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BEHAVIORAL VOICE THERAPY IN SCHOOL-AGE CHILDREN WITH VOCAL FOLD NODULES

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The Effects of Matrix Strategy Intervention on Improving Word Combination Skills in Preschool Children With Intellectual Disabilities

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Structured Abstract

Clinical Question: Is the matrix strategy intervention effective for expanding word combinations in children with intellectual disabilities?

Method: Evidence-based practice process

Study Sources: electronic databases, reference lists, key journals (hard copies), existing networks, relevant organizations, and conference proceedings

Search Terms: matrix strategy OR matrix training OR intellectual disabilities OR mental retardation OR Down Syndrome

Primary Results:
Children with intellectual disabilities are able to improve their expressive and receptive language skills in combining two words by using matrix strategy intervention. Of the nine studies included in this review, the available treatment evidence was judged as conclusive for one study, suggestive for three studies, and inconclusive for the remaining five studies.

Conclusions:
Evidence supporting the effectiveness of the matrix strategy as an intervention approach to improving expressive and receptive language skills is very limited.

Clinical Scenario

Emily is 4 years old and has Down Syndrome. She was born in the United States, but her family emigrated from South Korea. Emily's first language is Korean. Her parents and older sister speak Korean at home throughout the day. Emily has received early intervention in English since her infancy, including weekly speech therapy and occupational therapy sessions. Since fall of 2010, she has been attending a half-day of preschool three times per week. Emily produces about 80 to 100 one-word expressions in English and Korean, such as "mama," "no," "umma" (mom), "appa" (dad), "mool" (water), and sounds such as "uh" and "ooo." Emily also has learned some signs, such as "more" and "done" from her speech-language pathologist (SLP), Abby. Emily's parents are open to augmentative or alternative ways to communicate and have used manual signs at home. The parents also have learned to use several graphic symbols in daily life that Emily learned in the classroom.

Children without any disabilities are capable of combining a core vocabulary to produce meaningful word combinations at about 18 months old. Emily already has a core lexicon of more than 40 words, but she needs to expand the appropriate usage of her vocabulary. Abby, Emily's SLP, recently learned about a *matrix strategy* approach that may be a useful intervention for Emily. The strategy would involve her family and classroom teacher. Before suggesting this approach, Abby needs to find evidence that answers the clinical question: *Is the matrix strategy intervention effective for expanding word combinations in children with intellectual disabilities?*

Background

As in Emily's case, many young children with intellectual disabilities have difficulties learning language and exhibit limited expressive language skills. One goal of language intervention is to expand appropriate words from single- to two- or multiple-word combinations. According to Neson (1973), typically developing children obtain 40 to 50 core single words by about 18 months old and begin to combine words to express elaborate meaning. They continuously produce new single words or utterances throughout the latter half of the second year and generate two-word combinations containing semantic relationships including action–object, agent–object, action–locative, entity–locative, possessor–possession, entity–attributive, and demonstrative–entity combinations (Brown, 1973).

In the continuum of child language development, a positional productive pattern, such as "drink water (action–object)," generally appears before a positional associative pattern, such as "stop that" or "come here" (Brown & Leonard, 1986). Brown and Leonard found that words in a positional productive pattern (marked by word combinations such as action + object, e.g., *eat cookie*) are among the first word combinations to emerge. After a child has acquired single-word utterances and expresses different communicative functions with or without speech, the transition from single to multiple word utterances to express two-term semantic relationships (e.g., action–object) is a benchmark of vocabulary and syntactic development (Greenfield et al., 1985).

Using the Matrix Strategy

SLPs use the matrix strategy in intervention to help learners use functional utterances and acquire novel combinations of target elements at various levels of lexical proficiency. This intervention has been used to teach organized word combinations including action–object (Karlan et al., 1982; Nigam, Schlosser, & Lloyd, 2006; Romski & Ruder, 1984; Striefel, Wetherby, & Karlan, 1976), object–location or preposition–location (Bunce, Ruder, & Ruder, 1985; Ezell & Goldstein, 1989), and descriptor (color)–object (Remington, Watson, & Light, 1990). It h also has been employed as an approach to broadening expressive communication skills, using signed English (Karlan et al., 1982), speech and manual sign (Romski & Ruder, 1984), manual signs (Light, Watson, & Remington, 1990; Remington et al., 1990), and graphic symbols (Nigam et al., 2006).

The matrix strategy involves two dimensions, each of which controls a separate response. Each linguistic element from one dimension can be combined with those from the other, generating a unique response for each cell in the matrix with those linguistic elements. For example, if the target combinations were three verbs (throw, drink, put in) and nouns (ball, box, milk), the resulting multiword combination would be available as shown in each cell as shown in Figure 1. Determining which multi-word combinations are appropriate for training is based on the functionality of the combinations. Clearly, only the three multi-word combinations in Figure 1 would be used to as target utterances because they have functional communication value. No other combinations have communicative value, so they would not be included.

	Action		
	throw	drink	put in
ball	throw ball		
box			put in box
milk		drink milk	

Object

Figure 1 Example of matrix strategy used with target utterances

Generally, the main goal of using the matrix strategy is for children to learn to combine existing vocabulary into more complex utterances and to generalize learned semantic relationships to untrained word combinations. Goldstein (1983a) defined these outcomes as *recombinative generalization.* The organization of target word combinations using a matrix strategy may provide an efficient intervention approach for direct and indirect teaching and learning of vocabulary in young children.

Searching for Evidence
Search Strategy

Relevant studies prior to August 2011 were located via electronic databases, reference lists, hand searching key journals, existing networks, relevant organizations, and conference proceedings with key words. The following databases were searched for this review: *Database of Abstract of Reviews of Effects* (DARE), the *Cumulative Index of Nursing and Allied Health* (CINAHL), the *Education Resources Information Clearinghouse* (ERIC), *Language and Linguistics Behavior Abstracts* (LLBA), *Medline,* and *PsycINFO.* The following keywords were used, respectively and in combination, in the search: *matrix strategy, matrix training, intellectual disabilities, mental retardation,* and *Down syndrome.*

All included studies were coded independently by two coders and were analyzed for the following characteristics:

1. Author(s) and year of publication

2. Study populations (i.e., participants' numbers, ages, and diagnosis)

3. Intervention type

4. Target communication skills (e.g., expressive and receptive communication skills, manual signs, symbol pointing)

5. Reported results

6. Effect sizes

7. Summary of research design

Inclusion Criteria

To be included in the review, studies had to: 1) have an experimental or quasi-experimental group or single-subject design, 2) have participants who had been diagnosed with intellectual disabilities, 3) have participants who were preschool- or school-age, and 4) have used the matrix strategy or matrix training as the intervention delivered.

Though descriptive designs and case studies do not demonstrate a causal relationship in intervention research, they often document the course of an intervention. Such is the case with the matrix training when applied to children with intellectual disabilities. The descriptive design reports and case studies identified in the literature search provide a more clinical context for the findings. However, these descriptive reports and case studies have such low-level evidence that it is inappropriate to use them in making evidence-based decisions (Wendt, 2009).

Search Results

The full text of 18 studies that met at least one inclusion criterion were evaluated. Only nine of these studies met all four inclusion criteria and provided sufficient information to be included in the review. Table 1 is a summary of the included studies.

Evaluating the Evidence
Guidelines for Evaluating the Studies

The quality of the included studies was compared to the *Certainty of Evidence Framework* (Simeonsson & Bailey, 1991) criteria for: a) quality of the research design, b) inter-rater reliability (IR), and c) treatment integrity (TI). The studies were then ranked as: 1) *conclusive,* 2) *preponderant,* 3) *suggestive,* or 4) *inconclusive.* The *conclusive* studies have adequate research designs and IR and TI values above 80%. The *preponderant* studies have minor research design flaws, but their IR and TI values are acceptable (at least 80%). The *suggestive* studies have numerous minor research design flaws with inadequate IR and/or TI values; either IR or TI may be completely missing. The *inconclusive* studies have fatal research design flaws and/or do not report IR and TI values.

Research Design

The included studies were assessed for quality of design, inter-rater reliability, and treatment integrity. Of the research designs represented, five of the nine included studies were single-subject experimental designs. Four of the five were multiple-probe or multiple-baseline designs, which were rated as "sound," and demonstrated appropriate design structure and controls. The fifth study, an alternating treatment design study, was judged inadequate because no treatment replication data were reported. The remaining four studies were descriptive studies that could not be rated due to insufficient reporting of data. Table 1 include a summary of the research study design assessment.

Participant Characteristics

Data were reported for 46 children (males = 14, females = 8, gender not reported = 24) with intellectual disabilities in the included studies. The average participant age was 8.8 years (range = 2.7 to 18.11 years). All participants had been diagnosed with moderate-to-severe intellectual disabilities, developmental delays, Down syndrome, or severe learning disabilities.

Treatment Effectiveness

The matrix strategy was the treatment approach used to improve multi-word performance of all participants in the nine included studies. As reported in Table 1, various modalities were used for the target communication skills, such as expressive and receptive language skills (Ezell & Goldstein, 1989; Goldstein, Angelo, & Mousetis, 1987; Goldstein & Mousetis, 1989; Mineo & Goldstein, 1990; Striefel et al., 1976); manual signs (Light et al., 1990; Remington et al., 1990); and pointing to graphic symbols (Nigam et al., 2006).

Data Analysis and Interpretation

Search results revealed that only single-subject design studies included effect size (ES) estimation, using the statistical procedure known as the Nonoverlap of All Pairs (NAP) method (Parker & Vannest, 2009). The NAP score indicates the data overlap between each baseline data point and each intervention data point. As illustrated in Figure 1, the NAP score is calculated by comparing each Phase A data point with each Phase B data point (Parker & Vannest, 2009). To calculate an NAP:

1. Calculate the total possible pairs (total N) by the number of data points in phase A times the number of data points in phase B ($N_A \times N_B$).

2. Any overlapping or tied data points between phase A and B are counted. If the phase A data points show any overlap with the phase B data points, the overlapped phase A data points earn one point. If the phase A data points show any tie with the phase B data points, the tied phase A data points earn a half point.

3. Subtraction from the sum of overlapped and tied points from the total possible pairs can be calculated. Finally, NAP is calculated by the total possible pairs minus the sum of overlapped and tied points divided by the total possible pairs.

NAP scores can be interpreted as a range of treatment effect from weak to strong as follows: 0–65% indicates weak effects, 66–92% indicates medium effects, and 93–100% indicates large or strong effects (Parker & Vannest, 2009).
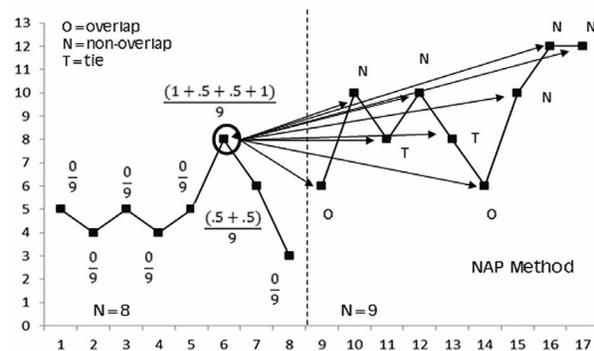
Figure 2 Illustration of NAP method for estimating size of treatment effect

(Adapted and reprint with permission from Parker & Vannest)

Evidence of Interrater Reliability

Interrater reliability (IR) refers to the agreement between the researcher and an observer's scoring or observation of the occurrence of target behavior in a study. High IR reflects reliable data collection, which is a prerequisite for evidence of internal validity. For the included studies, IR was defined as the agreement between two observers of the expressive and/or receptive language production, during matrix strategy interventions. All nine studies reported appropriate IR (ranging from 88% to 100%), for at least 20% of the sessions. The individual study IR outcomes are summarized in Table 1.

Evidence of Treatment Integrity

The third study reviewed for quality, treatment integrity (TI) refers t the consistent and prescribed delivery of the intervention as reported in the study. According to Kennedy (2005), about 20% to 30% of the total sessions in a study are needed to be able to calculate TI. For the purposes of this review, the studies that implemented the matrix strategy were measured by observers who recorded the delivery of the training during the intervention. If a study reported 80% or greater TI, the implementation followed the treatment protocol as planned. Among the review studies, only one study (Nigam et al., 2006) reported TI greater than 80%. The remaining eight studies provided no indication of TI.

The effect sizes of the treatment for each participant were calculated with the NAP method for four of the five single-subject design studies. The *conclusive*-rated study (Nigam et al., 2006) measured the correct responses of the action and object combinations in which each of the three participants pointed to one verb and one object symbol in a specified order. The effect size for each participant ranged from 98.9% to 99.2%, indicating a strong impact of treatment.

For the three *suggestive*-rated studies (Goldstein et al., 1987; Goldstein & Mousetis, 1989; Mineo & Goldstein, 1990), the treatment effect was measured by the correct responses of expressive and receptive language. For the expressive language, the combined NAP score of the three studies was an average of 96.8% (range = 85.4% to 100%) and for receptive language, the combined NAP score average was 96.9% (range = 76.9% to 96.9%), indicating an overall strong treatment effect.

The remaining studies were all descriptive group designs and were judged as *inconclusive* in study quality (Ezell & Goldstein, 1989; Light et al, 1990; Remington et al., 1990; Romski & Ruder, 1984; Striefel et al., 1976). These studies also reported the responses of correct expressive and/or receptive languages, manual signs, or speech and manual signs (total communication). However, due to the nature of the descriptive group design flaws no data were available to assess the strength of the matrix strategy treatment and no quantitative effect size could be calculated. Individual effect sizes for all available measures are presented in Table 1.

Conclusions

The question posed by Abby, the SLP, was "Is the matrix strategy intervention effective for expanding word combinations in children with intellectual disabilities?"

Only one of the included nine studies demonstrated conclusive support for the matrix strategy as an effective approach to expanding word-combination skills, by using graphic symbols (Nigam et al., 2006). The remaining conclusive- and suggestive-rated studies also reported high success rates with children and adolescents, ages 6 to 18 years old. The data from these studies does provide evidence, though limited, for a potential intervention effect.

Three of the four single-subject design studies were ranked as *suggestive*, indicating that it is plausible that the matrix strategy resulted in the improvement of expressive and receptive language skills (Goldstein et al., 1987; Goldstein & Mousetis, 1989; Mineo & Goldstein, 1990). In Mineo and Goldstein's study, four children (ages 3–5 years) participated in the matrix training. All participants demonstrated higher success rates for expressive language skills (85.4% to 96.2%) and receptive language skills (76.9% to 100%), and the study was appraised as *suggestive.*

The Ezell and Goldstein (1989) alternating treatment study was rated as *inconclusive* and interpreted as offering inadequate support for the matrix strategy to improve multi-word vocabulary. All the other *inconclusive* studies were descriptive case studies, which were not expected to provide experimental evidence of the treatment effect. The purpose of a descriptive case study is to focus on an application of an intervention with the potential for more informed and controlled study, and to offer a narrative context of the treatment of interest. The case studies provided a consistent description of the use of the matrix strategy with intellectually disabled children, but without the accompanying data support.

The evidence in this review suggests that the matrix strategy is, at least, a potentially viable approach for improving the multi-word productions of intellectually disabled children. For Abby, the answer to her question of the effectiveness of the matrix strategy is a firm "maybe." The decision to adopt a matrix-strategy approach must be made in light of this evidence, as well as a variety of factors that account for cultural, linguistic, school, family, and Emily's presenting behavior needs. This is not to suggest that the matrix strategy is not effective, only that the existing evidence is inadequate to provide unqualified support of the approach for broad scale application. The few single-subject studies reviewed point to the need for a body of evidence that is methodologically appropriate treatment efficacy research and addresses the effectiveness of the matrix strategy intervention for a wider adoption.

Table 1 Summary of Studies by Inclusion Criteria Met

Study	Subjects (*n*, ages, genders, and diagnosis)	Experimental Design	Target Communication Skills	Results	Effect Size NAP	Appraisal
Nigam, R., Schlosser, R., & Lloyd, L. (2006)	3 children (7, 11, and 13 years old, one boy and two girls) with moderate intellectual disabilities	Multiple probe baseline across action–object combinations with generalization probes	Pointing to graphic symbols	Two of three participants learned to combine action–object symbols and demonstrated generalizations on untrained graphic symbols.	P1: 99.2% P2: 98.9%	**Conclusive** Sound design Inter-rater reliability (94–98%) Treatment integrity (96–97%)
Goldstein, H., Angelo, D., & Mousetis, L. (1987)	3 children (9:3, 9:5, and 18:11, two boys and one girl) with severe intellectual disabilities	Multiple baseline across object–location combinations	Expressive and receptive language skills	Matrix training with a limited number of responses was enough to generalize untrained works in expressive and receptive language skills.	**Expressive Lang.** P1: 97.8% P2: 100% P3: 100% **Receptive Lang.** P1: 97.8% P2: 100% P3: 93.8%	**Suggestive** Sound design Inter-rater reliability (96–100%) No treatment integrity
Goldstein, H., & Mousetis, L. (1989)	6 children (6:9–9:3, gender unknown) with intellectual disabilities	Multiple baseline across preposition–location combinations and across object–preposition–location combinations	Expressive and receptive language skills	Participants learned and generalized two- (preposition–location) and three-word (object–preposition–location) combinations.	**Expressive Lang.** P1: 92.5% P2: 100% P3: 100% P4: 100% P5: 100% P6: 100% **Receptive Lang.** P1: 100% P2: 100% P3: 100% P4: 100% P5: 100% P6: 100%	**Suggestive** Sound design Inter-rater reliability (93–100%) No treatment integrity

Table 1 Summary of Studies by Inclusion Criteria Met, continued

Study	Subjects (*n*, ages, genders, and diagnosis)	Experimental Design	Target Communication Skills	Results	Effect Size NAP	Appraisal
Mineo, B. A., & Goldstein, H. (1990)	4 children (2:7–4:11, four boys) with developmental delays	Multiple probe baseline across verb–object combinations	Expressive and Receptive language skills	The participants increased their word combinations (verb–object) with trained and untrained words. In addition, their spontaneous speech and mean length of utterance (MLU) were increased.	**Expressive Lang.** P1: 96.2% P2: 91.3% P3: 85.4% P4: 94.9% **Receptive Lang.** P1: 76.9% P2: 100% P3: 95.8% P4: 95.5%	**Suggestive** Sound design Inter-rater reliability (94–98%) No treatment integrity
Light, P., Watson, J., & Remington, B. (1990)	**Study 1** 2 children (4:8 and 9:11, two boys) with intellectual disabilities (severe learning disabilities) **Study 2** 4 children (10:4–16:9, one boy and three girls) with intellectual disabilities	Descriptive design	Manual signs	In both studies, participants improved their responses with learned sign combinations as well as new sign combinations.	Only individual data provided Unable to calculate	**Inconclusive** No experimental design No treatment integrity Inter-rater reliability (88–100%)
Remington, B., Watson, J., & Light, P. (1990)	**Study 1** 2 children (4:10 and 9:5, one boy and one girl) with intellectual disabilities (severe learning disabilities) **Study 2** 8 children (5:10–16:3, gender unknown) with intellectual disabilities	Descriptive design specify	Manual sings	Participants learned appropriate signs directly taught and the items that had not been exposed.	Only individual data provided Unable to calculate	**Inconclusive** No experimental design No treatment integrity Inter-rater reliability (90%)

Table 1 Summary of Studies by Inclusion Criteria Met, continued

Study	Subjects (*n*, ages, genders, and diagnosis)	Experimental Design	Target Communication Skills	Results	Effect Size NAP	Appraisal
Romski, M., & Ruder, K. (1984)	10 children (3:11–7:10, gender unknown) with Down syndrome	Descriptive design	Expressive language skills and manual signs (= total communication)	Participants learned speech and speech + sign combinations successfully. In addition, there were no significant differences between two conditions.	Only individual data provided Unable to calculate	**Inconclusive** No experimental design No treatment integrity Inter-rater reliability (98–100%)
Striefel, S., Wetherby, B., & Karlan, G. R. (1976)	2 children (12 years old, two boys) with intellectual disabilities	Descriptive design	Receptive language skills	Participants were trained to respond correctly using verb–noun combination. Two children responded correctly with untrained combinations.	Only individual data provided Unable to calculate	**Inconclusive** No experimental design No treatment integrity Interrater reliability (95–100%)
Ezell, H. K., & Goldstein, H. (1989)	2 children (6:1 & 9:11, 1 boy and 1 girl) with moderate intellectual disabilities	Alternating treatment design	Expressive language skills	Participants improved their correct responses during receptive identification trial sessions with and without imitation of object–location phases.	Unable to calculate	**Inconclusive** Missing treatment replications No treatment integrity Interrater reliability (94–100%)

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