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Abstract

Previous think-aloud studies have shown that struggling elementary and middle school students tend to fall into processing profiles that can be used to drive scaffolding and feedback. The current study used *k*-means clustering of constructed responses to explore the extent to which high school readers showed patterns of strategy use while reading informational texts. We found that several reading behaviors, including production of paraphrases, bridging inferences, and switches between strategies, could be used to develop four different profiles of readers. Further analysis revealed that these patterns of behavior were related to participants' reading skill and prior knowledge.

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Text comprehension theories suggest that readers engage in various processes and strategies to construct a coherent mental model of the text (e.g. McNamara & Magliano, 2009). Analysis of constructed responses that readers produce as they think-aloud or self-explain during reading can reveal the coherence-building processes involved in mental model construction, as well as the metacognitive strategies involved in coordinating those strategies (McNamara & Magliano, 2009; Pressley & Afflerbach, 1995). The goal of the present study is to explore reading profiles of high school students with specific consideration to the extent to which they switched between strategies that support coherence building.

Background

Readers' use of comprehension strategies (e.g., *paraphrasing* the sentence that was just read, *bridging* to the prior discourse content, and *elaborating* based on semantic knowledge associated with the discourse context) are related to comprehension skill (e.g., Magliano et al., 2011). Of particular interest in the current study is the ability to leverage readers' strategy use to identify profiles of learners. For example, researchers have been able to categorize struggling elementary and middle school students as paraphrasers, elaborators, and lateral connectors (McMaster et al., 2012; Rapp et al, 2007; Carlson et al., 2014). These profiles can help researchers and educators provide more individualized interventions that target specific comprehension issues (McMaster et al., 2012).

A limitation to the extant work is that comprehension strategies are often examined in isolation and at the aggregate. However, readers are likely to coordinate and combine strategies across the text as texts vary from sentence to sentence in terms of their content and inclusion of cohesive features, syntactic complexity, or vocabulary (McNamara & Magliano, 2009). Thus, readers may differ not only in the types of strategies they use, but also in their flexibility in switching between strategies. There has been limited work investigating the temporality of strategy use, but this work suggests that flexible strategy use is beneficial for comprehension (Cromley & Wills, 2014; Seipel et al., 2017). One on hand, skilled readers may be more sensitive to differences within a text and therefore more likely to adjust or switch their

strategy use to match the text. On the other hand, constantly shifting between strategies could be inefficient, indicating participants are not being thoughtful in how they explain a text. Thus, additional exploration into flexibility in strategy use is warranted. The current study is an initial exploration into this work. We used a simple gauge of strategy flexibility by examining how often readers switch between comprehension strategies.

The Current Study

The current study is an exploratory analysis of archival data (McCarthy et al., 2018). Our aim was to create profiles of comprehension behaviors in high school readers. More specifically, we used *k*-means cluster analyses to examine patterns of paraphrasing and bridging behaviors as well as strategy switching and the extent to which these profiles related to individual differences known to predict comprehension (i.e., reading skill, prior knowledge).

Method

The self-explanations come from the pretest of a self-explanation training intervention (McCarthy et al., 2018). High school students (n = 233) generated self-explanations as they read a science text. They then completed a comprehension test, as well as measures of reading skill (Gates-MacGinitie) and a general prior knowledge test.

Coding for Coherence-Building Strategies

The self-explanations were scored by expert raters using the Self-Explanation Rubric (McCarthy et al., 2021). Rather than coding for which strategy a self-explanation reflected, each protocol was coded for the presence (1) or absence (0) of each of three strategies: paraphrase, bridging, elaboration. We converted these presence scores to assign each self-explanation to one of eight categories: none, paraphrase only, bridge only, elaboration only, paraphrase and bridge combined (parabridge), paraphrase and elaboration combined, bridge and elaboration combined, and all three strategies combined.

Preliminary analysis revealed that Paraphrase and Paraphrase and bridge combined (i.e., “Parabridge”) were by far the two most dominant strategies used (means > 1.00). Thus, we chose to focus our analysis on these two strategies.

Switching Score

To capture how a student used the strategies during reading, we computed a switching score to indicate when a participant changed the strategy combination they used as they read. For example, if a participant produced paraphrase only in their first self-explanation and then produced a paraphrase-bridge combination in their second response this would be counted as a strategy switch. if the participant then went back to a paraphrase only on their third response, this would count as a second switch. Participants were prompted to produce self-explanations at 9 target sentence locations. Thus, participants could receive a switching score from 0-8.

Results

As a preliminary analysis, we calculated descriptive statistics and correlations among reading behaviors and individual differences in reading skill and prior knowledge (see Table 1).

Table 1

Range, Means, Standard Deviations, and Correlations of Measures

	Range	*M*	*SD*	GMRT	PK	Para	Para-bridge
Gates Reading Proportion Score (GMRT)	0-1.00	0.58	0.21				
Prior Knowledge Proportion Score (PK)	0-1.00	0.58	0.14	.66**			
Paraphrase (Para)	0-9	3.43	2.22	-.22**	-.22**		
Parabridge (Parabridge)	0-9	4.42	2.25	.22**	.18*	-.71**	
Switch Score	0-8	4.26	1.92	-0.04	.04	-.11	-.26**

Note. * indicates $p < .05$; ** indicates $p < .01$

Cluster Analysis

The optimal number of clusters was selected based on the elbow curve method. A *k*-means cluster analysis revealed four clusters that explained 69.5% of the total variance in the model. See Table 2 for cluster *n*s and means based on scaled data.

Table 2

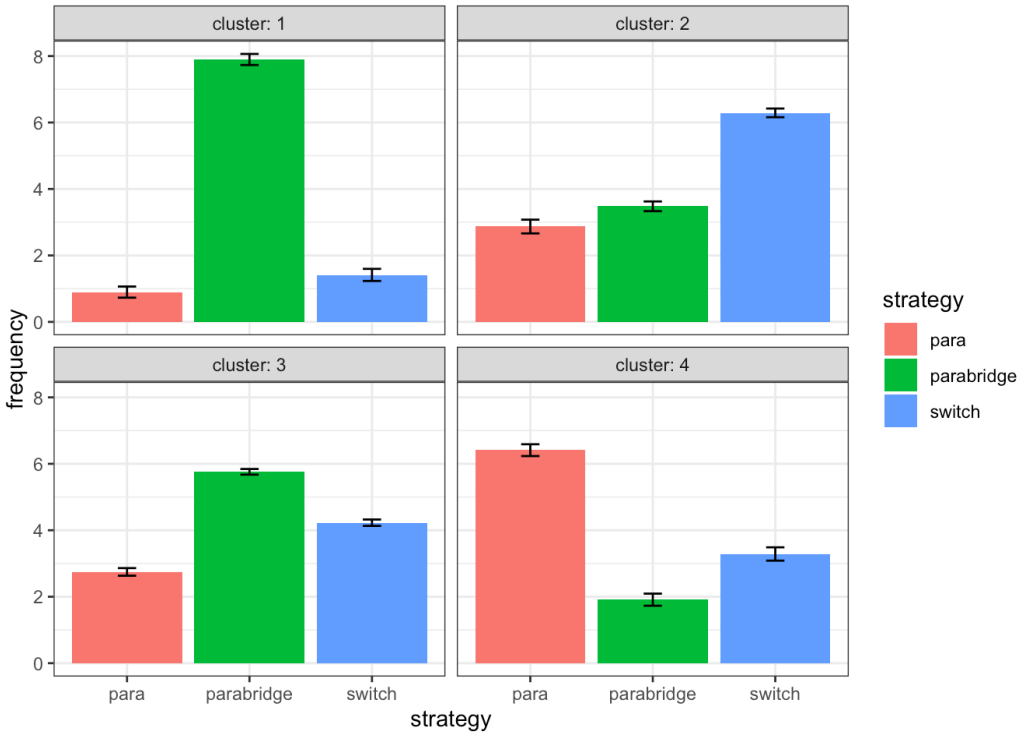
Cluster n*s and means*

	n	Paraphrase	Parabridge	Switching
Cluster 1	29	-1.14	1.54	-1.48
Cluster 2	69	-0.25	-0.42	1.05
Cluster 3	79	-0.31	0.59	-0.02
Cluster 4	56	1.34	-1.12	-0.51

To interpret the cluster, we examined the frequency of reading behaviors for each cluster (Figure 1). Participants in Cluster 1 can be characterized as "parabridgers" who predominantly engaged in both paraphrasing and bridging in a single self-explanation, with infrequent strategy switching. Cluster 2 can be characterized as participants who engaged in more frequent switching ("switchers"). Cluster 3 could be characterized as "relatively balanced", such that these participants tended to parabridge, but switched to other strategies more often than participants in Cluster 1. Finally, Cluster 4 is marked by participants who generated a high number of paraphrases, with minimal use of parabridging and switching between strategies ("paraphrasers").

Figure 1

Frequencies of Reading Behaviors for Each Cluster

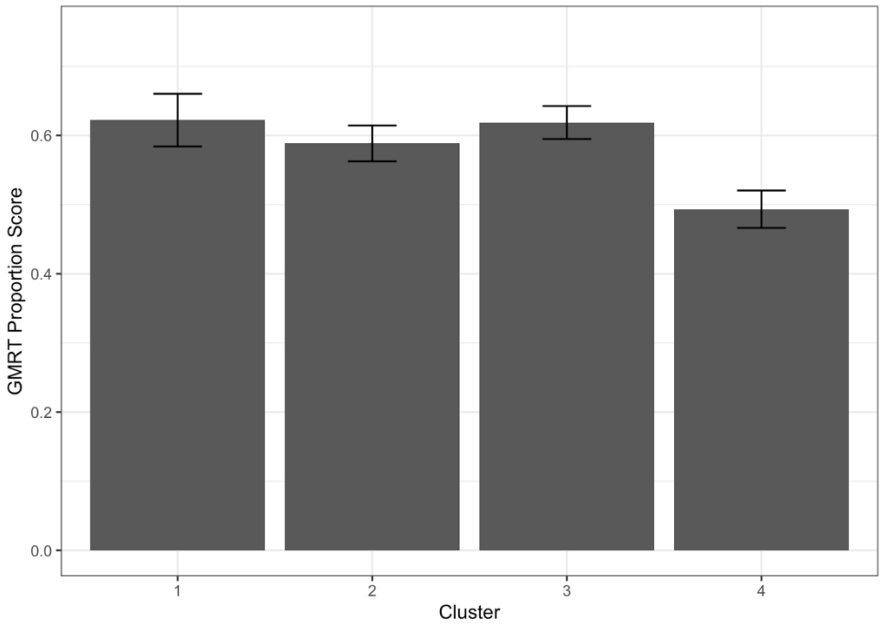


Relations Between Clusters and Individual Differences

A between-subjects analysis of variance (ANOVA) showed that reading skill (as measured by GMRT proportion score) differed as a function of the clusters, $F(3, 229) = 4.51$, $p < .01$, $\eta p^2 = .06$. Post-hoc Tukey tests indicated that participants in Cluster 4 (paraphrasers) had significantly lower GMRT scores than participants in Cluster 1 ($p = .04$) and Cluster 3 ($p < .01$) and marginally lower GMRT scores than those in Cluster 2 ($p = .06$; Figure 2).

Figure 2

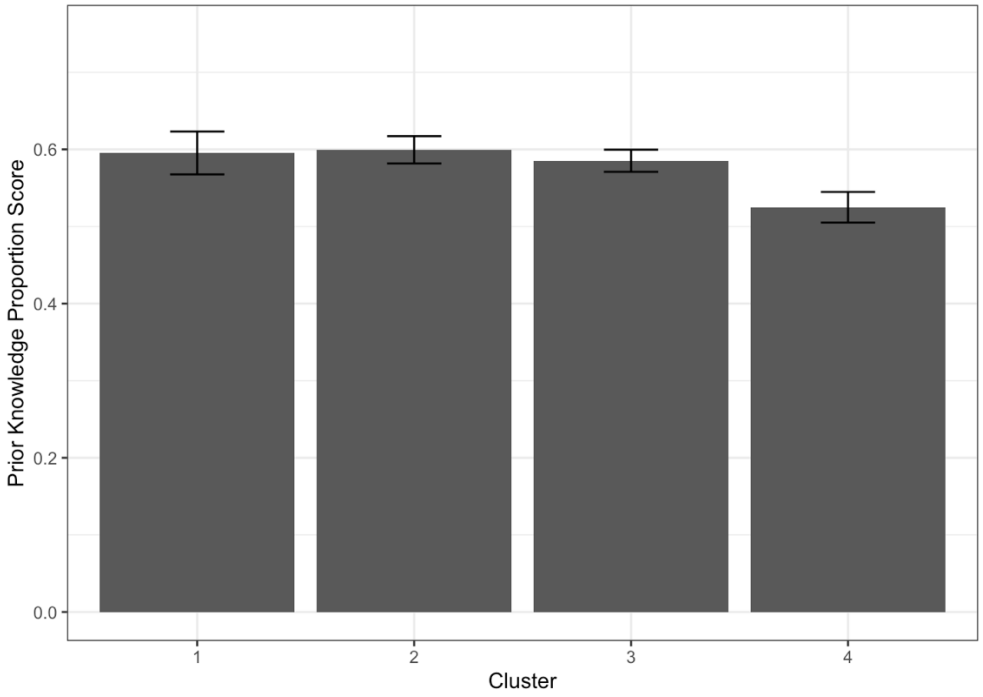
Reading Skill (GMRT) as a Function of Cluster Group



A similar pattern was found with respect to general prior knowledge (Figure 3). The ANOVA revealed that prior knowledge score differed across clusters, $F(3, 229) = 3.36$, $p = .02$, $\eta p^2 = .04$. Post-hoc Tukey tests revealed similar trends to those for reading skill, albeit less pronounced, such that participants in Cluster 4 had lower prior knowledge scores compared to participants in Cluster 2 ($p = .02$) and marginally lower prior knowledge scores relative to Cluster 3 ($p = .07$).

Figure 3

Prior Knowledge as a Function of Cluster Group



Discussion & Future Directions

Consistent with prior work on profiles of readers (e.g., McMaster et al., 2012; Rapp et al., 2007), our analysis demonstrated a cluster of "paraphrasers" comprised of less skilled and less knowledgeable readers. Our results also reveal a smaller group of readers who regularly engaged in "parabridging" (Cluster 1). Notably, "parabridge" as a moniker implies that the response includes a paraphrase followed by a bridge, but this is not the case. Our coding approach only indicates that a "parabridge" includes both aspects of paraphrase and aspects of bridging within the response. A future direction is to more deeply explore the nature of combining paraphrasing and bridging relative to paraphrase or bridging on its own in order to better understand how readers are leveraging this coordination to make sense of text.

Our analyses revealed that the more skilled and more knowledgeable readers were in Clusters 2 and 3, which were characterized by fewer paraphrases and more switching between strategies. This

supports the notion that more skilled readers may be more flexibly using strategies in reaction to changes across the text.

A key limitation in this study is that our approach to evaluating strategy switching is relatively simplistic. Although switching captures an aspect of temporality, the score still reflects an overall sum. Further, changing from one strategy or combinations of strategies to another is not inherently useful. More skilled readers may switch less frequently but do so more strategically. We are considering ways of conceptualizing and evaluating switching between strategies in more nuanced ways to include *when* switches occur in the text and characterize *what* reading behaviors switching entails (e.g., lag-sequential analysis, Markov chains, recurrence analysis). We will also examine the extent to which the reading behaviors found in this dataset replicate across other datasets of constructed responses.

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