The Effects of Hearsee/Say and Hearsee/Write on Acquisition, Generalization, and Retention

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Abstract

This study examined the effects of training in 2 yoked learning channels (hearsee/say and hearsee/write) on the acquisition, generalization, and retention of learning. Four 5th-grade participants were taught the lowercase letters of the Greek alphabet; 12 letters were taught in the hearsee/say channel and 12 letters were taught in the hearsee/write channel for equal amounts of time. The hearsee/say channel reached higher frequencies at the end of training and showed higher acquisition celerations than the hearsee/write channel. However, the hearsee/write channel showed higher accuracy and retention than the hearsee/say channel. The hearsee/write channel also showed greater generalization across learning channels including the see/say, think/say, think/write, and see-name/draw-symbol channels. This research has implications for the design of instruction.

Keywords Acquisition · Generalization · Learning channels · Precision teaching · Retention

One contribution of precision teaching to education is the notion of learning channels. A learning channel is a combination of one or more sensory inputs (e.g., hear, see) with one or more responses described in terms of action verbs (e.g., say, write). For example, a see/say channel would involve the learner seeing a picture as the sensory input and saying the name of the picture as the response. Thus, we can have a see/say channel that is different from a see/write channel that is different from a see/match channel. All three may involve the same sensory input, but the response makes each combination a different behavior (Haughton, 1980; Lindsley, 1994, 1998). They are considered different behaviors not only because they represent different topographies but also because they are affected differently by other variables (e.g., a student may learn

the same material faster with the see/say channel than with the see/write channel).

The notion of learning channels resulted from the lack of clear descriptive language in the field of education. Learning channels help clarify the way information is presented and in what way a person responds. Traditional educational statements like “knows,” “recognizes,” “is able,” and “understands” are changed to more clear-cut actions describing the environmental inputs and responses (Haughton, 1980). For example, a more specific way to describe that Anthony “knows” his letter sounds is to state what he does and the conditions under which he does it: Anthony can hear-letter-name/say-its-sound, hear-letter-sound/write-the-letter, see-letter/say-its-sound, and so forth.

Haughton (1980) developed three matrices (the activity matrix, the mobility matrix, and the academic-personal-social matrix) to display many of the possible channel combinations. He ordered the inputs from bottom to top on the left side of the matrix while listing the outputs across the bottom. The intersections formed by rows and columns are called channel sets. Figure 1 shows Haughton’s academic-personal-social development matrix. This matrix captures behaviors typically seen in educational settings, as well as in personal and social environments. When used by educators, the matrix can facilitate the writing of concise learning objectives by filling in as many intersecting boxes as possible. The end result is a collection of numerous ways one may choose to

Research Highlights

- Learning channels facilitate communication with parents and therapists.
- Learning channels help clarify instructional procedures.
- Learning channels facilitate planning of instruction.
- Learning channels help in the evaluation of student performance.

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Fig. 1 Eric C. Haughton's learning matrix

INPUT	Think (T)											
	Touch (To)											
	Taste (Ta)											
	Sniff (Sn)											
	See (Se)											
	Hear (H)											
	Feel (F)											
		Aim (A)	Do (Do)	Draw (D)	Emote (E)	Mark (Mk)	Match (M)	Say (S)	Select (St)	Tap (Tp)	Thought (Tt)	Write (W)
OUTPUT												

teach a specific objective (see Kubina & Cooper, 2000; Lin & Kubina, 2004). Also, by looking at a partially filled matrix, new ways to combine learning channels may become more apparent. This is an important point to consider because using multiple channels with the same target behavior has been said to add variety to instruction and practice and may also promote generalization (Stokes & Baer, 1977).

Although the matrix has been very helpful in organizing learning channels, it is only capable of displaying two-dimensional descriptions. That is, it cannot easily be used to yoke different channel components. Yoking refers to combining two or more components on either side of the learning channel. For example, hearsee/say indicates hearing and seeing a stimulus, then saying the response. See/saywrite involves seeing a stimulus, then saying its name and writing it down (Lindsley, 1998).

In addition to the benefits of clear description and lesson planning derived from the use of learning channels, they have also been used to choose teaching formats. Lindsley (1998) noted that the channel a learner performs best in (the highest frequency) is not always the channel that the student learns best in (the steepest deceleration). Precision teachers often try to identify a learning channel that produces the best learning for particular students and exclusively teach in that channel while remediating the channels that are weaker. Lindsley (1998) also suggested that the hear/say learning channel is the best entry channel when starting a new curriculum. However, more research is needed to determine the best entry and teaching channels for different curricula and children.

Arnesman (1982) investigated the relative independence of four learning channels: hear/write, see/write, see/say, and touch/say. His participants included five developmentally delayed adults. He hypothesized that learning in one channel would be independent of learning in the other channels. He found slightly better accuracy and higher ending frequency levels for the see/write and see/say channels. Additionally, there was more deceleration of errors in the see/say channel, which led him to conclude that the see/say channel produced the best performance and learning for these students. Thompson (1985) compared four learning channels, see/write, hear/write, see/say, and hear/say, across three reading levels with six learning-disabled and two emotionally disturbed middle school children. Thompson found no significant differences in the deceleration of correct responses for the different learning channels. However, there were differences in the median ending frequencies for correct responses and incorrect responses, with the see/say channel producing much higher median correct responses and slightly higher incorrect responses than the other channels.

To date, research and practice have concentrated on the independence of learning channels in terms of learning and performance. An additional way to approach the independence of learning channels is to ask what learning channels produce the most generalization and retention. However, limited research has been performed with regard to this. In one study, Young, West, and Crawford (1985) looked at the acquisition and maintenance of reading skills by intellectually

handicapped deaf students. The direct instruction procedure used in their study was effective in teaching both see/sign and see/match tasks, but resulted in maintenance at a 4-month check for only the see/sign task.

Although only two formal studies looking at the effects of generalization in learning channels were found, there have been many informal reports of generalization occurring in certain learning channels. For example, Lindsley (1994) reported that the Morningside model uses fluency rates in the see/say learning channel to produce generative responding in the see/write channel. Others, however, have reported that learning did not generalize across learning channels. For example, Shrivastava and Leach (2000) investigated the effects of fluency building and generalization using three- and five-phoneme nonwords. Little generalization was found in testing from the see/say channel to the hear/say channel. Even less generalization was found in testing from the see/say channel to the hear/write channel. In another study, Nam and Spruill (2005) taught three students with special needs to accurately say multiplication facts to fluency in the see/say channel. They noted that the accuracy and fluency in the see/say channel did not generalize to the see/write channel. However, performance in the see/write channel improved after the children were trained in the hear/say channel.

This literature suggests that learning and performance in one channel are often independent of learning and performance in another channel and that channel effectiveness may vary across learners. There is also some evidence that channels may differently generalize to other channels and that not all channels produce the same retention. However, to date, none of this research has involved yoked channels.

The present study seeks to analyze the acquisition, performance, generalization, and retention obtained from two yoked channels, hearsee/say and hearsee/write, in teaching the Greek alphabet to typically developing fifth graders.

Method

Participants and Setting

The participants were four typically developing girls between the ages of 10 and 11 years. They attended fifth grade at a private parochial school located in Denton, Texas. At the request of the experimenter, the principal selected participants from a broad range of academic performance levels. One participant was considered an A student (JB), two participants were B students (CC and KS), and the fourth was a C student (SD). The parents signed consent forms, and the participants signed assent forms agreeing to their participation.

The study took place in a conference room adjacent to the fifth-grade classroom. The room had two rectangular folding tables placed side by side with 10 chairs around the perimeter of the tables. The experimenter sat at the corner of one table, and the participant sat to her right.

Materials

The stimuli consisted of the 24 lowercase letters from the Greek alphabet and their printed names. The alphabet was divided into two sets of 12 lowercase letters. Each set contained names of similar lengths (between two and seven letters), and each set of printed names contained about the same number of total letters: Set A was 50 letters, and Set B was 52 letters.

The Greek letters and their printed names were presented in several formats. Each of the 24 lowercase Greek letters was printed in random order down the left column on a sheet of paper. The right column contained a line for the participant's response. A line at the bottom of the sheet was left for the experimenter to record the duration of the task. The names of the Greek letters were also presented in this format. All 24 names of the Greek letters were listed down the left column, whereas the right column contained a line for the participant to draw the corresponding symbol. A blank version of this sheet with nothing printed in the left column was also used. During one test, the experimenter recorded the participant's verbal responses in the right column. In another test, the participants wrote their own responses in the right column. The left column was used for scoring purposes on both sheets.

Another format utilized 2.5 in. × 4 in. (6.35 cm × 10.16 cm) cards printed on medium-weight card stock. Each letter was printed in black ink and centered on the front of the card. The letter name, printed in light gray ink, was centered on the back of the card.

The letters from Set B were also printed on an 8.5 in. × 11 in. (21.59 cm × 27.94 cm) sheet of paper set horizontally. This sheet of paper was divided into three columns, and each contained 15 letters printed in random order with a line next to each letter for the participant's written response.

Other materials used included a timer, a counter, three sharpened #2 pencils, timings charts, and the daily standard celeration chart.

Measurement

Dependent variables The dependent variables were the frequency and celeration of correct responses, incorrect responses, and passes per week. Responses included saying the name of each letter, writing the letter, and drawing the letter. A saying response was counted as correct when the participant pronounced all the syllables of the letter name correctly, as incorrect when the participant mispronounced

the letter name or said the wrong letter name, and as a pass when the participant said “pass” on any stimulus presentation. A writing response was counted as correct when the participant wrote all the letters composing the correct letter name, as incorrect when the participant wrote the wrong letter name or wrote the right letter name but spelled it incorrectly, and as a pass when the participant drew a line or left the line blank. A drawing response was counted as correct when the participant drew the corresponding symbol for the letter name listed, as incorrect when the participant drew the wrong symbol or did not draw the symbol with the appropriate features, and as a pass when the participant drew a line or left the line blank. For the purpose of data analysis, all passes were counted and charted as incorrect responses. However, it is worth noting that lumping the pass responses with the incorrect responses led to a loss of information that could have been useful.

Independent variables The independent variables in this study were two instructional formats that involved the yoking of different learning channels: hearsee/say and hearsee/write. Hearsee/say consisted of the participant seeing the stimulus on a card, hearing the name of the stimulus, and then saying the name of the stimulus. Hearsee/write consisted of the participant seeing the stimulus on a sheet, hearing the name and spelling of the stimulus, and then writing the name of the stimulus on the line next to it.

Timing procedures Two timing procedures were used to calculate the speed of responding: a fixed time and a total duration time. The fixed timing lasted for 15 s or 1 min. The total duration timing lasted for the amount of time required to complete the task.

Design

To compare the relative effectiveness of different learning channels, a single-subject multiple-treatments design was used (Kazdin, 1982). Each participant experienced both instructional formats: 12 of the Greek letters were taught using the hearsee/say channel, and the remaining 12 were taught using the hearsee/write channel.

Procedures

The participants were seen individually Monday through Friday starting at 12:30 p.m. The experimenter went to the fifth-grade classroom, and the teacher selected one of the four participants to go to the experimental session. When a participant finished and went back to the classroom, the teacher sent the next participant to the experimental room.

Pretest Before training, both the see/say and see/write learning channels were tested. In the see/say test, all 24 cards were

shuffled and presented to the participant. The participant was instructed to look at each card and say the name of the letter or to say “pass” if she did not know the name of the letter. In the see/write test, the participant was presented with a sheet containing all 24 letters printed in random order. The participant was instructed to write the name of each letter on the line next to it or to draw a line to indicate a pass on that item if she did not know the name of a letter.

The timer was set to the count-up mode, and the participant was asked, “Are you ready?” Once the experimenter got confirmation that the participant was ready, she then said, “Please begin,” and pressed start on the timer. The experimenter stopped the timer when the participant indicated that she was finished with the task. Upon completion of the pretests, the experimenter said to each participant, “Good job! We will start training next week.”

Hearsee/say and hearsee/write training A training session consisted of a 1-min practice timing and three 15-s sprint timings for both learning channels. The 1-min practice timing, performed first, was intended to build accuracy. Three 15-s sprint timings followed and were intended to build speed. During these timings, the experimenter and participant worked together. The timer was set for the desired time (1 min or 15 s), and the participant was asked, “Are you ready?” Once the experimenter got confirmation that the participant was ready, she then said, “Please begin,” and pressed start on the timer. When the timer beeped, the experimenter pressed the stop button and counted the number of correct responses, incorrect responses, and passes. All training sessions began with the hearsee/say channel and ended with the hearsee/write channel.

During the hearsee/say training, the participant was supplied with a deck containing 12 cards from Set A. The experimenter demonstrated for the participant how to flip through the cards one at a time and told her the following instructions: “Please continue flipping through the deck until the timer beeps. I will say the name of each card first, and you should repeat after me.” As the participants became more fluent in each saying response, they would say the names in unison with the experimenter. Corrections in pronunciation were made as needed.

During the hearsee/write training, the participant was supplied with a training sheet containing the 12 letters from Set B. This sheet was used continuously for the 1-min timing, three 15-s sprint timings, and the 1-min test. Lines were drawn where the participant stopped at the end of each timing. The following timing was started where the participant left off from the previous timing. The experimenter told the participants the following instructions: “During the 1-minute timing and three 15-second sprint timings, I will say and spell the name of each letter, and you should write the name on the

line.” As the participant became fluent in each writing response, the experimenter no longer spelled the letter names but continued to say them.

Daily 1-min test After training in each channel was completed, a 1-min test was conducted as a learning check. The participant worked independently, and the experimenter did not provide corrective feedback.

Cross-channel tests During these two tests, the participant was required to say the 12 letter names she had learned to write and write the 12 letter names she had learned to say. For the cross-channel say test, the experimenter told the participant the following instructions:

I am going to give you a new deck of cards that show the 12 Greek letters that you were taught to write. Say each

name as you flip through the deck, or say pass if do not know the name of the letter. This test will be timed for 1 minute.

For the cross-channel write test, the experimenter told the participant the following instructions:

I am going to give you a new sheet that shows the 12 Greek letters that you were taught to say. Write each name on the line next to it, or draw a line if you do not know the name of the letter. This test will be timed for 1 minute.

The experimenter did not provide corrective feedback.

See-name/draw-symbol test During this test, the participant was to draw the Greek letter when given the name of the letter. The participant was given a sheet that had all the names of the

Fig. 2 Learning pictures for see/say and see/write learning channels; Cel. = celeration

letters typed in a column on the left side of the page. The experimenter told the participant the following instructions: “Draw the symbol as best as you can on the line next to each name. When you are finished, put your pencil down, and I will stop the timer.” Corrective feedback was not provided.

Think tests There were two think tests: think/say and think/write. For the think/say test, the experimenter told the participant the following instructions: “Please say as many names from the whole Greek alphabet as you can, and I will write them down on the think/say sheet. Tell me to stop the timer when you are finished.” During the think/write test, the participant was supplied with the think/write sheet, and the experimenter told the participant the following instructions: “Please write down as many names from the whole Greek alphabet as you can remember. I will stop the timer when you place your pencil down.” Corrective feedback was not provided during these tests.

Posttests The posttests were a repetition of the pretests in both the see/say and see/write learning channels. They were

administered following the completion of training and the other tests.

Retention tests Approximately one month after the training was completed, the experimenter readministered all the tests in this order: see/say all, cross-channel say, cross-channel write, think/say, think/write, see-name/draw-letter, and see/write all.

Results

Figure 2 shows the accuracy and speed of responding during the daily 1-min tests for all participants in the see/say (top graphs) and see/write (bottom graphs) learning channels. Each column shows a participant’s performance in both channels. The black dots represent correct responses per minute, and the Xs represent incorrect responses per minute. Xs displayed below the 1-min floor line indicate that no errors were made during that timing. Acquisition celeration lines are drawn in light gray, and their values are displayed to the right. Each celeration line is based on the data from the beginning of

Fig. 3 Median acquisition celerations for the see/say and see/write learning channels; Mdn = median

teaching until the first day that the participant made zero errors. The slope and direction of the line were determined visually by using the focused method (Graf & Lindsley, 2002). That is, a line was placed over the data. Then, the line was moved up and down and tilted until the same number of dots could be seen above and below the line for the length of the line. The slope of the celeration is expressed as a factor (e.g., X1, X10, /15, /30) and quantifies the amount of weekly change in behavior.

JB's correct responding in the see/say learning channel accelerated at X3.5 per week, whereas her incorrect responding decelerated at /100 per week. JB's correct responding in the see/write learning channel accelerated at X50 per week, whereas her incorrect responding decelerated at /10,000 per week. SD's correct responding in the see/say learning channel accelerated at X8 per week, whereas her incorrect responding decelerated at /100 per week. SD's correct responding in the see/write learning channel accelerated at X3 per week, whereas her incorrect responding decelerated at /15 per week. CC's correct responding accelerated at X3.5 per week in the see/say learning channel, whereas her incorrect responding decelerated at /100 per week. CC's correct responding in the see/write learning channel accelerated at X3 per week, whereas her incorrect responding decelerated at /10 per week. KS's correct responding in the see/say learning channel accelerated at X5 per week, whereas her incorrect responding decelerated at /60 per week. KS's correct responding in the see/write learning channel accelerated at X3.1 per week, whereas her incorrect responding decelerated at /10 per week.

Figure 3 shows a summary of the acquisition celerations during the see/say and see/write learning channels. The results are displayed on a base-10 multiplying scale with X1 in the

center of the chart. Two cycles of multiplying factors go above this line (e.g., X10 and X100), and two cycles of dividing factors go below this line (e.g., /10 and /100). The black dots represent correct responses and the Xs represent incorrect responses. For example, a dot on the 10 line that is above the midline of the graph would represent a celeration of 10 for correct responses, whereas an X on the 10 line that is below the midline of the graph would represent a deceleration of 10 for incorrect responses. The greater-than symbol (>) is used to indicate the median value. The median celeration for correct responses during the see/say learning channel was X4, and /100 for incorrect responses. The median celeration for correct responses during the see/write learning channel was X3, and /12.5 for incorrect responses.

Figure 4 shows the last frequencies from the daily 1-min see/say and see/write tests. The results are displayed as a count per minute on a base-10 multiplying scale with a question mark below the 1 to represent a value of 0. The median frequency of correct responses during the 1-min see/say test was 78 per minute, and 0 for incorrect responses. The median frequency of correct responses during the 1-min see/write test was 26 per minute, and 0 for incorrect responses.

Figures 5 and 6 follow a similar format as Figure 3. Figure 5 shows the frequency jump of correct and incorrect responding from posttest to retention test for the see/say and see/write learning channels. The frequency jump is calculated by dividing the highest frequency by the lowest frequency from the posttest and the retention test. A multiplication sign is used when the retention frequencies are higher than the posttest frequencies. A division sign is used when the retention frequencies are lower than the posttest frequencies. Thus, if there was no change from the posttest to the retention test, a dot would be placed on the 1. The median frequency jump in

Fig. 4 Median last frequencies for correct and incorrect responding for see/say and see/write learning channels

Fig. 5 Median frequency jumps for correct and incorrect responding for the see/say and see/write retention test data

the see/say learning channel was /1.5 for correct responding and X5 for incorrect responding. The median frequency jump in the see/write learning channel was /1.2 for correct responding and X1.25 for incorrect responding.

Figure 6 shows the frequency jump of correct and incorrect responding during the crossover tests. The frequency jump is calculated by dividing the highest frequency by the lowest frequency from the posttest and the crossover test. In the write-to-say crossover test, the median frequency jump for correct responses was /1.1, and X1 for incorrect responses. In the say-to-write crossover test, the median frequency jump for correct responses was /1.4, and X12 for incorrect responses.

Figure 7 shows the number of names correctly spoken during the think/say posttest and think/say retention test. The white bars represent responses trained in the hearsee/say channel, and the black bars represent responses trained in the hearsee/write channel. There were 12 possible correct responses for each channel. JB said 11 names from the say set and 11 names from the write set during the posttest. Her retention test data show a decrease of five responses from the say set and a decrease of one response from the write set. SD said seven names from the say set and seven names from the write set during the posttest. Her retention test data show a decrease of one response from the say set and an increase of one response from the write set. CC said nine names from the say set and seven names from the write set during the posttest. Her retention test data show a decrease of one response from

the say set and an increase of one response from the write set. KS said 8 names from the say set and 11 names from the write set during the posttest. Her retention test data show an increase of 1 response from the say set, and responding maintained at 11 responses in the write set.

Figure 8 shows the number of names correctly written during the think/write posttest and think/write retention test. The white bars represent responses trained in the hearsee/say channel, and the black bars represent responses trained in the hearsee/write channel. There were 12 possible correct responses for each channel. JB wrote 8 names from the say set and 11 names from the write set during the posttest. Her retention test data show an increase of 1 response from the say set, and responding maintained at 11 responses from the write set. SD wrote four names from the say set and seven names from the write set during the posttest. Her retention test data show an increase of one response from the say set and a decrease of two responses from the write set. CC wrote three responses from the say set and five responses from the write set during the posttest. Her posttest data show an increase of one response from the say set and an increase of four responses from the write set. KS wrote 3 responses from the say set and 10 responses from the write set during the posttest. Her retention test data show the three say responses maintained, as well as a decrease of two responses from the write set.

Figure 9 shows the number of symbols correctly drawn during the see-name/draw-symbol post- and retention tests. The white bars represent responses trained in the hearsee/

Fig. 6 Median frequency jumps for correct and incorrect responding in the write-to-say and say-to-write tests

say channel, and the black bars represent responses trained in the hearsee/write channel. There were 12 possible correct responses for each channel. JB drew 11 symbols from the say set and 11 symbols from the write set during the posttest. Her retention test data show a decrease of 4 responses from the say set, and responding maintained at 11 responses from the write set. SD drew four symbols from the say set and seven symbols from the write set during the posttest. Her retention test data show a decrease of two responses from the say set and a decrease of four responses from the write set. CC drew seven symbols from the say set and nine symbols from the write set during the posttest. Her retention test data show an increase of one response from the say set and an increase of three responses from the write set. KS drew six symbols from the say set and nine symbols from the write set during the posttest. Her retention test data show a decrease of two responses from the say set and a decrease of three responses from the write set.

Discussion

The results show that for three of the four participants, the hearsee/say learning channel produced higher acquisition celerations per week than the hearsee/write learning channel. Participant JB, however, displayed higher acquisition celerations in the hearsee/write channel. All participants reached higher frequencies (fluency) in the hearsee/say channel than in the hearsee/write channel. However, participants'

errors in the hearsee/say channel took longer to drop out after 100% accuracy had been achieved for the first time. In contrast, no errors occurred in the hearsee/write channel after participants reached 100% accuracy for the first time.

These results support previous observations that learning (celeration) and performance (fluency) differ for different channels. Also, individual learners may vary in terms of what channels produce the best celerations and frequencies. Current precision-teaching practices favor learning channels that the student learns best in. This is due to the fact that the precision-teaching community universally accepts the research that higher frequencies (fluency) produce better retention, endurance, application, and performance standards (REAPS), or better retention, endurance, stability, application, and adduction (RESAA; Binder, 1996; Johnson & Layng, 1992, 1996). Following this recommendation, precision teachers would have chosen to teach three of the participants from this study in the see/say channel and teach the fourth participant in the see/write channel. However, the retention and generalization data do not support this decision. The present data suggest that teaching all children in the hearsee/write channel would be more efficient.

Notably, the child who performed best in the see/write channel showed a very large jump in frequency in the first two sessions. It was unknown why this child performed so much better in the see/write channel. It would be worthwhile to study children who perform significantly better in the see/write channel or who perform significantly better in other channels. It may be possible to identify certain prerequisite skills

or other factors that contribute to strong performance in a certain channel, and these skills could be taught to other learners.

The results show that the channel with higher rates of responding did not produce better retention. The hearsee/write channel produced better retention independent of frequency and celeration of responding. These findings were consistent across all retention tests administered. Even though high rates of fluency

have been a good predictor of retention (e.g., Binder, 1996; Johnson & Layng, 1992; Lindsley, 1998), the present study shows that the learning channel may be a better predictor. Perhaps the fluency hypothesis (i.e., higher rates lead to better RESAA or REAPS) only applies to different tasks within the same channel. A study by Young et al. (1985) may be cited as evidence supporting the fluency hypothesis. In this study, higher

Fig. 7 Number of say and write responses for the think/say post- and retention tests

frequencies appeared to be correlated with better retention. Unfortunately, it is not clear if these results are due to the fluency effects or the nature of the channel; that is, the see/sign channel could have produced better retention than the see/match channel independently of its celeration and fluency rates. In contrast, the present study found better retention to be correlated with the slower channel. This suggests that the nature of the channel is

more important for retention than fluency is for retention. Further research is needed to explore this issue.

Precision teachers assume very little generalization from one learning channel to the next. Consequently, they teach material in all the relevant channels at once. For example, letters may be taught simultaneously in the see/say channel, see/write channel, hear/point channel, hear/write channel, and so forth. Furthermore,

Fig. 8 Number of say and write responses for the think/write post- and retention tests

generalization is supposed to be a product of fluency, not the channel (Binder, 1996; Johnson & Layng, 1992; Lindsley, 1998). However, the present study and the study by Nam and Spruill (2005) do not support that conclusion. In this study, material trained in the hearsee/write channel generalized much better than material trained in the hearsee/say channel. For example, the amount of crossover from the write-to-say channel showed that both accuracy and frequency of responding were at the same rate

as the original hearsee/say channel. The crossover from say to write, however, produced a large increase in errors with a corresponding decrease in correct responses. Letter names trained in the hearsee/write channel occurred more often in the think/say test than names trained in the hearsee/say channel. During the think/write test, letter names trained in the hearsee/write channel occurred more often than ones trained in the hearsee/say channel. Also, the participants were able to draw more symbols from the

Fig. 9 Number of say and write responses for the see-name/draw-symbol post- and retention tests

hearse/write channel than they could from the hearsee/say channel. Thus, these data show that different learning channels can produce different amounts of generalization. Shrivastava and Leach (2000) found little generalization from the see/say channel to the hear/say channel and even less generalization from the see/say channel to the hear/write channel. Perhaps, if the experimenters had taught in the hear/write channel, they would have produced strong generalized effects to both the see/say and hear/say learning channels. The findings from the present study would suggest that.

In general, training in the hearsee/write learning channel proved to be very powerful for all participants in terms of generalization and retention. Because learning channels may differentially affect teaching outcomes, it is necessary to further study what relationships lay within and across different learning channels. It may be that by training in a double-yoked channel such as hearsee/saywrite, the outcome may be even more beneficial for the learner. More efficient ways of teaching particular learners could be derived from this research.

Compliance with Ethical Standards

Conflict of Interest All authors report no conflicts of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of North Texas Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study and their parents.

References

- Amesman, M. D. (1982). *Comparing learning channels in a community-based program for retarded adults* (Unpublished master's thesis). University of Kansas, Lawrence, Kansas.

- Binder, C. V. (1996). Behavioral fluency: Evolution of a new paradigm. *The Behavior Analyst*, 19(2), 163–197. <https://doi.org/10.1007/BF03393163>.
- Graf, S., & Lindsley, O. R. (2002). *Standard celeration charting 2002*. Poland, OH: Graf Implements.
- Haughton, E. C. (1980). Practicing practices: Learning by activity. *Journal of Precision Teaching*, 1(1), 3–20.
- Johnson, K. R., & Layng, J. T. (1992). Breaking the structuralist barrier: Literacy and numeracy with fluency. *American Psychologist*, 47(2), 1475–1490. <https://doi.org/10.1037/0003-066X.47.11.1475>.
- Johnson, K. R., & Layng, J. T. (1996). On terms and procedures: Fluency. *The Behavior Analyst*, 19(2), 281–288. <https://doi.org/10.1007/BF03393170>.
- Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings*. New York, NY: Oxford University Press.
- Kubina, R., & Cooper, J. (2000). Changing learning channels: An efficient strategy to facilitate instruction and learning. *Intervention in School and Clinic*, 35(3), 161–166. <https://doi.org/10.1177/105345120003500306>.
- Lin, F.-Y., & Kubina, R. M. (2004). Learning channels and verbal behavior. *The Behavior Analyst Today*, 5(1), 1–14. <https://doi.org/10.1037/h0100134>.
- Lindsley, O. R. (1994). “Point/see/say” or “Slide/see/say” learning channels. *Journal of Precision Teaching*, 12(1), 2–7.
- Lindsley, O. R. (1998). Learning channels next: Let's go! *Journal of Precision Teaching*, 15(2), 2–4.
- Nam, S., & Spruill, M. (2005). Learning channel intervention to develop and generalize fluency in multiplication facts. *Journal of Early and Intensive Behavior Intervention*, 2(2), 103–111. <https://doi.org/10.1037/h0100305>.
- Shrivastava, R., & Leach, D. (2000). *The effects of fluency building on generalization across learning channels in reading and spelling*. Washington, DC: Poster session presented at the annual conference of the Association for Behavior Analysis.
- Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis*, 10(2), 349–367. <https://doi.org/10.1901/jaba.1977.10-349>.
- Thompson, J. A. (1985). *Comparison of four learning channels over three reading levels on middle level special students* (Unpublished master's thesis). University of Kansas, Lawrence, Kansas.
- Young, K. R., West, R. P., & Crawford, A. (1985). The acquisition and maintenance of reading skills by intellectually handicapped deaf students. *Journal of Precision Teaching*, 5(4), 73–78.

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