Critical Review:
What is the independent role of rapid naming deficits in reading difficulties?

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This critical review examines the evidence regarding the hypothesized independent contribution of rapid automatic naming (RAN) in reading deficits. A literature search was completed and yielded six studies with the following research designs: 2 single group designs (1 with and 1 without randomization), 2 case control designs (quasi-experimental, non-randomized), 1 cross-sectional, single group design (randomized) and 1 longitudinal single group design (randomized). Overall, the results of these studies provide mixed results regarding the independent contribution of RAN to reading deficits. Clinical implications and future recommendations are discussed.

Introduction

The primary belief among researchers to-date has been that word reading difficulties are, in large part, due to deficits in phonological skills, including phonological awareness (Waber, Wolff, Forbes, & Weiler (2000). A considerable amount of empirical support has accumulated for the contribution of phonological skills to reading development (Manis, Doi & Bhadha, 2000). Bowers and Wolf (1999), however, have argued that this phonologically-based hypothesis for reading deficits is insufficient. Many children with reading disabilites have been found to have naming-speed deficits, or the difficulty rapidly retrieving highly familiar lexical items (Denckla & Rudel, 1976). It has been suggested that rapid naming facilitates fluent reading and comprehension.

Wolf and colleagues (Bowers & Wolf, 1993; 1999) have demonstrated that naming-speed deficits and phonological deficits represent separable sources of reading impairment. As a result, they have proposed a Double Deficit hypothesis of reading in which naming speed is considered to be an independent contributor, in addition to phonological awareness. This hypothesis is often examined using rapid automatized naming (RAN) tasks, which were designed by Denckla & Rudel in 1976 (Manis, Doi, & Bhadha, 2000). The RAN task involves the ability to recall and name various familiar numbers, pictures, letters, or colors in a serial order as quickly as possible.

The double deficit hypothesis holds that a reading impairment may occur in the presence of either a phonological awareness or a rapid naming deficit, but will be more severe in the case of a double deficit in both phonological awareness and rapid naming (Bowers & Wolf, 1999). According to this hypothesis, naming speed is an important and unique contributor to reading development.

Given that many studies have examined the role of phonological awareness, more research is needed to examine the specific, unique role that rapid naming plays in reading difficulties. This paper critically examined the evidence that rapid naming is an independent contributor to reading deficits.

Objectives

The primary objective of this paper was to critically evaluate the existing research literature regarding the independence of rapid naming effects in reading deficits.

Methods

Search Strategy

Computerized databases including PubMed, PsycINFO, and SCOPUS were searched using the following search criteria:

> (independence) OR (specificity) AND (rapid naming) OR (rapid automatized naming) AND (reading deficits) OR (dyslexia) OR (reading development)

Databases and reference lists of those articles found were searched for relevant articles.

Selection Criteria

Studies selected for inclusion in this critical review paper were required to examine the independence of rapid naming specific to reading deficits, but not excluding other learning disabilities.

Data Collection

Results of the literature search yielded the following types of articles congruent with the aforementioned selection criteria: (1) single group design (non-randomized, post-test only), (1) single group design

(randomized, post-test only), (2) case control designs (quasi-experimental, non-randomized), (1) cross-sectional, single group design (randomized, post-test only) and (1) longitudinal single group design (randomized, post-test only).

Results

Waber, Wolff, Forbes, & Weiler (2000) conducted a level 2b quasi-experimental, non-randomized case control study. The purpose was to evaluate how predictive naming speed deficits are of reading disabilities, compared to other learning problems in general.

A group of 188 school-aged children with learning disability with or without reading impairments participated. Reading impairment was identified based on well-known standardized tests. The group comparisons made included learning impaired children and controls, learning impaired children with RD and learning impaired children with adequate reading (accuracy or speed), learning impaired children with adequate reading (accuracy or rate) and controls.

The distribution of naming speed deficits (NSD) and reading deficits (RD) within the sample revealed that 68% of the children with learning impairment demonstrated a NSD. However, different prevalence rates for RD depended whether or not it was defined by speed or accuracy. The researchers found that 41% of children with a NSD also had a RD specific to accuracy measures compared to 68% when using speed measures, which was statistically significant ($p<0.0001$).

An appropriate logistic regression analysis was used to compute the receiver operating characteristic (ROC) and establish how well RAN performance could predict group membership. RAN performance was most effective at discriminating RD vs control (untimed = 0.95; timed = 0.92). RAN performance was also able to generally discriminate between LI vs control (0.84). To a lesser extent, LI children w/o RD were differentiated from the control group (untimed = 0.79; timed = 0.72). When the LI group only was considered, RAN performance was less effective in differentiating RD vs non-RD (untimed = 0.76; timed = 0.74). Similarly, descriptions of clinical profiles revealed that NSD was not specific to a type of learning impairment.

Lastly, significant pearson correlation coefficients were found between the four RAN subtests (letters, numbers, colors, and objects) and each of the four reading measures (word attack, sight words, phonological decoding) as well as a numerical operations test. The degree of correlation was less for the colors and objects subtests, with some significant and non-significant probability levels.

One limitation of this study was that the authors did not comment on how they determined that their sample size was adequate enough to compute a ROC analysis. One strength of this study was the use a population of children who were referred for evaluation of heterogeneous learning difficulties. This enabled the researchers to compare not only whether RAN deficits are specific to RD, but also whether RAN deficits are found in children with other learning problems and adequate reading skills.

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Heikkila, Närhi, Aro, & Ahonen (2009) did a level 2c quasi-experimental, non-randomized case control study as an extension of the Waber et al. (2000) study previously discussed. Their specific purpose was to verify whether or not the Waber et al. results were confirmed when a different cultural group and language background were used, specifically Finnish.

A group of 193 Finnish children, ages 8-11 years with learning disability with or without reading impairments participated. Those with reading impairment were group by reading speed vs. accuracy deficits. During analysis, the researchers looked at the percentage of RD-speed for learning impaired versus naming speed deficit versus no naming speed deficit group members. The same comparisons were then done for the percentage of non-RD accuracy group participants. The researchers also included a control group of 119 randomly selected children who were divided into non-RD-speed and non-RD-accuracy groups. Overall, the primary group comparisons consisted of LI vs. controls, LI with RD vs. controls, LI without RD vs. controls, and LI with RD vs. LI without RD.

In comparison with the Waber study (2000), the researchers found that naming speed deficits (NSD) were significantly less prevalent in all groups. The prevalence of NSD in learning impaired individuals was 58%, compared to 68% found in Waber ($p<0.05$). They concluded that because Waber et al.'s control group had faster naming times, their data produced a greater distance or gap between the learning impaired versus the control group which, in turn, increased their prevalence of naming speed deficits.

ROC analysis was used in a similar manner to Waber's study to determine how well RAN performance could predict group membership. The researchers found that RAN performance was able to significantly discriminate groups better than chance. They also found that reading disability, for both accuracy and speed, was significantly more prevalent in both the learning impaired and naming speed deficit groups. Their findings were in agreement with those obtained from the original study in that rapid naming tasks were able to equally discriminate learning impaired participants from controls as well as reading deficit (speed) from controls. The researchers differed, however, in their results that reading deficits have a specific, strong connection to rapid naming. Specifically, they concluded that rapid naming was able to discriminate between reading deficit and non-reading deficit participants, when defined by speed, better than it discriminated between non-reading disability participants from controls.

Clinical profiles were described as well, however, unlike the Waber profiles, the current sample found a prevalence of NSD in 26-30% of the non-RD learning impaired group compared to 59-89% of the RD learning impaired group. A second contrasting observation was that the prevalence of NSD in the current sample increased with the classification of RD, as compared to the prevalence of NSD increasing with the co-occurrence of other LI from Waber's sample.

Some limitations of this study included a redundancy in their comparison group which was not explained, specifically. The researchers also failed to control the demographics of the clinical group to ensure a balance in gender, with 76.6% of the sample boys. The researchers also failed to use multiple measures of reading to evaluate different components of the participant's reading ability. A strength of this study was that the researchers were able to extend the previously completed research by including a new cultural group for comparison. Further, they used a wide age range in their sample but controlled for the effects of this on the rapid naming results by using z scores, specifically obtained for each age group separately. (8, 9, 10, and 11 years).

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Manis, Doi, Bhadha (2000) used a level 3 randomized single group design to examine how verbal ability, phonological awareness and naming speed contribute independently or additively in predicting orthographic skills, amongst other reading measures. They used a sample of 85 randomly selected students who were part of a separate longitudinal study spanning from grade 1-2. Data collected for this study were taken when the sample group were in grade 2 and included a wide age-range between 7.0-8.11 years of age.

The researchers used several standardized tests of reading ability as well as phonological awareness and an adapted form of Denckla & Rundel's RAN task and included only the digits and letters naming tasks. They also created a picture naming task to further evaluate naming speed using familiar, age-appropriate images.

Pearson correlation coefficients were significant ($p<0.05$) for RAN-letters and RAN-digits with orthographic measures (range of r value from -0.30 to -0.42) and with phonological measures (range of r value from -0.20 to -0.44). Hierarchical regression analyses were used to calculate how much the independent contribution of RAN could account for independent variance in the seven criterion variables of reading. Vocabulary scores were entered as the first predictor variable to control for the participants verbal skill, then separate analyses were completed by adding RAN-letters, RAN-digits, and for RAN-pictures (for their unique contribution) as well as with sound-blending and sound-deletion (for common contribution to variance). RAN-pictures did not significantly account for variance in the reading measures. RAN-digits and RAN-letters were both significant independent predictors for each of the reading variables, with RAN-letters (ranged from 7.1% to 27.7%) generally accounting for a greater amount of variance than RAN-letters (ranged from 4.3% to 19.6%).

Subgroups were created using an arbitrary 25th percentile cut-off score. An analysis of variance (ANOVA) revealed significant subgroup differences in that the phonological-deficit (PD) subgroup scored lower on phonological tests than the no-deficit (ND) group. The double-deficit (DD) subgroup generally scored below the other subgroups across all tasks. Computing an ANOVA for this research study was not a strong statistical test to compare the subgroups. Firstly, the sample size was relatively small to begin with, and subgroup membership yielded even smaller groups for comparison (name speed-deficit [NSD], n=8; PD, n=13; DD, n=8; ND, n=50). Further, this division was arbitrary. This small sample size would affect the level of power that we can attribute to the results. Moreover, effect size was not calculated to

determine the amount of overlap between these subgroups.

A limitation of this study was that the authors did not determine an RD and non-RD group membership from the beginning. If they had calculated the relative correlations and predictions of PA and RAN on reading abilities, the evidence would have been much stronger. A strength of this study was that it provided detailed information regarding the demographics of the participants, which were well balanced in gender, socioeconomic status, and cultural background. Finally, the participant sample was an unselected, randomized group representing a full range of reading difficulties.

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Schatschneider, Carlson, Francis, Foorman, & Fletcher (2002) did a level 3 cross-sectional, single group study to investigate the relationship between naming speed and phonological awareness skills and the implications of this relationship for the classification of children who are at risk of a reading disability. Two groups of grade 1and 2 testing results were drawn from an available data pool. Appropriate standardized tests of reading and phonological awareness were administered. Naming speed was evaluated using the Denckla & Rudel's (1976) RAN task.

Pearson correlation coefficients and regression analyses were generated to investigate the relationship between RAN and PA along with a sample of reading measures. They found a positive correlation between between naming speed and phonological awareness. Further, naming speed was more closely related to measures of reading fluency than word identification. They suggested that this relationship would affect any comparisons being made across subgroups (e.g. those with a double deficit; comparing their PA and RAN scores would not be valid). With this relationship, they further found that the relative, related contributions of PA and naming speed in predicting reading equated their unique contributions. Concluded that findings are consistent with the hypothesis that naming speed in children with a double deficit is primarily a phonological process.

The authors are valid in stating that a comparison of subgroup means (subgroup categories based on less than 1 SD below mean) could lead to false conclusions because PA and RAN are correlated. Determining the nature of the relationship between PA and reading measures as either linear or curvilinear was a suitable analysis to check for the assumption that a linear relationship exits. However, the authors came up short with their research question and did not perform a similar analysis between RAN and reading measures.

A limitation of this study was that they did not include a comparative sample with reading impairment, which limits the generalizability of these results. A strength of this study was that it controlled the demographics of its participant group to ensure balance across gender and ethnic population. They avoided a sampling bias by randomly selecting their participant group from a representative pool. It also provided a more detailed evaluation of reading ability, including measures specific to comprehension, efficiency, and letter-word identification.

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Wolf et al. (2002) used a level 3 single group, non-randomized design to evaluate the independence of naming speed and phonological awareness in predicting reading skills.

The sample included 144 children with severely impaired reading skills from grades 2 and 3 with IQ scores above 70 and no history of serious psychological diagnosis

The researchers used several standardized tests of reading ability as well as phonological awareness and an adapted form of Denckla & Rundel's RAN task and included only the letters naming task.

To evaluate the relationship between the phonological awareness, naming speed, age, and IQ variables, the researchers conducted Pearson product-moment correlations and found that naming speed was significantly correlated to both phonological awareness measures at $p < 0.001$. They also found that both IQ and age were not significantly correlated with naming speed. The researchers then used Pearson correlations and multiple regression analyses to evaluate the relationship between naming speed and reading variables. Naming speed standard scores were found to be significantly correlated to the reading measures of word attack, identification, and comprehension at $p< 0.001$. The independent contributions of naming speed to reading variables were then examined using a series of step-wise regression analyses which revealed that naming

speed and phonological awareness were significant predictors of all three reading measures employed.

Although specific findings regarding phonological measures examined in this paper were not reported here, it was concluded that phonological measures contribute more of the variance to those aspects of reading skill that involve decoding or word attack skills, while naming speed measures contribute more to skills involved in word identification, as mentioned above.

One limitation of the study was they failed to include a normally developing control group for comparison which would have helped their generalizability. A strength of the study was that they controlled for various other confounding variables, including IQ, age, and socioeconomic status. Also the researchers included valid measures of reading with several reading subtest measures to evaluate different components.

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Lervag, & Hulme (2009) used a level 3 randomly selected, longitudinal single group study to examine the relationship between the naming speed and the ability to learn to read.

A group of 233 unselected, grade 1 children from Norway completed RAN tasks at 5 time points over a 37-month period. The first and second testing time points compared the children before and after reading instruction, and text reading fluency was also measured at time points 2-5.

Structural equation modeling examined how well Time 2 RAN and reading were predicted from Time 1 RAN. Results revealed that reading fluency, phoneme awareness, and RAN at Time 2 strongly predicted Time 1 RAN measures. RAN was found to be an important predictor of later text-reading fluency. In latent growth curve analysis, nonaphanumeric RAN predicted the non-linear growth of text-reading fluency over all time points.

The results showed that nonalphanumeric RAN is a good predictor of later variations in reading skill, and that early variations in reading ability are not good predictors of later variations in RAN. Therefore, after reading instruction has started, RAN continues to exert an influence on the development of reading fluency over the next 2 years. However, there is no evidence of a reciprocal influence of reading fluency on the growth of RAN skill. Later in development, once literacy skills had started to develop, alphanumeric RAN predicted the further growth of text-reading fluency. However, text-reading fluency did not predict growth in RAN. Therefore, RAN and reading do not show reciprocal influences on one another.

A limitation of this study was that they only included 2 text-reading fluency tests to evaluate reading, which did not account for reading comprehension. Further, a detailed description of the demographics beyond gender was not provided. A strength was that they balanced the sample for gender. Also, they used a different cultural group, which helps to extend the research conducted on this topic to other cultural and linguistic backgrounds.

Considering the strengths and limitations, this study demonstrates suggestive evidence for the independence of naming speed in reading deficits.

Discussion

The six studies reviewed above demonstrate mixed results regarding the independence of naming speed and phonological awareness in reading. Overall, four of the studies reported that RAN is an independent contributor to reading, however, the other two studies reported that RAN and PA were not independent. It is important to note that there were some methodological limitations found within these studies which suggest the results should be interpreted with caution.

A number of the research designs were not truly randomized and included a clinically referred sample. This can often produce biased results and usually cannot be generalized without robust research evidence. Further, four of the six studies did not control for intelligence in their evaluation of naming speed in relation to reading deficits. This is important to note because there is some evidence to suggest that children whose IQ is below average with similarly matched reading levels, do not have similar naming speed deficits. This, in turn, would affect the predictions of reading from naming speeds in samples with lower-IQ and are poor readers.

Finally, it is important to consider the limited sample group sizes once participants were divided into subgroups for comparison (e.g. reading deficit vs. non-reading deficit, naming speed deficit vs. PA deficits). This small sample size would affect the level of power that we can attribute to the results. Moreover, effect size was not calculated to determine the amount of overlap between these subgroups.

Given that these groupings were determined by differing cut-off criteria, for future research it is recommended that a consistent cut-off criteria be determined and used. In future, more research is required to specifically investigate the inter-related nature of phonological awareness and naming speed to minimize the bias within this research field. Finally, it is recommended that greater consistency in the tests used to measure reading and phonological awareness skills be established to minimized the variability and improve the generalizability of those results across studies.

Clinical Implications

While there are some limitations to these studies, there are also some important clinical implications to be considered. As a group, the articles provide suggestive evidence that naming speed may be an independent contributor to reading. While caution is still warranted, clinicians may find measures of both phonological awareness and naming speed helpful in understanding reading difficulties in specific children.

With more evidence, this finding would be particularly relevant to the intervention approaches taken by SLP's in the future when remediating reading difficulties.

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