What's in an Error? Development of an Error Taxonomy for Phonological Awareness

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ABSTRACT

There are currently no studies that examine the types of phonemic awareness errors children are making on tests of phonemic awareness. This study aimed to: (a) develop a taxonomy to categorize the different types of errors made on a test of phoneme segmentation by grade one children, (b) determine which error categories and error types occur most frequently, and (c) determine which types of words were the most difficult to segment. We examined errors made by 215 children on a test of phoneme segmentation, and developed a taxonomy for classifying the different categories and types of errors observed. The most frequently occurring category of errors was Addition errors, specifically the addition of a schwa vowel to a phoneme in the word. Additionally, children made more errors on test items that contained consonant blends. Knowledge of the different types of phonemic awareness errors children make will be valuable for teachers and speech-language pathologists when providing phonemic awareness instruction or intervention. Further research in this area is required to determine how meaningful different types of phonemic segmentation errors are in relation to overall phonemic awareness abilities and reading abilities.

BACKGROUND

Phonemic awareness is the ability to identify and manipulate individual sounds within a word. Research evidence has shown that it is a crucial skill in reading and spelling development (Bradley & Bryant, 1983; McBride-Chang, 1995; Vloedgraven & Verhoeven, 2009). Current evaluation methods for phonemic awareness interpret the total number of errors as a measure of good or poor phonemic awareness skills without considering the type of error being made.

There is currently no information in the research literature regarding the types of errors made by children on tests of phonemic awareness. The purpose of this study was to determine the types of errors made by grade one children on a test of phonemic awareness in order to support intervention practices.

Phonological Awareness

Phonological awareness refers to an individual's "ability to attend to and make judgements about the general sound structure of language" (Schuele & Boudreau, 2008, p. 6). This skill may be broken down into varying levels including awareness of word boundaries, stress patterns, syllables, onset-rime units, and phonemes.

The terms 'phonological awareness' and 'phonemic awareness' are often used synonymously. However, the two terms are not synonymous, but share an important relationship. 'Phonological awareness' is an umbrella term encompassing general knowledge of the speech sound system and the sound structure of individual words. This includes the ability to analyze spoken words in terms of individual syllabi and phonemes. 'Phonemic awareness' is considered phonological awareness at the phoneme level and encompasses the ability to segment, blend, delete, and manipulate sound segments of spoken words. For example, a phoneme segmentation task involves segmenting a word into individual sounds (e.g., /mæt/[1] → /m/-/æ/-/t/). Phoneme blending involves listening to isolated phonemes and combining them to form a word (e.g., /m/-/æ/-/t/ → /mæt/). Phoneme deletion involves deleting a phoneme from a word (e.g., say /mæt/ without /m/ → /æt/) and phoneme manipulation involves adding

[1] IPA symbols surrounded by slashes are used to represent phonemes.

or changing a phoneme in a word (e.g., adding /m/ to the beginning of the word /æt/ to form /mæt/ or changing the /æ/ in /mæt/ to /ɛ/ to form /mɛt/).

Phonemic Awareness and Relationship to Reading

Previous research has found phonemic awareness to be one of the strongest predictors of performance in word reading and spelling (Ukrainetz, Nuspl, Wilkerson, & Beddes, 2011). A strong causal relationship between phonemic awareness and reading has been established, whereby, children who have poor phonemic awareness skills were more likely to be poorer readers, while children with good phonemic awareness skills were more likely to be better readers (Helfgott, 1976; Ehri, 2000).

Evidence also suggests that instruction in phonemic awareness supports phonemic awareness, reading, and spelling development. Ehri et al. (2001) conducted a meta-analysis of 52 experimental studies examining the effects of phonemic awareness instruction on reading and spelling acquisition. The 52 studies examined included an experimental group that received phonemic awareness instruction and a control group with other or no instruction, and measured phonemic awareness, reading, and/or spelling outcomes. Despite variations in the types of phonemic awareness taught, student characteristics, and instruction methods, Ehri et al. (2001) found a large effect size of phonemic awareness instruction on phonemic awareness acquisition (d = 0.86), and moderate effect sizes of phonemic awareness instruction on reading and spelling abilities (d = 0.53 and d = 0.59, respectively), thus confirming the causal relationship between phonemic awareness abilities and reading.

Phonemic Blending and Segmenting

Among all the different phonemic awareness skills, phonemic blending and segmenting tasks have been shown to be more effective than other tasks in supporting the acquisition of phonemic awareness skills. Furthermore, the ability to blend and segment phonemes correlates highly with reading ability.

For example, Yeh (2003) compared two different instructional approaches: one focused on story activities, rhyming, and alliteration and the other focused on phoneme segmenting and blending while sounding out actual words. Yeh found that the latter approach was more effective at teaching phonemic awareness and letter-sound knowledge.

Bradley and Bryant (1983) demonstrated a clear causal relationship between phoneme segmentation abilities and reading abilities. That is, children who were able to segment phonemes in words were more likely to become better readers than children who had difficulty segmenting phonemes in words. Ehri et al. (2001) also compared phonemic awareness instruction that focused on blending and segmenting to other multiple-skill phonemic awareness instructions and found that blending and segmenting had a significantly greater effect size (d = 0.67) than multiple-skill phonemic awareness instruction (d = 0.27) on reading ability.

Child Performance Considerations on a Test of Phonemic Awareness

Assessment of phonemic awareness is conducted for a variety of reasons including: monitoring children's acquisition, determining the need for intervention, and monitoring the effect of intervention. Current evaluation methods interpret the total number of errors made by a child compared with same-aged peers on particular phonemic awareness tasks as a

measure of good or poor phonemic awareness skills. However, this approach does not consider the types of errors children exhibit. Two children may receive the same total score on a test of phonemic segmentation, for example, but one child omits sounds when segmenting words, while the other child segments words into onset-rime units, thus demonstrating differing levels of phonemic awareness knowledge.

Linguistic Factors. Although the specific types of errors children make on phonemic awareness tests has not been examined, there is a body of research examining test performance related to the complexity of items on a test of phonemic awareness. Linguistic complexity has been shown to impact young children's performance on several tasks (e.g., rhyming, sound identification, blending, segmenting, and deleting).

Examination of studies focused on phoneme segmentation revealed that linguistic factors such as the number of consonants and consonant blends can affect child performance on the segmentation task. Chafouleas, VanAuken, and Dunham (2001) examined the influences of the total number of phonemes (3-5) in a word with kindergarten and first grade children and found that as the number of phonemes increased child accuracy decreased. Stahl and Murray (1994) investigated the influence of single versus consonant blends at the beginning and end of words with kindergarten and first grade children. Results indicated that segmenting words with single consonants was easier than words with consonant blends. Further, children had more difficulty segmenting consonant blends at the end of a word (e.g., la*mp*) than consonant blends at the beginning of the word (e.g., *st*ate). However, in both word positions, children tended to treat consonant blends as a single sound rather than as two separate sounds.

Child Factors. In addition to linguistic factors, child factors need to be considered when considering performance on phonemic awareness tests. Socioeconomic status and child age have been shown to influence child performance.

Socioeconomic Status. Research evidence has shown that children from low socioeconomic (SES) backgrounds are at a greater risk for reading difficulties (Whitehurst & Lonigan, 1998). These authors speculated that this discrepancy may be due to children from low SES backgrounds having fewer experiences that facilitate emergent literacy (e.g., book ownership, shared reading experiences with parents, parent language input) than children from more affluent families. Further, Ehri et al.'s (2001) meta-analysis showed that while SES did not have an impact on a child's ability to acquire phonemic awareness skills, children from low SES backgrounds had less transfer of their phonemic awareness skills to spelling and reading outcomes.

Age. Although phonemic awareness develops during the preschool period, this knowledge becomes more important as children transition into grade one, when learning to read becomes the instructional focus (Erdogan & Erdogan, 2010). By grade one, almost all children have acquired some phonemic awareness skills, and many have mastered phonemic awareness tasks requiring deeper levels of awareness, such as phoneme segmentation (Bradley & Bryant, 1983; Schuele & Boudreau, 2008).

Reading and Van Dueren (2007) investigated the optimal time to begin teaching phonemic awareness skills, as well as the amount of time required to teach children these skills. Children were split into two treatment groups. One group received phonemic awareness instruction over the course of kindergarten and daily for 30 days at the beginning of grade one.

The second group did not receive any instruction during kindergarten but received the same 30 days of daily instruction in grade 1 as children in the first group. Although children who received the kindergarten and grade one instruction exhibited better early literacy skills at the beginning of grade one, there were no significant differences in literacy skills between the two groups of children by the middle of grade one. Therefore, Reading and Van Dueren determined that grade one was the appropriate time to provide phonemic awareness instruction and also that it is possible to acquire these phonemic awareness skills in a relatively short period of time.

Analysis of Child Errors

While the specific types of errors children make on tests of phonological awareness has not been investigated, analysis of child errors is considered an important element of effective language intervention. Vigil and van Kleeck (1996) and van Kleeck and Richardson (1986) posited that the collection and analysis of a corpus of errors provides a window into a child's mind. By locating where breakdowns occur, it becomes possible to address them in a manner that is specific to the child's error profile. Of interest in the present study were the error taxonomies developed and used in the assessment of reading and spelling abilities.

Reading. Goodman (1969) developed a system to examine the oral reading proficiency of children, which he called *miscue analysis*. Miscue analysis is based on the principle that child errors are not random. Goodman provided a taxonomy of miscues in reading which allowed for a comparison between a child's observed reading response and the expected reading response. This process examined the types of errors (i.e., substitutions, omissions, additions, hesitations, alterations) made during reading. The patterns that emerged produced an in-depth picture of the reading process in the individual reader. Goodman sought to use the information gleaned

from this analysis to further understand reading development and improve methods of reading instruction.

Miscue analysis allows educators a window into the prediction, confirmation, and meaning-making processes children apply while reading (Stahl, 2009). This allows educators to more easily: (a) identify an individual's strengths and weaknesses, (b) accurately monitor children's reading progress, and (c) modify teaching techniques to best suit individual child areas of deficit. Miscue analysis is now a common feature in formal and informal reading assessments.

Spelling. Miscue analysis has also been applied to children's spelling as a means to support child-specific instruction. For example, Apel and Masterson (2010) developed an analysis system to compare children's observed spellings with expected spellings. They illustrated the advantages of the miscue analysis approach over the traditional correct/incorrect scoring approach. For example, using traditional scoring, children who misspell 'TRICK[2]' as "TEK" and "TRIK" would each be scored as incorrect. However, a miscue analysis of these errors reveals different levels of knowledge. A spelling of "TEK" indicated spelling difficulties related to phonemic awareness knowledge (omission of letter representing /r/) and orthographic knowledge (wrong vowel used, and incorrect representation of the final /k/ sound). A spelling of "TRIK" indicated spelling difficulties related to orthographic knowledge only (incorrect representation of final /k/ sound). Thus, miscue analysis of child errors provides insight regarding the development of children's underlying knowledge banks, and would allow for instruction to be provided based on specific child needs.

[2] Capital letters are used to represent letter names.

Arndt and Foorman (2010) examined the most frequent types and categories of errors made by second-grade children on a dictated spelling test. Each phoneme of a target word was analyzed for the presence of phonological, orthographic, orthographic image, morphological, and transposition error types. In addition to analyzing spelling errors, Arndt and Foorman examined whether children with different reading abilities made different types of spelling errors. Spelling errors made by children whose test scores on the reading test were in the bottom quartile were compared to children in the remaining three quartiles. Although the poorest readers made a greater number of errors, Arndt and Foorman found that the types of spelling errors were similar across both groups. This finding is instructionally relevant for teachers indicating that, irrespective of reading ability, children made similar spelling errors. Thus, all children may benefit from spelling instruction focused on the knowledge bases (i.e., phonological, orthographic, orthographic image, morphological, transposition) shown to be in need of support, albeit the poorest readers may need more instructional support.

Different forms of miscue analysis have been used to investigate children's reading and spelling errors in order to support or improve instructional practices. This approach may also be useful in examining children's phonemic awareness errors to support PA instruction.

Purpose

The types of errors made on tests of phonemic segmentation by children are presently unknown. Current evaluation methods interpret the total number of errors present as a measure of good or poor phonemic awareness skills, without considering the types of errors children exhibit. Information about the types of errors children make is vital to interpreting potential differences in phonemic segmentation skills. Such knowledge would allow teachers to

focus on specific aspects of phonemic segmentation in the classroom, and allow speech-language pathologists to design intervention programs to target specific areas of difficulty.

Based on the need for information on phonemic segmentation errors, the current study was descriptive in nature. We developed a miscue analysis taxonomy for a test of phonemic segmentation to provide information regarding the different types of errors made on specific items, and on the test as a whole. We then examined the errors made by grade one children to determine:

1. The most frequent error categories and types of errors within each category,
2. Items on the phoneme segmentation test on which the greatest number of errors were observed.

METHOD

Participants

Participants were part of a larger study examining phonemic awareness and reading assessment methods of grade one children from low SES neighbourhoods. The phonemic awareness assessment data from 215 English-speaking participants were examined for this study. All participants lived in low SES neighbourhoods in Edmonton, Alberta, as determined by local area postal codes. The sample contained 115 females and 100 males, with a mean age of 79.0 months (range: 65.4 - 91.7 months). The ethnic makeup of the sample was 47.0% Caucasian, 24.4% Asian, 11.2% Aboriginal, 9.8% African, 2.8% South American, 2.3% Other, and 2.8% unknown. The distribution of mother's education levels in the sample was 45.8% post-

secondary graduates, 34.7% high school graduates, 15.3% some high school education, 2.3% no formal education, and 1.9% unknown.

Materials

Participants were administered the Yopp-Singer Test of Phoneme Segmentation (Y-STPS, Yopp, 1995) as a part of the larger study. This test was designed to measure children's ability to segment and produce the individual phonemes of a given word in the correct order. The test items consist of 22 single-syllable words (see Appendix A for a complete list of words). The examiner presented each word orally to the participants, who were then required to segment the word into individual phonemes and produce each phoneme of the word in the correct order. For example, on the item "dog," the correct response would be "/d/-/ɔ/-/g/." The test includes three unscored Practice items to familiarize participants with the task. Participant's responses were audio-recorded using a 200m H2 Handy Recorder, after which digital audio files were compiled.

Yopp (1988) analyzed the reliability and validity of the Y-STPS in a study examining 96 kindergarten students. Reliability was calculated using Cronbach's alpha ($\alpha = 0.95$), and indicated a high level of internal consistency. A factor analysis of the Y-STPS and 9 other tests of phonemic awareness found the Y-STPS to have high construct validity for phonemic awareness. Predictive validity was also determined to be high based on a correlation of Y-STPS raw scores to scores on a criterion test of novel word reading ($r = 0.67$).

Procedure

Error coding. Prior to coding the data, it was necessary to develop an error taxonomy to identify and categorize the different types of errors that children made on the Y-STPS. The

researchers listened to audio files of a subsample of the participants' Y-STPS protocols, then transcribed and labelled all observable errors for each phoneme in each of the 22 test items. A list of all phonemic awareness errors made by children in this subsample was compiled, and the researchers created error categories based on the types of errors identified. This resulted in 11 major error categories, some of which contained different error types. After the categories and error types were determined, the audio files of the remaining Y-STPS protocols were transcribed and coded. New errors encountered during the coding process were labelled and added to the list of possible error categories and types (see Appendix B for a complete list of error categories, error types, and exemplars).

When participants made more than one error on a single phoneme, it was necessary to establish how many errors would be coded per phoneme. In order to keep the coding process manageable, we coded a maximum of three errors per individual phoneme. A separate error code was created to indicate if a child made more than three errors on a single phoneme (see Appendix B - Multiple Errors). Multiple error coding exemplar are provided in Appendix C.

Coding Reliability. To ensure that all errors were captured and agreed upon, the audio files of the 215 children were randomly divided into three groups prior to coding. Two members of the research team coded each group independently. Thus, each child's Y-STPS protocol was coded independently by two researchers. Once coding was completed, the researchers compared coding results. Discrepancies were re-evaluated by both researchers independently. If agreement could not be reached, a third researcher listened to the audio file of the item in question without knowledge of the code assignments. In these cases, final code assignments

were obtained by a majority ruling. Team members were blind to all participant information while coding the data (including raw scores from Y-STPS and reading tests).

RESULTS

Error Categories and Error Types

Nine distinct error categories were identified that accounted for the specific errors children made while attempting to segment words into phonemes on the Y-STPS. Two additional categories (i.e., Unintelligible; No Response) accounted for child responses that could not be analysed accurately from the audio files or for items children did not provide a response.

The most frequently occurring error category was Additions, which accounted for 29% of the total errors made, followed by Segmentations, at 27%, Substitutions, at 23%, Insertions, at 9%, Repetitions, at 5%, and Omissions, at 3%. Three error categories each accounted for 1% of the total errors, while two error categories each accounted for <1% of the total. Frequency counts for all identified error categories are shown in Table 1.

Table 1

Error Category Frequencies (from most to least frequent)

Error Category[a]	Frequency of Occurrence	Error Category	Frequency of Occurrence
Additions	29%	Reversals	1%
Segmentations	27%	Multiple errors	1%
Substitutions	23%	No Response	1%
Insertions	9%	Rhyme	<1%
Repetitions	5%	Unintelligible	<1%
Omissions	3%		

We next determined the most frequently occurring types of errors within the 11 categories. Within some categories only a single error type was identified; however for several

error categories several different types of errors were identified (see Appendix B for descriptions and examples of error types identified within categories). Insertion of a schwa with a target phoneme was the most frequently occurring error and accounted for 28% of the total errors made by children. Onset-rime segmentation, substitution of a letter name for a phoneme, substitution of an incorrect phoneme for the target phoneme, and no segmentation were the next most frequently occurring error types at 12%, 10%, 10%, and 9% respectively. Eight error types each accounted for between 2% to 5% of the total error count (see Table 2). Finally, seven error types each accounted for 1% of the total error count and 5 error types each accounted for <1% of the total number of errors (see Table 2).

Table 2

Error Type Frequencies

Error Type[a]	Frequency of Occurrence	Error Type	Frequency of Occurrence
Addition 1	28%	Addition 2	1%
Segmentation 2	12%	Segmentation 5	1%
Substitution 2	10%	Segmentation 6	1%
Substitution 1	10%	Insertion 4	1%
Segmentation 1	9%	Reversal 2	1%
Repetition 1	5%	Multiple Errors	1%
Insertion 2	4%	No Response	1%
Substitution 3	3%	Reversal 1	<1%
Insertion 1	3%	Repetition 2	<1%
Omission	3%	Repetition 3	<1%
Segmentation 3	2%	Rhyme	<1%
Segmentation 4	2%	Unintelligible	<1%
Insertion 5	2%		

[a]*Note.* Error types are listed in order from most frequently occurring to least frequently occurring.

Yopp-Singer Test of Phonemic Segmentation (Y-STPS) Item Errors

We next sought to determine which items on the Y-STPS had the greatest number of errors. Frequency counts of errors for each word in the Y-STPS are shown in Table 3. There

were a total of 4142 errors made on the test by the 215 children. Based on our examination of the total number of errors identified for each of the 22 Y-STPS items we created four subsets of items with respect to segmentation accuracy ranging from most (Subset 1) to least (Subset 4) number of errors. Subset 1 represented items for which 250+ errors were made (i.e., fine, three, grew.) Subset 2 represented items with 200-249 errors (i.e., keep, wave, ice, that). Subset 3 represents items for which 150-199 errors were made (i.e., race, lay, sat, red, she, dog, job, in, top, by). Subset 4 represents items with <150 errors (i.e., me, at, no, do).

Table 3

Frequency of Errors on Individual Items of the Yopp-Singer Test of Phoneme Segmentation

Item Number	Item	Number of Errors	Error Frequency[a]
3	fine	305	7.4
15	three	303	7.3
7	grew	286	6.9
2	keep	248	6.0
6	wave	242	5.8
18	ice	240	5.8
8	that	238	5.7
13	race	190	4.6
20	top	188	4.5
14	zoo	173	4.2
9	red	168	4.1
12	lay	170	4.1
17	in	169	4.1
11	sat	163	3.9
16	job	158	3.8
1	dog	153	3.7
5	she	154	3.7
21	by	154	3.7
10	me	134	3.2
19	at	107	2.6
4	no	103	2.5
22	do	96	2.3
Total number of errors		4142	

[a]*Note.* Items are listed in order from those with the most error to those with the least errors. In situations where items have the same frequency of errors, the item that appeared earlier on the test is listed first.

Errors on the words “fine,” “three,” and “grew” occurred in the highest frequency accounting for 7.4%, 7.3%, and 6.9% of the total errors respectively. We then determined the specific types of errors children made on these three items. Of the 305 errors made on the word “fine”, the three most frequently occurring errors included 100 occurrences of an insertion of a schwa with a target phoneme, 53 occurrences of a substitution of an incorrect phoneme for a target phoneme , and 50 occurrences of onset-rime segmentation . On the word "three", a total of 303 errors were made; the most frequent errors included 58 occurrences of an insertion of a schwa with a target phoneme, 47 occurrences of a substitution of an incorrect phoneme for a target phoneme, and 41 occurrences of omission. There were a total of 286 errors for "grew"; 69 occurrences of onset-rime segmentation, followed by 43 occurrences of an insertion of a schwa with a target phoneme, and 22 occurrences of both no segmentation and phoneme repetition. Frequency counts for the error types for "fine," "three," and "grew" are shown in Table 4.

Table 4

Error Type Frequencies for the Three Items with the Most Errors on the Yopp-Singer Test of Phoneme Segmentation

Fine		**Three**		**Grew**	
Error Type	Occurrences	Error Type	Occurrences	Error Type	Occurrences
A 1[a]	100	A 1	58	Seg 2	69
Sub 1	53	Sub 1	47	A 1	43
Seg 2	50	O	41	Seg 1	22

[a]See Appendix B for descriptions of abbreviated error type labels.

DISCUSSION

Our first goal was to develop an error taxonomy to capture the types of errors children made on a phonemic segmentation test. Although different forms of error analysis had previously been used to study reading and spelling, this type of analysis had not been used to examine phonemic segmentation errors. We were interested in whether it would be possible to develop an error taxonomy system to capture this information reliably.

Development of the final set of error categories and error types involved an iterative process. We found that two of our initial error codes were too broadly defined and that the coding of schwa vowels required special consideration.

Segmentation

In the original coding taxonomy, four different codes were established to account for the types of segmentation errors we identified: 'No segmentation' (/ais/), 'Onset-rime segmentation' (/s/-/æt/), 'Phoneme segmentation based on letter names' (/t/-/h/-/æ/-/t/), and 'Onset-rime-like segmentation' (/dɑ/-/ɑg/). The 'Onset-rime-like segmentation' error code was used to capture any segmentation error that could not be captured by the first three error codes. Analysis of our data indicated that this was a frequent error made by children in our sample. Therefore, we re-examined this particular error type to ascertain if we had adequately captured the error types children made with this label. Our examination revealed three distinct error types; the errors were reclassified as: 'Middle-vowel segmentation absent' (/ki/-/ip/), 'Consonant blend segmentation absent' (/θr/-/i/), and 'Only last phoneme segmentation' (/sæ/-/t/) which resulted in a total of six segmentation error codes and allowed for clearer specification of Segmentation errors made by children.

Addition

A similar issue was found for an Addition error code. In the original coding taxonomy, a single error code existed to account for additions of schwas, vowels, and consonants to make a syllable: 'Addition of a phoneme to create a syllable' (e.g., /f**ə**/-/aɪ/-/n/). Analysis of our data indicated that this particular code was also one of the most frequent error types that appeared in our sample. As a result of the finding, we re-examined this error type and identified two distinct types of errors: 'Schwa added to target phoneme' (/f**ə**/-/ai/-/n/) and 'Non-schwa phoneme added to target phoneme' (/f/-/ai/-/n**d**/) which resulted in the two Addition error codes allowing for a clearer specification of Addition errors.

Schwa Vowel

Due to the variable length of schwas, we struggled to implement the 'Schwa added to target phoneme' error code reliably. The schwa vowel was sometimes difficult to hear, and we were concerned this may have led to inter-rater reliability problems. To overcome possible scoring reliability issues, any trace of a schwa vowel, subtle or overt, resulted in the use of the 'Schwa added to target phoneme' error code.

Error Categories and Error Types

Our next goal was to identify the most frequently occurring error categories error types made by grade one children on a test of phonemic segmentation. The most frequently occurring error category was Additions. This was followed by Segmentations, Substitutions, Insertions, Repetitions, and Omissions. There was a clear separation between the top three error categories and the rest of the error categories identified. Additions, Segmentations, and

Substitutions accounted for 79% of the errors made by children. Thus, the majority of errors made by grade one students on the Y-STPS predominantly fell in three error categories.

Examination of the most frequently occurring error types within error categories revealed that they were within more frequently occurring error categories. The most frequently occurring error type, by far, was the addition of a schwa with a target phoneme. This error type accounted for 28% of the total errors made and more than double the occurrence of the second most frequently occurring error type, onset-rime segmentation, which accounted for 12% of the total errors made. The frequency counts for the remaining 25 error types revealed an interesting trend. Only four of the twenty-five error types identified in our study occurred with a frequency of 10% or greater (see Table 2). The remaining twenty-one error types each accounted for less than 10% of the total errors made by children in the study. Although the types of phonemic segmentation errors made by grade one children was varied, there were specific errors which represented the majority of errors made on the Y-STPS.

Yopp-Singer Test of Phonemic Segmentation (Y-STPS) Item Errors

Our final goal was to identify on which items of the Y-STPS children exhibited the most errors. When the frequencies of errors for each word are examined, it became clear that children erred most often on three particular items: fine, three, and grew. When examining "fine", the test item that produced the highest amount of individual errors, close to 1/3 of all errors made was the addition of a schwa with the target phoneme (e.g., /f**ə**/-/ai/-/n/). On this item, children frequently added a schwa to the initial /f/ and final /n/. Clearly, many children had great difficulty producing these phonemes without adding a schwa. A further 1/3 of the errors made on this item were split rather evenly between two error types: incorrect phoneme

substituted for target phoneme (e.g., /f/-/ai/-/d/ for /f/-/ai/-/n/) and onset-rime segmentations (e.g., / f/-/ain/ for /f/-/ai/-/n/). With respect to “three”, the addition of a schwa with the target phoneme was once again the most frequently occurring error type. The schwa was most often added to the first phoneme in the word, /θ/. Many children also substituted an incorrect phoneme for target phoneme, omitted a phoneme, or segmented the word into onset and rime units. For "grew", onset-rime segmentations made up 1/4 of the errors. Addition of a schwa with a target phoneme, no segmentation and phoneme repetition respectively were the next most frequently occurring error types.

It was not surprising to see that onset-rime segmentations were among the more frequent errors observed in "three" and "grew". These latter words differ in linguistic complexity compared to other items on the test because of the consonant blend at the beginning of each of these words. As shown by Stahl & Murray (1994), items with consonant blends are predictably more difficult to segment due to their linguistic complexity. This likely contributed to the number of errors on these items; however, this does not explain the difficulty that children had with the item "fine". Chafouleas et al. (2001) had found that as the number of phonemes increased child accuracy decreased; the item "fine" had the same number of phonemes as "three" and "grew" and the absence of a consonant blend made it less linguistically complex than these other items. As previously mentioned, children seem to have difficulty producing the /f/ and /n/, without adding a schwa. However, there were other items that contained voiceless initial fricatives and nasals in the word final position. The significance and importance of this error deserves further investigation.

Limitations

The present study is unique, in that no prior research exists identifying the types of phonemic segmentation errors children make on tests of phonemic awareness. As a result, there were no existing phonemic awareness taxonomies with which to compare our findings. As any newly developed system, our taxonomy required modifications several times throughout the course of this study as new errors were observed and error types were refined. While we were able to capture all observed errors in our sample, this taxonomy may require further modification due to the potential of additional errors that may be observed with other grade one children or on different phonemic segmentation tests.

Additionally, the sample for this study included only children residing in low-SES neighbourhoods in Edmonton, Alberta, and thus may not be representative of children with differing demographics.

Directions for Future Research

Results from this study indicated a pattern in the types of phonemic segmentation errors children are making, in that some types of errors occurred much more frequently than others. As a result, we are able to identify not only the variety of errors made by children in grade 1, but also which errors were more frequently made. However, we were not able to interpret what these errors mean with regard to overall phonemic awareness and reading abilities.

Future research in this area needs to explore the relationship between types of phonemic segmentation errors and overall phonemic awareness abilities, as well as the relationship between types of phonemic segmentation errors and reading abilities. It would be

prudent for researchers to investigate whether these relationships exist, in an effort to ascertain the relative importance of individual error types. Any association found between particular errors and poor reading scores would be useful for teachers and SLPs in determining a need for phonemic awareness intervention, as well as to tailor interventions to address child-specific deficits in phonemic awareness knowledge. It may be that more frequently occurring errors have a greater impact on a child's phonemic awareness abilities, so targeting these errors in treatment may be more effective in improving overall phonemic awareness and reading skills. On the other hand, it may be that more frequently occurring errors are common, developmental errors common amongst all children that may not warrant intervention. If certain errors are prevalent among both the good and poor readers, then they may be considered as typical development rather than as atypical errors. Exploration as to how different types of errors reveal different levels of phonemic awareness knowledge is necessary for effective intervention planning and to provide further insights on the relationship between phonemic awareness and reading abilities.

Investigation on the effects of linguistic complexity in item difficulty on phonemic segmentation tasks is also warranted. Similar to Stahl & Murray (1994), we observed that errors occurred more frequently on items that were more linguistically complex (i.e., contained a consonant blend).

We know that phonemic segmentation instruction is an effective method of teaching phonemic awareness (Yeh, 2003), which is an important skill for reading acquisition (Schuele & Boudreau, 2008). Knowing the types and frequencies of errors made on a test of phonemic segmentation is a good first step toward future research examining which errors are more

indicative of poor phonemic awareness and reading skills. This study provides an ideal foundation for future examination of the types of phonemic segmentation errors made by children and how such knowledge can be effectively applied to classroom and clinical settings.

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Appendix A

Items on the Yopp-Singer Test of Phoneme Segmentation (Yopp, 1995)

1. dog
2. keep
3. fine
4. no
5. she
6. wave
7. grew
8. that
9. red
10. me
11. sat
12. lay
13. race
14. zoo
15. three
16. job
17. in
18. ice
19. at
20. top
21. by
22. do

Appendix B

Phonemic Awareness Error Categories and Types

Error Category	Type	Target word	Error exemplar
Addition	A 1. Schwa added to target phoneme	fine /f/-/ai/-/n/[a]	/fə/-/ai/-/n/
	A 2. Consonant or non-schwa vowel added to target phoneme	fine /f/-/ai/ -/n/	/f/-/ai/-/nd/
Segmentation	Seg 1. No segmentation	ice /ai/-/s/	/ais/
	Seg 2. Onset-rime segmentation	sat /s/-/æ/-/t/	/s/-/æt/
	Seg 3. Only last phoneme segmentation	sat /s/-/æ/-/t/	/sæ/-/t/
	Seg 4. Consonant blend segmentation absent	three /θ/-/r/-/i/	/θr/-/i/
	Seg 5. Middle vowel segmentation absent	Keep /k/-/i/-/p/	/ki/-/ip/
	Seg 6. Phoneme segmentation based on letter names	that /ð/-/æ/-/t/	/t/-/h/-/æ/-/t/
Substitution	Sub 1. Substitution of incorrect phoneme for target phoneme	fine /f/-/ai/-/n/	/f/-/ ai/-/d/
	Sub 2. Substitution of letter name for target phoneme	no /n/-/o/	N-O[b]
	Sub 3. Substitution of incorrect letter name for target phoneme	wave /w/-/ei/-/v/	O-F-U
Insertion	I 1. Phoneme inserted at the beginning of a word	she /ʃ/-/i/	/d/-/ʃ/-/i/

	I 2. Phoneme inserted in the middle of a word	she /ʃ/-/i/	/ʃ/-/ʌ/-/i/
	I 3. Phoneme inserted at the end of a word	she /ʃ/-/i/	/ʃ/-/i/-/d/
	I 4. Syllable inserted in word	grew /g/-/r/-/u/	/g/-/r/-/u/-/tɛ/
	I 5. Letter name inserted in word	lay /l/-/ei/	/l/-/ɛ/-Y
Repetition	Rep 1. Phoneme repetition	sat /s/-/æ/-/t/	/s/-/s/-/æ/-/t/
	Rep 2. Consonant blend repetition	grew /g/-/r/-/u/	/gr/-/gr/-/u/
	Rep 3. Repetition - other	fine /f/-/ai/-/n/	/f-/ain/- /ain/
Omission	O. Phoneme omitted	grew /g/-/r/-/u/	/g/-/u/
Reversal	Rev 1. Phonemes reversed	no /n/-/o/	/o/-/n/
	Rev 2. Letter names reversed	no /n/-/o/	O-N
Multiple Errors	ME. More than three errors related to a single phoneme	wave /w/ -/e/-/v/	/v/-/wʌ/-/wʌ/-W-/ev/
No Response	NR. Did not produce target item		
Rhyme	Rhy. Produced target item and rhyming word without segmenting	sat /s/-/æ/-/t/	/sæt/-/kæt/
Unintelligible	U. Response was unintelligible on audio file		

Note. Error categories in this table are listed in order from most frequently occurring to least frequently occurring.
[a] IPA symbols surrounded by slashes are used to represent phonemes. [b]Capital letters are used to represent letter names.

Appendix C

Multiple Errors on a Single Phoneme Coding Exemplars for Target Item "dog"

Correct segmentation: /d/ - /ɑ/ - /g/

Exemplar #1. Participant response: D - /gə/ - /ɑg/

- Errors:
    - Segmentation into onset-rime instead of individual phonemes (Seg 2)
    - Addition of schwa vowel (A 1)
    - Substitution of /g/ for /d/ (Sub 1)
    - Insertion of letter name D (I 5)

Exemplar #2. Participant response: /dɑ/ - /gə/ - /gə/ - G

- Errors:
    - Segmentation of last phoneme only (Seg 3)
    - Addition of schwa vowel (A 1)
    - Repetition –other /gə/ (Rep 3)
    - Insertion of letter name G (I 5)

Exemplar #3. Participant response: /dɑ/- /ɑ/ - /ɑ/ - /æ/ - O - /ɑg/

- Errors:
    - Middle phoneme not segmented (Seg 5)
    - Repetition of phoneme /ɑ/ (Rep 1)
    - Insertion of phoneme /æ/ (I 2)
    - Insertion of letter name O (I 5)