Performance on WAIS-III relates to the Ability to Derive Relations

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Abstract: Experimental evidence suggests that derived relational responding (DRR) may provide a behavioral model of complex language phenomena. This study assigned 72 students to groups based upon their performance on a complex relational task. It was found that performance on DRR relates to scores on the WAIS-III.

One reason for the interest in derived relational responding, and stimulus equivalence in particular, is that a model of symbolic relations can be provided. The symbolic relations refer to relational frames among stimuli in the world which are represented in the form of symbols like words or numbers. The bi-directional relationship between a word and its meaning may be a *derived,* or untrained relation. For example, when trained that A is the 'same as' B, a subject typically choses B as the 'same as' A. When trained A = B, B = C, a subject typically derived a relation A = C. Hayes and Bisset (1998) discovered that subjects responded with more accuracy and speed to nonsense words that were semantically related than to those which were unrelated.

With pre-linguistic children, performance on derived relational responding tasks varies with language performance (Pelaez, Gewirtz, Sanchez, & Mahabir, 2000). Pelaez, et al. (2000) found that infants can derive relations like stimulus equivalence even before they acquire language. Also, Barnes, McCullagh, and Keenan (1990) compared equivalence class formation in non-hearing impaired children and hearing impaired children. Complex derived relational performances emerge readily in language-able subjects.

Derived relational responding and the WAIS-III

The Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) was used in this study to relate the subjects' verbal performances in this test to their ability to derive relations. We were interested in the verbal performance on the WAIS-III, specifically the vocabulary and arithmetic performances. This study looked only at the subjects' performance on the sub-tests indicating verbal IQ factors (verbal comprehension and arithmetic) because these particular sub-tests contribute to the growing literature on derived stimulus relations and provide the first step to increasing the relevance of behavioral approaches to language within mainstream psychology.

Thus, the vocabulary, arithmetic, and digit symbol coding sub-tests were assessed and compared in this study. The vocabulary sub-test contributes to the verbal comprehension index and verbal IQ factors; the arithmetic sub-test contributes to the working memory index and verbal IQ factors; while the digit symbol coding sub-test contributes to the processing speed index and performance IQ factors.

Derived Relational Responding

Human subjects can be trained to respond to a variety of derived relations. Barnes-Holmes et al (2001) Relational Frame Theory (RFT) emphasizes that:

Persons with a highly elaborated vocabulary will tend to have highly elaborated

> relational repertoires. Nevertheless, it is the relational skills that are key, not merely not merely verbal content in a formal sense. A task, such as learning to spell is far less relationally rich than learning word meaning, and thus it is no surprise that spelling performance will correlate less with overall levels of intellectual behavior even though both tasks involve verbal material. (p. 160)

For this reason, it was predicted that higher levels of proficiency on derived relational responding (DRR) tests should be a better predictor of performance on a vocabulary sub-test on the WAIS-III than on other, less relationally-rich sub-tests. This study was an experimental demonstration of this prediction.

Method

Subjects

Twenty-six monolingual and forty-six bilingual college students, ranging from 18 to 54 years of age, received partial course credit in Psychology for their participation in this study. All students were enrolled in Florida International University, and none had previous knowledge of either the study of derived relational responding or the WAIS-III scale.

Design

The laboratory consisted of three small rooms. The subject arrived at his/her designated appointment time, was welcomed into the waiting room, and given the informed consent form to read, sign, and date. The student then completed a brief demographic questionnaire concerning age, ethnicity, country of birth, length of time in Miami, major, and grade point average. Included on this form were questions of whether the subject was monolingual or bilingual, their primary and secondary languages, and a self-assessment of fluency in the second language. At this point, the lab assistant administered and audio recorded an assessment of Spanish comprehension.

The subject was then escorted into an adjacent control-observational room where he/she completed the relational responding task on one of the Apple iMac computers. Only the Z and M keys were used by the subject during the experiment. PsyScope software was used for its ability to control presentation of stimuli and record responses (Cohen, MacWhinney, Flatt, & Provost, 1993). The amount of time required for this section of the experiment varied by subject, but averaged ninety minutes. Upon completion, the subject made an appointment with the lab assistant to return for the third section of the experiment, the Wechsler Adult Intelligence Scale-III (Wechsler, 1997). The results of three sub-tests were used to assess each subject.

Procedure

Subjects participating in this study were exposed to three separate tasks: (1) an assessment of language comprehension; (2) a complex relational task administered on a computer; (3) the WAIS-III vocabulary, arithmetic, and digit-symbol coding sub-tests. After completion, the subjects were debriefed and left the laboratory. Following is a brief description of the three tasks.

Monolingual-Bilingual Assessment

The Spanish Language Comprehension Assessment was used in order to test second language ability. From a bank of ten questions, one was read aloud in Spanish by the experimenter and answered aloud by the subject, who then both read and answered aloud the second question. The third question was read silently by the subject and his/her answer was written. (All responses were in Spanish.) Both expressive and receptive language skills were scored by two fully bilingual psychology graduate students. The subjects were assigned to one of four groups based upon their scores: fully monolingual, monolingual, bilingual, or fully bilingual.

Relational Task

The relational task used (O'Hora et al, in press) trained subjects to respond according to specific relations (e.g., *before* and *after*, and *same* and *different*). An additional phase tested the generalization of the derived relational responding performance in the presence of novel stimulus sets. Subjects read minimal instructions presented on the computer and experimenters gave no verbal cues. Subjects who completed the relational task were assigned to the Relational Consistent Responding (RCR) group, while those failing any part of the task were assigned to the Relational Inconsistent (RIR) group.

Wechsler Adult Intelligence Scale-Third Edition (WAIS-III)

The WAIS-III is a clinical instrument used to measure the intellectual ability of adults (16-89 years of age). It contains fourteen sub-tests, however, only the vocabulary, arithmetic, and digit-symbol coding were considered in this study. The vocabulary test consisted of the subject defining 33 words which were orally and visually presented by the trained examiner. If the response was vague or not clear, the examiner asked him/her to "tell me more about it" or "tell me what you mean". No other instructions were given. The examiner recorded the subject's answer verbatim. The second sub-test consisted of a series of 20 arithmetic problems presented orally by the examiner. The subject's task was to solve each problem mentally and respond within a certain time limit. The subject's answer and time were recorded. The digit-symbol coding test allowed the subject 120 seconds to draw the hieroglyphic-like symbols for as many numbers as possible. The digits one through nine and their related symbols were shown at the top of the paper used by the subject. Complete descriptions of the tests, administration directions, and scoring procedures may be seen in the WAIS-III Administration and Scoring Manual (Wechsler, 1991, 1997).

Results

Descriptive Analysis of the Data

The high number of subjects employed in the current study precludes the presentation of individual data. Rather, salient characteristics of subjects' performances on Monolingual/Bilingual Assessment, the Relational Task, and the WAIS-III sub-tests are discussed.

Monolingual/Bilingual assessment. The number of subjects assigned to each monolingual/bilingual category was as follows: 15 Fully Monolingual (a score of 5-7); 11 Monolingual (a score of 8-10); 8 Bilingual (a score of 11-15); 41 Fully Bilingual (a score of 16-25). Subjects in both the Fully Monolingual and Monolingual categories were treated as Monolingual (N=26) and subjects in both the Fully Bilingual and Bilingual categories were treated as Bilingual (N=49) for statistical analyses.

Computer-Based Model of Instructional Control. Thirty-two subjects failed to achieve the mastery criterion on Relational Training for *before* and *after*. The remaining 43 subjects achieved the mastery criterion on this phase and also satisfied the mastery criterion on this relational responding test, as well as the training and test for *same* and *different*. Of these 43 subjects, 31 passed the Tests for Instructional Control and Generalization with 24 novel stimulus sets. In total, therefore, 31 subjects successfully completed the derived relational test (relational-consistent responding; RCR) and 44 failed (relational-inconsistent responding; RIR).

The Wechsler Adult Intelligence Scale-Third Edition (WAIS-III). Mean scores of each of the four experimental groups were calculated on each of the three WAIS-III sub-tests. On the vocabulary sub-test, the highest mean score was obtained from the Monolingual RCR group (*M* = 13.1, *SD* = 1.85) and the lowest from the Monolingual RIR group (*M* = 10.6, *SD* = 1.78). On the arithmetic sub-test, the highest mean score was obtained from the Monolingual RCR group (*M* = 12.0, *SD* = 1.94), and the lowest from the Monolingual RIR group (*M* = 10.2, *SD* = 2.04). On the digit-symbol encoding sub-test, the highest mean score was obtained from the Monolingual RCR group (*M* = 12.4, *SD* = 2.8), and the lowest from the Bilingual RIR group (*M* = 11.1, *SD* = 2.62).

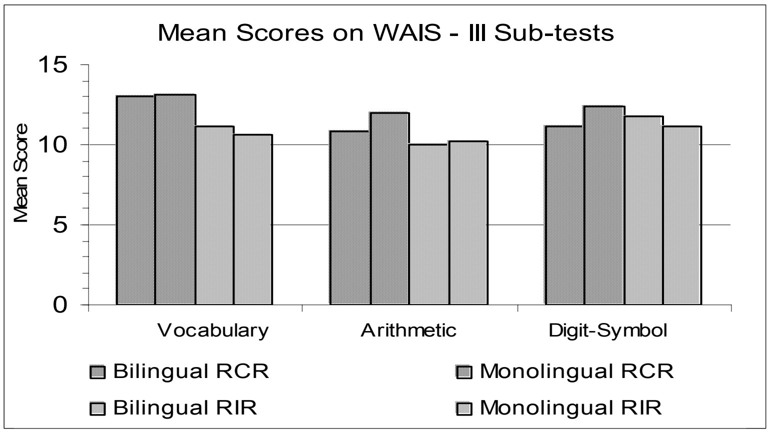

Figure 1. The bars represent the mean scores on each of the three WAIS-III sub-tests (vocabulary, arithmetic and digital coding) for each of the four groups of subjects. The bilingual relational consistent responding (RCR), the bilingual relational inconsistent responding (RIR), the monolingual relational consistent responding (RCR), and the monolingual relational inconsistent responding (RIR).

Statistical Analyses

The first analysis conducted was a Multivariate Analysis of Variance (MANOVA). A 2 (RCR vs. RIR) X 2 (bilingual vs. monolingual) analysis on three dependent measures (i.e., the three WAIS-III subtests: vocabulary, arithmetic, and digit-symbol coding) was conducted. This MANOVA yielded a significant main effect for the RCR (*N*=31) vs. RIR (*N*=44) groups (F(3,69) = 7.31, *p* = .0002) using Wilk's Lambda (.759), Roy's Greatest Root (.318), Hotelling-Lawley Trace (.318), and Pillai Trace (.241). No significant effect due to bilingual vs. monolingual was found, and no interaction effect between the two factors was obtained. Given no difference between monolingual and bilingual subjects, the data of the monolingual and bilingual groups were collapsed (*N* = 75) for subsequent independent ANOVAs on the three main dependent measures. The first ANOVA yielded a significant difference between the performances of the RCR group (*N* = 31; *M* = 13.05, *SD* = 1.81) and the RIR group (*N* = 44; *M* = 10.9, *SD* = 1.87) on the vocabulary sub-test of the WAIS-III (*F* (1, 71) = 21.78, *p* <0001). In addition, a significant effect for the arithmetic sub-test (*F*(1, 71) = 5.90, *p* = .017) was found between RCR (*N* = 31; *M* = 11.42, *SD* = 2.02) and the RIR group (*N* = 44; *M* = 10.09, *SD* = 2.25). No significant effects (*p*> .05) were obtained between the RCR group (*N* = 31; *M* = 11.5, *SD* = 2.71) and the RIR group (*N* = 44; *M* = 11.6, *SD* = 3.14) on the digit-symbol encoding sub-test.

An additional analysis was conducted to measure the relationship between the performance on the first relational training phase and the performance on the vocabulary and arithmetic sub-tests. To conduct this analysis, the percentage of correct responses produced by each subject on the relational training phase was calculated. Two separate Pearson *r* correlations revealed significant correlations between scores on the vocabulary sub-test and the number of correct responses during Relational Training for *before* and *after* ($r = .342$, $p = .002$, $N = 74$) and between scores on the arithmetic sub-test and the number of correct responses on this relational training phase ($r = .231$, $p = .003$, $N = 74$).

Conclusion

In our current study, performance on a complex relational task predicted performance on verbal sub-tests of the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III). This finding contributes to the growing body of research that suggests that derived relational responding (DRR) and language are closely related phenomena. From a developmental perspective, the development of DRR provides an alternative to ‘bootstrapping’ accounts of children’s progress from non-language to language development (see Altmann, 2001 for a detailed discussion). From an evolutionary perspective, Dickens and Dickens (2001) have suggested that DRR may be critical to understanding how humans as a species have made the same transition. Such a behavioral account may go along well with recent biological research on the plasticity of brain function and the importance of context on these types of performances (e.g., Robertson & Murre, 1999).

Further studies might well consider employing the full WAIS-III instrument in order to analyze relationships between derived relational performances and both verbal comprehension and verbal IQ factors, and also use each of the full compliments of sub-tests (cf. Taub, 2001). Such future work might allow for isolation of specific properties of language performance as traditionally defined that is particularly similar to specific derived relational performances.

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