LNF (bk) RAN-Letters (bk)	750	.443	
Reduced Model: LNF (bk)	750	.406	.037

Note. The dependent variable for all models is the Reading Composite Score in the middle of kindergarten comprised of First Sound Fluency, Letter Naming Fluency, Phoneme Segmentation Fluency, and Nonsense Word Fluency. All models and delta R^2 are significant, $p < .001$. No interaction effects were significant, $p > .05$. RCS is Reading Composite Score, comprised of First Sound Fluency and Letter Naming Fluency at the beginning of kindergarten. LNF is Letter Naming Fluency. bk is beginning kindergarten.

1. Does RAN Total contribute to the Reading Composite Score in predicting middle-of-kindergarten Reading Composite Score?

In the first comparison of models, RAN Total contributed about 2.5% additional variance over and above the RCS, which is a significant, modest but potentially important additional variance explained.

2. Does RAN Letters contribute to the Reading Composite Score in predicting middle-of-kindergarten Reading Composite Score?

In the second comparison of models RAN Letters contributed about 2.4% additional variance over and above the RCS which is also a significant, modest but potentially important contribution. The contribution of RAN Letters was similar to RAN Total. Although it appears that RAN Letters explains 0.1% less additional variance than RAN Total, the difference is exaggerated by rounding and is actually only 0.000236, a trivial difference. Thus, in terms of additional variance explained, it appears that RAN Total and RAN Letters would be virtually interchangeable.

3. Does RAN Total contribute to the Letter Naming Fluency in predicting middle-of-kindergarten Reading Composite Score?

In the third comparison of models, RAN Total contributed about 3.6% additional variance over and above LNF, which is again a significant, modest but potentially important additional variance explained. This comparison is of interest because some have argued that LNF provides a good indicator of RAN. However, these findings indicate that RAN Total is contributing variance explained distinct from LNF.

4. Does RAN Letters contribute to the Letter Naming Fluency in predicting middle-of-kindergarten Reading Composite Score?

In order to delve deeper into the distinct variance explained by RAN controlling for alphabet knowledge, in the fourth comparison of models RAN Letters contributed about 3.7% additional variance over and above LNF, which is, yet again, a significant, modest but potentially important additional variance explained. While both measures involve naming of alphabetic symbols and are timed, the RAN measure consists of repetitions of the same 5 easy letters and requires high accuracy for a valid score. In contrast, the LNF measure consists of all letters and assesses both accuracy and fluency with letter names.

5. What values of RAN Total could be used to indicate Low-Risk and At-Risk status on RAN Total at the beginning of kindergarten?

The likelihood or probability of being At or Above Benchmark on the middle-of-kindergarten RCS as a function of RAN Total time was examined in a logistic regression analysis. Similar analyses were also conducted for RAN Objects, RAN Letters, and RAN Numbers. The results are reported in Table 3.

Table 3

Predicting At or Above Benchmark on the Middle-of-Year Reading Composite Score

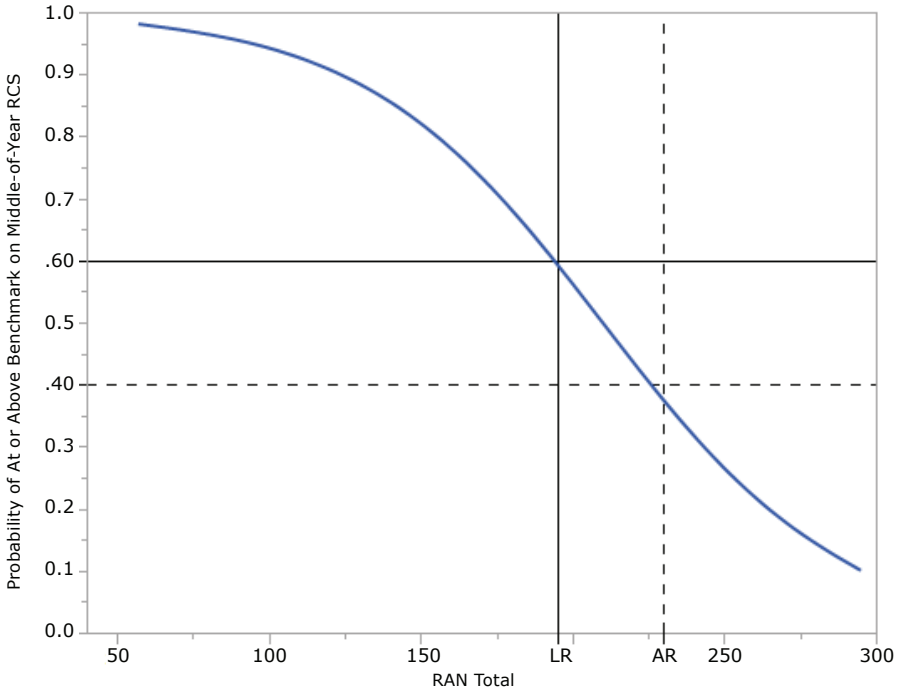
RAN Measure	*N*	Generalized R^2	AUC	At-Risk	Low-Risk
RAN Total (bk)	803	.225	.765	230	195
RAN Objects (bk)	803	.144	.717	126	105
RAN Letters (bk)	750	.192	.751	126	103
RAN Numbers (bk)	684	.196	.744	123	100

Note. bk is beginning kindergarten. The Low-Risk score represents the RAN time at or below which the probability of being At or Above Benchmark in the middle of kindergarten is .60 or higher. The At-Risk score represents the RAN time at or above which the probability of being At or Above Benchmark in the middle of kindergarten is .40 or lower. All models significant, $p < .0001$.

RAN Total was a significant predictor of the probability or likelihood of being At or Above Benchmark in the middle of kindergarten, explaining about 23% of the variance. The curve representing the probability of being At or Above Benchmark in the middle of kindergarten for each score on RAN Total is provided in Figure 1. For RAN Total scores where the curve is above the solid, horizontal reference line at .60 (195 or less) the student is likely to meet the middle-of-kindergarten benchmark. For RAN Total scores where the curve is below the dashed, horizontal reference line at .40 (230 or more) the student is unlikely to meet the middle-of-kindergarten benchmark. For values of RAN Total between the reference lines (196–229), a reasonably confident prediction of meeting the middle-of-kindergarten benchmark is not possible.

Figure 1

Predicted Probability of Being At or Above Benchmark on the Reading Composite Score in the Middle of Kindergarten for Each Value of RAN Total in Schools with at Least 90% Complete and Valid Screening at the Beginning of Kindergarten



Note. LR is Low-Risk. RCS is Reading Composite Score. AR is At-Risk.

Similar procedures were used to establish Low-Risk and At-Risk values for RAN Objects, RAN Letters, and RAN Numbers. RAN Total had the highest R^2 and Area Under the Curve.

6. What are the instructional implications of risk status on RAN Total at the beginning of kindergarten?

To examine the instructional implications of risk status on RAN Total at the beginning of kindergarten two sequential logistic regression models were fit. The full model included the beginning-of-kindergarten RCS, RAN Total risk status using the Low-Risk and At-Risk values reported in Table 3, and the interaction effect. The results are reported in Table 4.

Table 4

Predicting At or Above Benchmark on the Middle-of-Year Reading Composite Score From Beginning-of-Kindergarten Reading Composite Score and RAN Total Risk

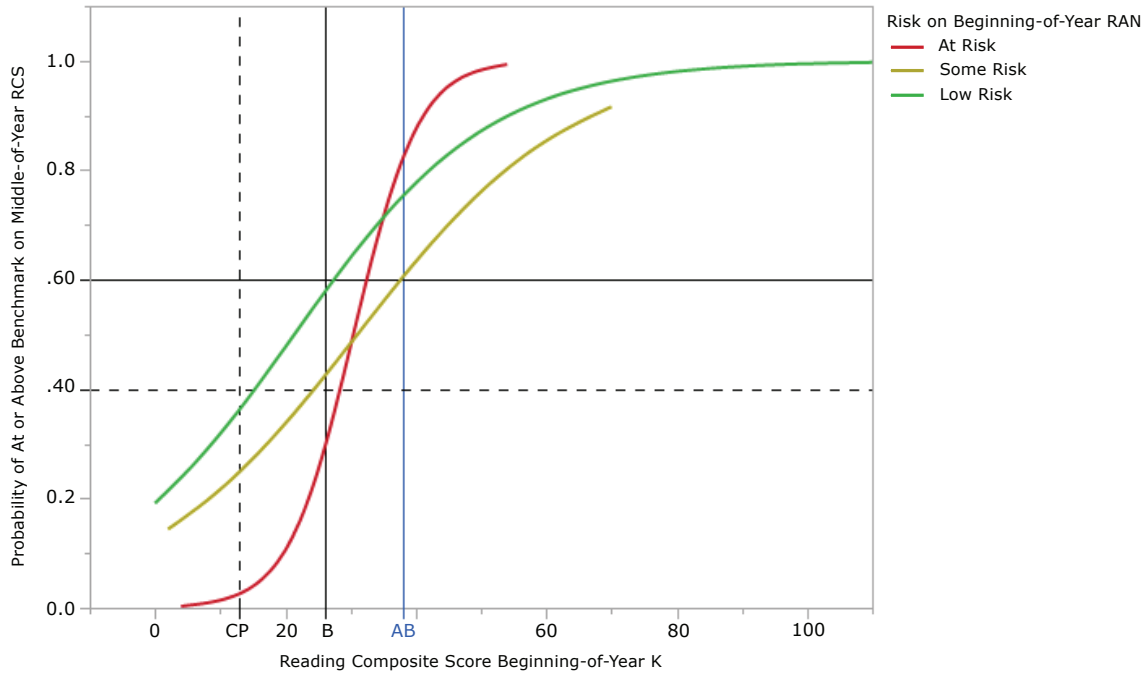
Model	*N*	Generalized R^2	AUC
Full Model: RCS (bk), RAN Total risk (bk), RCS*RAN Total risk	803	.413	.854
Reduced Model: RCS (bk)	803	.390	.846

Note. Change in R^2 = .023. RCS is Reading Composite Score. bk is beginning of kindergarten. RAN Total main effect, p = .0618; RCS*RAN Total risk interaction effect, p = .0189.

Adding RAN Total risk status to the RCS explained an additional 2.3% of the variance in likelihood of attaining the middle-of-kindergarten benchmark for the RCS. The contribution of RAN Risk was modest in magnitude, and significant at $p < .05$. The importance and instructional implications were examined by graphing the logistic regression curves for each risk status as illustrated in Figure 2. These implications for instruction are summarized in Table 5 along with the sample size in each combination of RAN Total risk and RCS status.

Figure 2

Predicted Probability of Being At or Above Benchmark on the Reading Composite Score in the Middle of Kindergarten for Each Value of Reading Composite Score and Each Level of Risk on RAN Total



Note. RCS is Reading Composite Score. CP is cut point. B is Benchmark. AB is Above Benchmark.

For students with RAN Total scores in the Low-Risk range (195 or less) the likelihood of meeting the middle-of-kindergarten benchmark was very close to design specifications: (a) less than .40 for students where were well Below Benchmark at the beginning of kindergarten on the RCS, (b) between .40 and .60 for students who were Below Benchmark, and (c) greater than .60 for students who were At or Above Benchmark.

However, students with RAN Total scores in the Some-Risk range (196–229) required Above Benchmark scores ($n = 49$) on the beginning-of-kindergarten RCS before the probability of reaching the middle-of-kindergarten benchmark was .60 or greater where they are likely to need core support to achieve the middle-of-kindergarten benchmark. If they were between the At Benchmark and Above Benchmark levels ($n = 17$), the probability of middle-of-kindergarten benchmark was roughly between .40 and .60, a level where they are likely to need strategic support to attain the middle-of-kindergarten benchmark. Those who were Below Benchmark ($n = 13$) had less than .40 probability of reaching the benchmark and were likely to need intensive support to achieve the middle-of-year benchmark.

Finally, for students with RAN Total scores in the At-Risk range (230 or more) the pattern is less clear. If they were At Benchmark ($n = 14$) or Above Benchmark ($n = 18$) their likelihood of meeting the middle-of-year benchmark for the RCS was often greater than for students with the same RCS with some risk, and sometimes

even for those with Low-Risk. Since these results are counter-intuitive and difficult to explain theoretically, we recommend caution in interpretation. It makes the most sense to us to consider these students as similar to those with some risk on RAN Total and consider them likely to need strategic support if they are between the At Benchmark and Above Benchmark level on the beginning-of-kindergarten RCS.

For students who were Below Benchmark or Well Below Benchmark on their RCS and who were At-Risk on RAN Total ($n = 6$), the probability of meeting the middle-of-kindergarten benchmark was extremely low, lower than for any other group of students in the study, and an indication that they are likely to need intensive support with additional and sustained explicit instruction, modeling, opportunities to respond, practice, and feedback if they are to achieve the middle-of-kindergarten benchmark. This combination or scores was rare, however, and the small sample size limits our confidence in these conclusions.

Table 5

Likely Need for Support by Reading Composite Score Status and RAN Total Level of Risk for Students

Reading Composite Score	RAN Total: Low-Risk (195 or less)	RAN Total: Some Risk (196–229)	RAN Total: At-Risk (230 or more)
Well Below Benchmark	Intensive Support ($n = 27$)	Intensive Support ($n = 13$)	**Intensive Support**[a] ($n = 6$)
Below Benchmark	Strategic Support ($n = 73$)	Intensive Support ($n = 17$)	Intensive Support ($n = 14$)
At Benchmark	Core Support ($n = 80$)	Strategic Support ($n = 23$)	Strategic Support ($n = 10$)
Above Benchmark	Core Support ($n = 506$)	Core Support ($n = 26$)	Core Support ($n = 8$)

[a] Likely to need additional and sustained explicit instruction, modeling, opportunities to respond, practice, and feedback.

Discussion

Limitations

The first and most important limitation of this study is the small sample size and the high performing nature of the sample. While it seems unusual to discuss the limitation of a small sample size in a study with $n = 803$, the problem arises when combined with a high performing sample resulting in only 46 scoring Well Below Benchmark on the beginning-of-kindergarten RCS, and only 6 of those additionally scoring in the at-risk range on RAN Total. It will be desirable to replicate these findings with a larger dataset and one that is more representative of the full range of performance.

A second limitation is the result of decisions about the selection criteria for the study. One reasonable use of RAN is for universal screening at the beginning of kindergarten. This study speaks most directly to that use. Another reasonable use of RAN would be targeted screening of students selected by their teacher or other educator as likely to have difficulty learning to read possibly related to low RAN. A sample selected for RAN screening may have a different percent of variance explained and a different pattern of significant effects.

Summary of Results and Implications for Practice

First, consistent with multiple prior studies, RAN Total was strongly correlated with future performance on essential early literacy and reading skills, at least from the beginning to middle of kindergarten. In addition, RAN Total contributed about 2.5% additional variance over and above the RCS, which is a significant, modest but potentially important additional variance explained. When RAN Total was evaluated as levels of risk,

risk and interactions with risk added about 2.3% additional variance explained over and above the beginning-of-kindergarten RCS. The instructional implications of this additional variance explained were to increase the likely need for support for students who were below the Above Benchmark status on the beginning-of-kindergarten RCS. Students who were Below Benchmark and Well Below Benchmark on the RCS and who were At-Risk on RAN Total appeared to be the most affected.

Second, the unique contribution of RAN Total appeared to be substantially less than some prior research (e.g., Gray et al., 2020). Both samples were relatively high performing, and the analytic approaches were similar. However, this sample was selected to represent a universal screening scenario while the Gray et al. (2020) sample may represent more students who were targeted for RAN screening potentially based on educator concerns, school practices, or other criteria. Another difference between the two studies is in the method of handling missing data. This study used list-wise deletion while Gray et al. used an alternative method of dealing with missing data.

Third, RAN Letters appeared to function very similarly to RAN Total in predicting future reading skills. A reasonable approach may be to utilize a multiple-gating approach. If students are in the Above Benchmark status on the RCS, no further RAN screening is necessary. For students who are not Above Benchmark, an additional screening assessment with RAN Letters would be conducted. If the student is at Low-Risk on RAN Letters, no additional RAN screening would be indicated. For students who are not Above Benchmark and who are not Low-Risk on RAN Letters, RAN Objects would also be administered to obtain a RAN Total score with the instructional implications outlined above.

While the multiple-gating approach would be more time efficient, we currently recommend universal screening with RAN Total for two reasons. First, levels of risk on RAN were spread throughout the range of RCS, including the Above Benchmark Status. Throughout that range, students who were at some risk on RAN Total experienced a lower probability of being At or Above Benchmark on the middle-of-kindergarten RCS and it seems potentially important for the teacher to be aware of that increased risk. Second, the combination of RAN Objects and RAN Letters (or RAN Numbers) ensures that the RAN score is a combination of non-alphanumeric and alphanumeric symbols, which increases our confidence that we are getting at the theoretical construct of RAN.

Future Research

Future research will examine Low-Risk and At-Risk values for other middle and end of kindergarten as well as beginning, middle, and end of first grade. Additionally, we will continue to examine the role that RAN plays in predicting outcomes for reading across grades K through 6. Finally, we will examine any differences in the value of RAN as a predictor as student grade level increases.

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