Phonemic Awareness as a Mediator of RAN and Later Reading Outcomes

Jacob S. Gray, Ph.D.
Kelly A. Powell-Smith, Ph.D.
Amy N. Warnock, B.S.
Acadience Learning Inc.

INTRODUCTION

Rapid Automatized Naming (RAN) involves quickly and accurately naming repeated sets of familiar items. RAN is a significant predictor of later reading skills, even when controlling for other reading skills, such as letter naming fluency (Gray et al., 2020). Additional questions remain as to why and how RAN predicts later reading outcomes.

One possible mechanism by which RAN predicts important reading skills is the so-called "double deficit hypothesis," which places students into one of four categories based on RAN and phonemic awareness (PA) skills (Cronin, 2011). Students who score highly on both RAN and PA are termed "no-deficit," while students who score poorly on both measures are considered "double deficit." Students who score well on RAN but poorly on PA are considered to have a "phonological deficit," while students who do poorly on RAN but well on PA are considered "poor with naming speed." Perhaps predictably, students with a double deficit fare the worst in reading skill development, while students with no deficit are comparably well-off.

The double deficit hypothesis perhaps conflicts with the model of RAN and orthographic knowledge provided by Martinez et al. (2021). According to this hypothesis, PA mediates the relationship between RAN and later reading fluency. Further, Wolff (2014) has suggested there is uncertainty regarding whether PA and RAN are distinct skills. The small study by Wolff indicated that PA and RAN both tap phonological processes in common with reading.

The purpose of the present study was to investigate if PA itself explains the relationship between RAN and later reading success, using a mediation model that specifies PA as a mediator. In other words, we sought to evaluate whether the mediation model proposed by Martinez et al. is a plausible mechanism or whether deficits in RAN and PA are distinct per Cronin (2011).

Figure 1
Acadience RAN Examples

METHOD

Measures

Measures included in this study were Acadience® Reading Phoneme Segmentation Fluency (PSF), the Acadience Reading Composite Score (RCS), and Acadience RAN.

Acadience Reading K–6

PSF is a 1-minute timed assessment of a student's fluency in segmenting a spoken word into its component parts or sound segments. The RCS is a combination of multiple Acadience Reading scores, which vary based on grade and time of year. The RCS is calculated at all grades and time points.

Additional information on the design specification for all Acadience Reading K–6 measures and the formulas for calculating the RCS are available in the *Acadience Reading K–6 Technical Manual* (Good et. al., 2019), available at www.acadiencelearning.org.

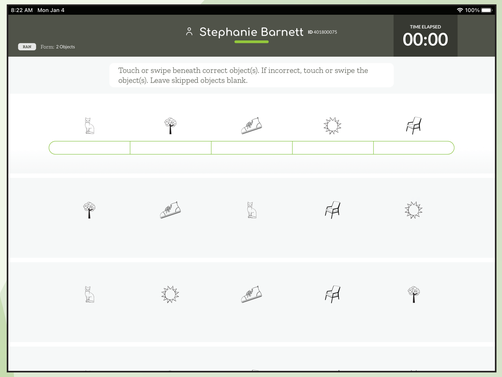
Acadience RAN

Acadience RAN is composed of three 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.

Acadience RAN is administered at the beginning, middle, and end of kindergarten and first grade. The measures may be administered and scored paper-pencil or scored on a tablet (please see Figures 1 and 2). The final scores reported for each measure are (a) the total time, in seconds, the student takes to complete the measure and (b) the number of errors the student made on the measure. If the student meets the discontinue rule, no scores are recorded for that measure. Additional information about Acadience RAN, as well as further details about the design specifications of the measures, can be found in the *Acadience RAN Assessment Manual* (Powell-Smith et al., 2020), available from www.acadiencelearning.org.

Every student included in this study had a score for RAN Objects, but since RAN Numbers was only used as an alternative for students who discontinued on RAN Letters, each student was assessed with RAN Numbers or RAN Letters, but not both. The RAN Total score is composed of either (a) the sum of Objects and Letters or (b) the sum of Objects and Numbers, given the manner in which the assessment is structured with RAN Numbers being an alternative to RAN Letters. This RAN Total score is the score for RAN that was used for each student.

Figure 2
Acadience RAN ALO Examples



Data Analysis

To answer the question of whether PA mediates the relationship between RAN and later reading skills, we ran a cross-lagged panel mediation model. The Acadience RAN Total score was used as the distal variable, while Acadience Reading PSF was the mediator variable. The end-of-year RCS was the outcome variable. Data were collected from students and schools who had entered data in the Acadience Data Management and Acadience Learning Online platforms during the 2019–2020 and 2020–2021 school years. The sample sizes were 2,668 kindergarten students from 68 schools and 1,557 first-grade students from 46 schools.

In kindergarten, it was possible to run the ideal model of the distal, mediator, and outcome variables all being assessed at different time points. This means that the RAN Total was assessed in the beginning of kindergarten, PSF in the middle, and RCS at the end of year. Because PSF is not typically given beyond the beginning of first grade, the model in first grade was altered such that it included both RAN and PSF administered at the same time point. The model of mediation between RAN, PSF, and the RCS is shown in Figure 3.

The students in the sample were nested within schools, which further complicated the analysis plan. Instead of simple OLS regression models, the mediation coefficients had to be calculated using multilevel models. Two multilevel models were run for each mediation model. The first model included the mediator, PSF, as the outcome with the predictor being RAN. The second model featured the RCS as the outcome, with RAN and PSF as the predictors. The formulas for the multilevel models are shown in Figure 3.

Prior to analysis, the predictor and outcome variables were all converted to z-scores in order to make the model coefficients comparable. The extent to which PSF mediates the relationship between RAN and later RCS was measured using the proportion mediated effect size. Confidence intervals were created using 1,000 bootstrap iterations in the mediation package in R (Tingley et al., 2014).

Figure 3
Model of PSF Mediating the Relationship Between RAN and RCS

Mediator model:

$$PSF_{ij} = \beta_{0j} + \beta_{1j} RAN_{ij} + e_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

Outcome model:

$$RCS_{ij} = \beta_{0j} + \beta_{1j} RAN_{ij} + \beta_{2j} PSF_{ij} + e_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{1j}$$

RESULTS

Results of the multilevel mediation models are presented in Table 1. Despite previous theories that RAN and phonemic awareness represent largely overlapping (or even redundant) skills, RAN was still a significant predictor of later RCS, even when controlling for PSF in the intervening time. To this point, RAN and PSF in kindergarten have a roughly equal relationship to later RCS, independent of each other. This finding is noteworthy when considering that the middle-of-year PSF score used from kindergarten is closer in time to end-of-year RCS outcome than the RAN Total is. In first grade, RAN and PSF were assessed at the same benchmark period (beginning of year), but RAN actually had a stronger relationship with the RCS than did the PSF score. Additionally, the relationship between RAN and PSF scores were significant, indicating a relationship between the proposed distal and mediator variables. These initial results suggest a plausible mechanism for mediation.

The Indirect Effect and Proportion Mediated rows in Table 1 represent the coefficients specific to the proposed mechanism of mediation under investigation. The indirect effect represents the relationship of RAN to the RCS that goes "through" the PSF score. This effect is significant, but rather small. The proportion mediated is the amount of the relationship between RAN and the RCS that is explained by PSF. PSF explains just under a quarter of the relationship between RAN and the RCS in kindergarten but less than 10% in first grade. These results indicate that, at most, PA (as measured by PSF) only explains a portion of the relationship between RAN and later reading skills. Both RAN and PSF have significant independent relationships with later RCS.

Table 1
Mediation of the Relationship Between RAN and Reading Composite Score via Phoneme Segmentation Fluency

	Kindergarten	First Grade
RAN ⟶ PSF (a path)	-.284 (-.373, -.188)	-.334 (-.373, -.294)
PSF ⟶ RCS (b path)	.325 (.251, .408)	.123 (.075, .171)
RAN ⟶ RCS (c' path)	-.353 (-.471, -.250)	-.478 (-.532, -.427)
Indirect Effect	-.104 (-.146, -.070)	-.041 (-.059, -.020)
Proportion Mediated	.227 (.144, -.330)	.080 (.042, .120)

Note. All values significant at p < .001. RCS = Acadience Reading Composite Score. PSF = Phoneme Segmentation Fluency.

DISCUSSION

This study examined the extent to which PA acts as a mediator of the relationship between RAN and later RCS. The results suggest that not only are RAN and PA distinct, but that PA accounts for only a small portion of the relationship between RAN and later reading skills. In kindergarten, PSF was a stronger mediator than in first grade. However, at most, PSF mediated less than a quarter of the relationship between RAN and the RCS.

Our results are both consistent with and different from previous research in this area. For example, Papadopoulus et al. (2016) found that PA contributed more to the RAN-reading relationship in the earlier phases of reading compared to later phases. However, their evaluation of earlier phases took place in first grade compared to later phases in second grade. The results of our study cast doubt that PA is able to wholly explain the RAN-reading relationship.

Limitations

1. The Acadience RAN and Acadience Reading K–6 measures were administered under uncontrolled conditions. Information on training of assessors and fidelity of assessment is unavailable. However, these data do represent the way these measures are used in practice.
2. While the research questions revolve around PA as a general skill, the present study used Acadience Reading PSF as an indicator of PA more generally. While PSF is both a strong measure of PA and predictor of reading, it is possible that there are some aspects of PA that were inadequately captured by this study.
3. RAN and PSF were administered during the same benchmark period in first grade, which limits the ability to conclude the temporal aspects of the relationship between RAN and PA.

Future Research

The present study shows that the reason RAN predicts later outcomes cannot be solely attributed to its relationship with PA, so some question remains as to the underlying processes that contribute to the power of RAN.

Future research should continue to explore which aspects of RAN overlap with existing reading skills and investigate further why RAN remains such a powerful predictor of reading outcomes. We may also wish to explore the role of orthographic processing in mediating the relationship between RAN and reading, similar to the research conducted by Papadopulous et al. (2016). For example, future research could examine scores from measures such as Acadience Spelling and Acadience Reading Nonsense Word Fluency Whole Words Read in first grade.

References available by contacting the authors.