Critical Review:
Do preschool children's speech sound error patterns predict their school-age phonological awareness skills?
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This critical review examines the predictive relationship between preschoolers' speech production and their preschool and school-age phonological awareness skills. A literature search using computerized databases was completed and yielded seven articles meeting the inclusion criteria. Study designs include: mixed factorial design, single group correlational design and single group longitudinal design. Articles were critically appraised and rated in accordance with NHMRC's levels of evidence (2009). Overall, the research indicates that specific preschool speech errors can predict weaknesses in select preschool and school-age phonological awareness skills but preschool articulation cannot adequately predict passing or failing a standardized test of phonological awareness administered at school-age. Additionally, preschool articulation test scores cannot predict phonological awareness skills in school.

Introduction

The link between phonological awareness (P.A.) skills and literacy development is well documented (Rohl & Pratt, 1995). Research suggests that children with reading impairments often have deficient P.A. skills (Gilbertson & Bramlett, 1998). In fact, we can identify at-risk readers based on their P.A. skills in school and implement early intervention in order to optimize later reading outcomes (Gilbertson & Bramlett, 1998). But is this early intervention "early" enough? Should we wait for students to demonstrate deficient P.A. skills before we intervene? What if we could predict weak P.A. skills by measuring specific attributes in preschoolers?

It has been proposed that there is a relationship between a child's oral language skills and their P.A. skills (Cooper et al., 2002). Just like we require internal phonological representations in order to manipulate a word's phonemes, we require the same representations in order to produce and perceive phonological structure (Mann & Foy, 2007). In children with deficient speech production abilities, an increased risk for deficits in P.A. has been reported (Foy & Mann, 2012). Some researchers suggest that specific types of speech errors, namely, those that are atypical in nature, may be indicative of weaknesses in the processing of phonological information (Preston & Edwards, 2010). These weaknesses in children's phonological representations may persist and reveal themselves as enduring deficits in phonological awareness (Preston & Edwards, 2010).

This review aims to examine whether we can predict early P.A. skills in preschool based on speech production. Given that P.A. skills continue to develop into school-age, it is difficult to assess these skills in their entirety during preschool. However, research suggests that early P.A. skills are in fact present in preschool (Gillon, 2005). It is worth investigating whether we can predict early P.A. skills based on something we can measure reliably in preschool: speech production skills.

Additionally, if we can also demonstrate that weaker P.A. skills in school can be predicted by preschool speech production, this will provide support for the hypothesis that impaired speech production skills reflect weak phonological representations which contribute to weaker P.A. skills over time (Preston & Edwards, 2010).

The identification of a precursor to a delay in P.A. skills, namely, specific speech errors in preschoolers, can allow us to address P.A. skills early on and potentially mitigate their negative effects on literacy during schooling.

Objectives

The primary objective is to examine existing literature addressing the predictive relationship between preschool speech sound accuracy and P.A. skills concurrently and longitudinally. The second objective is to provide clinical recommendations for school-based Speech-Language Pathologists working in the domain of early intervention.

Methods

Search Strategy
Online computerized databases ProQuest Education, PsychInfo and Western Libraries were searched using the terms ("phonological awareness") AND (articulat*) OR (speech error*) OR (speech sound disorder*) AND (predict*) OR (impact*) OR (associat*) AND

(preschool*) OR (kindergarten). Other articles pertaining to the topic of interest were discovered within the reference lists of previously searched studies.

Selection Criteria
Papers were selected based on the requirement that they assess articulation and P.A. skills in preschoolers and examine the predictive relationship between the two either concurrently or longitudinally.

Data Collection
Results of the advanced search of the literature yielded 7 studies that were congruent with the topic of interest. The studies involved the following designs: (3) Single Group Correlational, (3) Single Group Longitudinal and (1) Mixed Factorial. The designs of these critically-appraised papers (CAPs) were rated in accordance with the National Health and Medical Research Council (NHMRC)'s Levels of Evidence (2009).

Results

Foy and Mann (2012) conducted a study with a Mixed Factorial Design examining the association between children's speech errors and their early reading skills at the beginning and end of kindergarten as well as whether improvements in speech errors over the course of the school year were significantly correlated with year-end reading skills. A group of 92 English-speaking Kindergarten children ages 4;6 – 5;7 years were recruited from four schools in a low income and ethnically-diverse region as part of a larger intervention study. Further details pertaining to the recruitment process and the nature of the intervention study were not provided.

Gold standard measures of articulation and early reading skills were administered at the beginning (T1) and end of Kindergarten (T2), in random order. Details pertaining to the location of test administration and the administrators were not provided. Acceptable interrater reliability was reported for audio recordings of articulation test data.

Though not a focus of a current study, children were categorized into the following groups based on initial assessment of early reading skills: eligible for intervention (intensive or strategic) or achieving benchmark. From these groupings and with additional teacher recommendation, 48 children completed intervention, while 44 did not. Intervention was 1:1, three times weekly, targeting early reading skills.

Appropriate between-groups and within-groups correlations and tests of difference were completed. Other measures related to vocabulary and working memory were also obtained but will not be addressed. Results demonstrated significant differences between groups (eligible for intervention vs. achieving benchmark) for specific speech errors and early reading skills at T1 and at T2. The authors found a significant predictive relationship between T1 omissions and T2 early reading skills. Additionally, improvements in specific speech errors were significantly correlated with specific early reading skills.

There is a moderate level of evidence provided by this study's multifactorial design lending support for the need to analyze speech sound errors in greater detail in order to to determine risk for weaker early literacy skills. Further, this study's incorporation of treatment for early reading skills and a measurement of its effects contributes uniquely to our knowledge of the relationship between speech sound errors and later phonological skills in that treatment of early reading skills may inadvertently improve articulation. This study's design corresponds to a Level 2a within NHMRC's Levels of Evidence (2009).

Single Group Correlational Design
Single group correlational designs are an appropriate means to address the relationship between speech sound error patterns and P.A. skills as these are variables that cannot be manipulated, but instead, occur naturally within the population. However, because single group designs are by nature vulnerable to threats to their internal validity (e.g. history threat), their findings must be interpreted and applied clinically with discretion. Single group correlational designs correspond to a Level 3 within NHMRC's Levels of Evidence (2009).

Mann and Foy (2007) conducted a single group correlational study examining whether children's speech production was linked with their early literacy skills and whether specific consonantal errors correlated with specific reading measures. One hundred and two children ages 4-6 were recruited from seven preschool or daycare programs. Further information regarding recruitment was not provided. Gold standard tests of articulation with accompanying phonological analyses were employed as well as P.A. tasks adapted from research. Articulation was classified as being delayed, typical or advanced based on errors observed.

Appropriate correlational analyses were carried out and produced significant correlations between specific speech sound errors, classified via developmental ordering of acquisition (early, middle and late) and select P.A. skills. Failure to acquire the early-8 sounds was associated with weaker P.A. skills. Regression analyses were employed to examine the predictive relationships queried and determined that errors on the

early-8 sounds significantly predicted rhyme awareness but did not predict phoneme awareness. Interestingly, the authors found that children with advanced articulation had significantly higher rhyme awareness and non-word repetition scores than children exhibiting typical speech development.

This study provides strong suggestive evidence that abnormalities in the developmental trajectory of speech sound acquisition may correspond to specific weaknesses in select P.A. skills in preschoolers.

McDowell, Lonigan and Goldstein (2007) conducted a single group correlational study examining numerous variables' explanation of unique variance in P.A. as well as whether the association between P.A. and speech sound accuracy is moderated by age.

Seven hundred children, ages 24-72 months of high and low socioeconomic status, were recruited from nine preschool centers. Further recruitment details were not provided. Gold standards tests of articulation and P.A. skills were administered by trained research assistants within the preschool centers. Two certified Speech-Language Pathologists transcribed responses from the tests of articulation yielding an interrater reliability of 93%. Vocabulary measures were also employed but their results will not be addressed.

Appropriate hierarchical regression analyses and bivariate correlational analyses were employed for the variables of interest. Age and speech sound accuracy (SSA) each explained significant unique variance in P.A. in a positive direction. Additionally, the interaction between age and SSA was significant and explained significant unique variance in P.A. In other words, the effect of SSA on P.A. was amplified as age increased. Moreover, the authors found a significant interaction between age and socioeconomic status (SES) in that SES increases led to enhancements in P.A. as age increased.

This study provides suggestive evidence that low speech sound accuracy may impact the developmental trajectory of P.A. skills in a negative manner. Further, low socioeconomic status may diminish this trajectory.

Preston and Edwards (2010) conducted a single group correlational design study to examine the degree to which P.A. can be concurrently predicted by different types of speech sound errors in children with speech sound disorders. Using well-specified recruitment criteria and conducting a screening in order to rule out ineligible participants, 43 preschoolers ages 4-5 were recruited with speech sound disorders of unknown origin. All participants completed four P.A. tasks

adapted from previous research and a 125-word picture-naming task (PNT). The PNT generated a speech sample from which Percent Consonants Correct (PCC) and a classification of errors were derived via a three-category coding system (distortions per consonant, typical sound changes and atypical sound changes). Atypical sound changes were those not considered to be a part of typical phonological development and included errors such as initial consonant deletion, glottal stops, backing and replacing stops with fricatives. Participants were tested either at home or in a quiet research laboratory. Adequate split-half reliability, internal consistency and agreement of responses were reported for the P.A. tasks and speech sample error coding.

Appropriate hierarchical multiple regression analyses were carried out and determined that atypical sound changes explained a significant amount of unique variance in P.A. while the other two types of errors did not. The authors also concluded that PCC did not contribute any significant unique variance to P.A.

This study provides suggestive evidence that specific types of speech sound errors may better explain the relationship between speech sound production and P.A. when compared to global measures like PCC.

Single Group Longitudinal Design
Single group longitudinal studies are an appropriate means to assess the clinical question at hand as they can provide descriptive and comprehensive data for a given group of participants over time. However, single group longitudinal design studies are particularly vulnerable to threats to their internal validity including but not limited to maturation threats, regression threats and mortality threats. Thus, their findings must be applied clinically with caution. This design corresponds to a Level 3 within NHMRC's Levels of Evidence (2009).

Preston, Hall and Edwards (2013) conducted a single group longitudinal study to examine whether pre-schoolers' speech error patterns predicted their P.A. skills 4 years later. Using well-specified recruitment criteria, 43 preschoolers with histories of speech sound disorders were recruited and completed a 125-word picture naming task designed to elicit specific speech sounds. Errors were categorized according to the three-category coding system (distortions, typical sound errors and atypical sound errors) introduced by Preston and Edwards (2010). Twenty-five children participated in the follow-up assessment where a gold standard measure of P.A. was employed by a certified Speech-Language Pathologist within the children's homes. The researchers attempted to limit the effects of a mortality threat by comparing the dropout group to the

nondropout group where they found significant differences only for a preschool vocabulary measure.

Appropriate correlational analyses were carried out and revealed a significant relationship between atypical errors at Time 1 and lower P.A. scores at Time 2. Follow-up analyses were performed based on dividing participants into those who made less or more than 10% atypical errors. The latter group had significantly poorer P.A. skills at Time 2.

Despite weaknesses in the study's methodology, specifically, its single group design and small sample size, this study provides strong suggestive evidence of a relationship between atypical speech errors in preschool and weaker P.A. skills in school.

Rvachew (2006) conducted a single group longitudinal study seeking to identify variables in preschoolers with speech sound disorders that predicted poor P.A. skills in school. Sixty-one children ages 4-5 were recruited using detailed recruitment criteria. All children were assessed by graduate students during the spring of their pre-kindergarten year using gold standard measures of articulation and P.A. (Time 1). Interrater reliability was not reported. Speech perception and vocabulary were also assessed but their results will not be discussed further. Forty-seven participants were assessed during the follow-up procedure during spring of their kindergarten year (Time 2) where the same assessment measures were used as in Time 1.

Appropriate hierarchical multiple regression analyses were employed and determined that number of errors on a test of articulation at Time 1 did not contribute any significant unique variance to P.A. skills at Time 2 despite the significant correlation noted between prekindergarten P.A. and prekindergarten articulation.

This study provides strong suggestive evidence that global measures of articulation in preschoolers do not significantly predict P.A. skills in school.

Rvachew, Chiang and Evans (2007) conducted a single group longitudinal study examining whether prekindergarten speech errors predicted P.A. skills during Kindergarten. Fifty-eight preschoolers ages 4-5 were recruited using well-specified recruitment criteria and were assessed using gold standard measures of articulation and P.A. during spring of their pre-kindergarten year and during spring of their Kindergarten year. Responses on the articulation measure were used to generate feature match ratios and were also coded via a five-category system: typical segment errors, atypical segment errors, typical syllable structure errors, atypical syllable structure errors and distortion errors.

Appropriate t-tests were carried out to compare groups on the variables of interest. No significant differences were found for preschool feature match ratios or for frequency of error types for children who passed or failed the kindergarten test of P.A. Additionally, no significant differences were found for preschool articulation severity rankings and kindergarten P.A. test performance.

This study provides suggestive evidence that preschool speech errors do not predict P.A. test performance one year later.

Discussion

Preschool Articulation and P.A.
In addressing whether preschool speech production predicted P.A. skills concurrently, research by Mann and Foy (2012) and Preston and Edwards (2010) concluded that delayed articulation and atypical sound changes were associated with weaker P.A. skills in preschoolers respectively. While Preston and Edwards' (2010) study design and methodology were valid, this is the first instance of the use of a "three-category" coding system for speech errors and as such, other validations of this system have not been reported. Further, several other "coding systems" exist for categorizing various speech sound errors. A universal, widely agreed upon coding system for speech errors is warranted.

Similar to the findings of Mann and Foy (2012) and Preston and Edwards (2010), McDowell et al. (2007) concluded that speech sound accuracy explained a significant amount of unique variance in P.A. in 2-year olds. That being said, McDowell et al. (2007) did not distinguish between motor-based and phonologically-based speech sound accuracy deficits. Furthermore, while 7 of the 8 groups studied contained an adequate amount of participants, one group (low SES, 2 years old) contained only one participant. As a result, the relationship between SSA and P.A. as reported by these authors, should be interpreted with caution. Lastly, Mann and Foy (2012) contributed uniquely to our knowledge of this relationship in their finding that advanced articulation was associated with advanced P.A. skills.

Taken together, these findings suggest that P.A. and speech production are related in preschool. This has implications for the evaluation and treatment of pre-schoolers with speech sound disorders with regards to mitigating their risk for later literacy problems. Further, advanced articulation may be indicative of stronger P.A.

which may provide opportunities for scaffolding of these skills. However, it is important to note that the relationship between speech production and P.A. might differ for different age groups, a point considered in the following section.

Preschool Articulation and School-Age P.A.
In examining whether preschool speech production predicted P.A. skills longitudinally, the findings from Preston et al. (2013) and Foy and Mann (2012) suggest that atypical speech errors in preschool predicted poorer P.A. skills in school. This finding has important implications for the manner in which speech-language pathologists assess and analyse articulation in pre-schoolers as specific error types may be early indicators of weaker P.A. skills later on. Further, improvements in speech production through the school year were associated with improvements on measures of early reading skills at year-end (Foy & Mann, 2012). This finding lends unique support for early intervention targeting early reading skills in that its benefits may extend beyond targeted skills and improve articulation in the process.

Contrary to these findings, Rvachew (2006) and Rvachew et al. (2007) did not find that preschool articulation was a reliable indicator of school-age P.A. performance. It is important to note that longitudinal findings from Rvachew (2006) and Rvachew et al. (2007) were based on a follow-up assessment during Kindergarten. Contrasting results from Preston et al. (2013) in which the second assessment was performed later in schooling, may suggest that the relationship between preschool speech production and school-age P.A. could be more robust in older children. This would be consistent with the findings from McDowell et al. (2007) who noted that age amplified the relationship between speech sound accuracy and P.A. Further, longitudinal predictions by Rvachew (2006) and Rvachew et al. (2007) were based on global test performance, as opposed to specific skills. Rvachew (2006) utilized test scores from standardized assessments of articulation and P.A. as opposed to examining these skills in greater detail. Rvachew et al. (2007)'s analyses involved the prediction of passing or failing a standardized measure of P.A., as opposed to predicting P.A. skills more specifically.

These findings have implications for the need to examine both articulation and P.A. skills more descriptively, beyond standardized test performance, in order to better understand the intricate relationship between these two variables.

Although 6 of the 7 articles reviewed correspond to lower levels of evidence characteristic of single group

correlational and longitudinal designs, they are appropriate designs to address the question at hand. Research by Foy and Mann (2012) contributes uniquely to the question at hand by examining the effects of a treatment approach and by consequence, it corresponds to a higher level of evidence (2a).

Clinical Implications

Findings from Mann and Foy (2007), Preston and Edwards (2010) and McDowell et al. (2007) suggest that there is a relationship between preschoolers' speech production and their P.A. skills that is explained by the the typicality and developmental appropriateness of their speech errors.

Similarly, findings from Preston et al. (2013) and Foy and Mann (2012) suggest that atypical errors in preschool can longitudinally predict poorer P.A. skills in school. Findings from Rvachew (2006) and Rvachew et al. (2007) indicate that P.A. skills in school cannot be longitudinally predicted by a test score for articulation in preschool, and further, that articulation skills in preschool cannot predict passing or failing a standardized measure of P.A. in school.

These findings suggest that preschoolers' articulation should not only be assessed, but be analyzed in greater detail beyond global measures such as standard scores, and PCC. A consideration of specific types of speech errors and their typicality for the child's age may provide insight into the child's P.A. skills and further, how these skills may manifest later in school.

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