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EXPERIMENTAL CONTROL OF NODALITY VIA EQUAL PRESENTATIONS OF CONDITIONAL DISCRIMINATIONS IN DIFFERENT EQUIVALENCE PROTOCOLS UNDER SPEED AND NO-SPEED CONDITIONS

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A within-participant comparison of simple-to-complex, complex-to-simple, and simultaneous protocols was conducted establishing different sets of three 7-member equivalence classes for 4 undergraduate students. The protocols were implemented under either accuracy-only or accuracy-plus-speed conditions while keeping number of presentations of training and testing trials equal. The results partially support previous reports of differential effects on acquisition, with participants completing more blocks in training under the simultaneous than the complex-to-simple and the simple-to-complex protocols. Across the protocols, however, the number of trials completed to criterion did not vary systematically. More important, response speed and accuracy did not decrease as a function of nodal number, with or without the speed contingency, or under any protocol. The latter results challenge the generality of previous reports of the nodality effect and the notion of ''relatedness'' of equivalence-class members, and support a reinforcement-contingency, instead of a structural, perspective on equivalence-class formation.

Key words: equivalence protocols, nodality effect, response speed, response accuracy, nodal number, stimulus equivalence, matching to sample, mouse click, humans

Using matching-to-sample (MTS) training that establishes conditional discriminations among arbitrary stimuli, Sidman equivalence requires that the stimuli exhibit the properties of reflexivity, symmetry, and transitivity (Sidman, 1994; Sidman & Tailby, 1982). For three stimuli A, B, and C, for example, following AB and BC training, positive tests of reflexivity (i.e., if A, then A; if B, then B, and if C, then C), symmetry (i.e., if A, then B; if B, then A, and if B, then C; if C, then B), and transitivity (if A, then B; if B, then C; therefore, if A, then C), would demonstrate equivalence among the stimuli. A simultaneous test for symmetry and transitivity also can be accomplished by selecting A in the presence of C (if C, then A), demonstrating a combined test for equivalence (Saunders & Green, 1992; Sidman, 1990; Sidman & Tailby, 1982; Spencer & Chase, 1996).

One of the structural variables described by Fields and Verhave (1987) as an important influence on equivalence-class formation is ''nodal distance'' (hereafter, nodal number; Sidman, 1994). Within an equivalence class, a node is a stimulus that connects two other stimuli by training. For example, given AB and BC training and the emergence of CA equivalence, B is a node because it links the A and C stimuli through prior training. Likewise, given AB, BC, and CD training and the emergence of DA equivalence, B and C are nodes because they link the A and D stimuli through prior training. According to the structural network account of equivalence, increasing the number of nodes in an equivalence class increases ''associative distance'' (Fields & Verhave, 1987 p. 322) and results in a decrease in performance accuracy on tests for emergent relations (Fields, Adams, & Verhave, 1993). Indeed, many studies have reported that response accuracy and speed are inversely related to nodal number (e.g., Bentall, Jones, & Dickins, 1998; Fields, Landon-Jimenez, Buffington, & Adams, 1995; Imam, 2001; Kennedy, 1991; Kennedy, Itkonen, & Lindquist, 1994; Spencer & Chase, 1996).

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What is unique about the Fields et al. (1993) account of this nodality effect is that it goes beyond the requisite training, and the associated reinforcement history, by relying on the number of nodes intervening between elements of pairs of stimuli in the equivalence class as a critical factor that produces permanent changes among class members. The associative-distance account of stimulus equivalence also suggests an unequal relatedness among equivalence-class members. This account represents a significant departure from the concept of stimulus classes, and stands in contrast to a reinforcement contingency account of equivalence (e.g., Saunders & Green, 1999; Sidman, 1994). Unequal relatedness is problematic from the reinforcement contingency standpoint principally because reinforcement contingencies specify the properties that determine class membership, and to the extent that these properties do not change, the stimuli in the class are substitutable for one another. If class membership is based on the color blue, for example, the class members should be substitutable based on the color blue, irrespective of their texture, shape, or size, the latter being properties that may define other classes. When new stimuli join a class of blue stimuli by training, therefore, the new members should become equivalent to the old ones (Sidman, 1994) and should not be differentially related to the old ones on account of increasing nodal number. According to this view, then, the history of reinforcement that accounts for the emergent equivalence relations renders the stimuli substitutable for one another (Sidman, 1990, 1994; cf. Fields et al., 1993) based on the common properties that characterize the class (the color blue in this example).

As Sidman (1994) noted, invoking nodal number as a variable with enduring influence on equivalence-class formation requires additional empirical exploration of variables such as equality of reinforcement history and whether requisite relations for emergent tests are themselves derived or trained directly. If the reinforcement contingency position is valid, then manipulating the history of reinforcement in establishing various stimulus pairs with different nodal numbers and ensuring that all such stimulus pairs share equal numbers of derived and directly trained requisite relations should reveal performances contrary to the nodality effect. Two recent studies provided some evidence consistent with this claim (Imam, 2001, 2003).

In the first experiment reported by Imam (2001), both response accuracy and speed were demonstrated to be inversely related to nodal number. Thus the nodality effect that has been so often reported (e.g., Spencer & Chase, 1996) was replicated. In that experiment, the AB, BC, CD, and DE conditional discriminations were trained serially, so subjects had less experience with the stimulus pairs introduced later (e.g., DE) than those introduced earlier (e.g., AB). Likewise, previous studies demonstrating the nodality effect did not control for the number of training or testing trials across stimulus pairs (e.g., Bentall et al., 1998; Fields, Adams, Verhave, & Newman, 1990; Kennedy et al., 1994; Spencer & Chase, 1996). Thus nodal number was confounded with exposure to the number of trials in training and testing. If during training, for example, newly introduced stimulus pairs appeared a fewer number of times than those preceding them, then the decrease observed in response accuracy and speed could be due to the smaller total number of times responding to these stimuli had been reinforced, and not due to their nodal number. A similar line of reasoning led Saunders and Green (1999) to predict a limited nodality effect between one- and two-node test trials, consistent with Spencer and Chase's (1996) findings. According to their analysis, given a set of AB, BC, CD, DE, EF, and FG conditional discriminations training, response speeds should be faster on one-node BD and DB relations than on two-node DG and GD relations ''because the former involve simple discriminations that were more likely to have been acquired than the latter'' (Saunders & Green, 1999, p. 132), the latter's baseline relations having been introduced much later in the series.

Imam's Experiment 2 (2001) addressed the problem of the confound between increasing nodal number and decreasing number of trials by equalizing the number of presentations of training (AB, BC, CD, DC, CE, and EF) and testing (transitivity and equivalence) trials. As in Imam's Experiment 1, in one condition a speed contingency was used whereby subjects had to respond both accurately and quickly. The results showed a substantially diminished nodality effect with only 2 of 12 cases of nodality effects on response speeds. By equalizing reinforcement history, the confound noted in the first experiment was eliminated, and the nodality effect observed in the second experiment thus was greatly diminished for one- through five-node trials, not simply the one-node and two-node trials predicted by Saunders and Green (1999) on account of the relative reinforcement histories of the one- and two-node relations noted above. Imam (2003) confirmed the results of the second experiment in the context of transfer of response speeds across speed and nonspeed equivalence classes; only 2 of 14 cases (i.e., 14.3%) of response speeds showed a nodality effect under the speed conditions.

The challenge posed by the evidence reported by Imam (2001, 2003) to the notion of associative distance and the role of nodality as a structural variable that yields differential stimulus-equivalence outcomes (Fields et al., 1990; Fields et al., 1995) resided in the experimental control of the number of presentations of trials that, hitherto, had not been present in previous reports of nodality. Fields et al. (1995) was an exception in that they controlled the number of reinforcers for different stimulus pairs by using a *simultaneous* protocol (SP) in which *all* baseline relations were trained before testing for any emergent relations. Two (out of 12) participants formed equivalence classes and both of them (i.e., 100%) exhibited the nodality effect in that study (see also Fields et al., 1997). A feature of the Fields et al. studies that is of interest in the context of the present study is that the researchers combined a linear-series (LS) training structure with the SP to study the nodality effect. Because the results of these two sets of studies (Imam, 2001, 2003, and Fields et al., 1995; Fields et al., 1997) of the nodality effect under conditions controlling reinforcement history appear to be at odds with each other, the roles of the training structures and the protocols used in these studies require further elaboration.

With respect to training structures, of the three training structures, including comparison-as-node (AB, CB), sample-as-node (AB, AC), and LS (AB, BC, CD) identified by Saunders and Green (1999), the LS structure is most suitable for the study of the effects of nodal number (see Imam, 2001; cf. Sidman, 1994); the other two structures have a single node by definition and, therefore, are not suitable. To illustrate the advantage of the LS training structure, consider a mixed training structure using AB, AC, and DC training, in which BD and DB relations having two nodes (A and C) require different numbers of trained and untrained relations for their derivation; BD requires BC transitivity and CD symmetry, whereas DB requires only CB equivalence along with the trained DC relation. Such a case raises questions about reports of nodality (see Sidman, 1994) because of the imbalance in the number of requisite trained and untrained trial types for relations of otherwise equal nodal numbers. As Imam (2001) pointed out, the LS training structure presents no such imbalance. Given AB, BC, and CD training, for example, a one-node (AC, CA) relation would require two trained (AB, BC) and two untrained (BA, CB symmetry) relations, whereas a two-node (AD, DA) relation would require three baseline (AB, BC, CD) and symmetry (BA, CB, DC) plus two transitivity (AC, BD) and equivalence (CA, DB) relations, and so on. Indeed, most studies of the nodality effect have used the LS training structure (e.g., Bentall et al., 1998; Fields et al., 1990; Fields et al., 1995; Kennedy et al., 1994; Spencer & Chase, 1996; cf. Kennedy, 1991), although it has a high probability of failure in establishing stimulus equivalence. What explains the high failure rate, according to Saunders and Green's (1999) simple-discriminations analysis of training and testing trial types in each of the three training structures, is that only successive discriminations are possible in the LS training structure, in contrast to the comparison-as-node training structure that involves both successive *and* simultaneous discriminations, both of which are essential for consistently positive equivalence results.

Regarding the role of training protocols, recent studies have reported significant differences in equivalence-class formation and in relatedness of equivalence-class members as a function of the training protocols used (e.g., Adams, Fields, & Verhave, 1993; Fields et al., 1997). These protocols include the *simple-to-complex* (STC), the *complex-to-simple* (CTS), and the SP. Figure 1 presents a general outline of each protocol, showing the global sequence of training and testing. Of the three protocols, the SP is unique in training all baseline relations *before* testing for any of the emergent

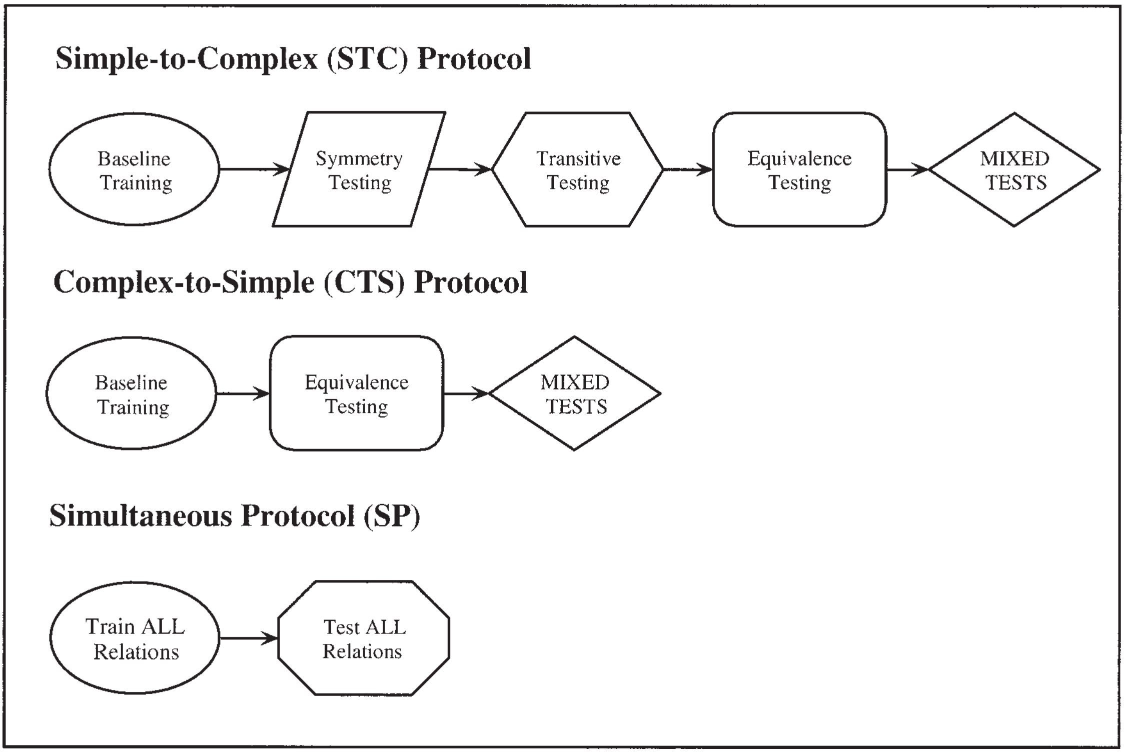


Fig. 1. General outline of each matching-to-sample (MTS) protocol showing the sequence of training and the type of tests for emergent relations.

symmetry, transitivity, or equivalence relations. In contrast, training and testing blocks in the STC protocol are interspersed incrementally, testing for symmetry, transitivity, and equivalence in that order, as new training relations are added. To illustrate, given AB and BC training, the AB relation is trained first, followed by the BA symmetry test. Next, BC training is conducted, followed by the CB symmetry test. The symmetry tests precede AC transitivity and CA equivalence tests. Positive results from all of these tests confirm the formation of equivalence classes. Unlike the STC protocol, following AB and BC training, the CTS protocol begins by testing the equivalence (CA) relation, implementing the symmetry tests (BA then CB serially) and then transitivity (AC) tests, only if the equivalence test fails. The CA test is then repeated before new relations are trained. Again, positive results on these tests demonstrate formation of equivalence classes. As noted above, significant differences have been reported using these protocols. In the SP, for example, fewer participants tend to form equivalence classes, unless they have had pretraining with the STC protocol (e.g., Fields et al., 1995; Fields et al., 1997). In addition, participants tend to form equivalence relations faster under STC than under CTS protocols (Adams et al., 1993).

The reported diminution or absence of nodality effects (Imam, 2001, 2003) has occurred under procedures that were similar to the CTS protocol. The pertinent features of those procedures occurred in the first phase of the experiment (described as the paced phase) in which training and testing blocks alternated. The first training block contained AB and BC trial types (just as in the CTS protocol), and subsequent training blocks added new trial types (from CD, DE, EF, and FG relations) serially. Test blocks contained the relevant transitivity and equivalence trial types derived from the most recently trained relations. Because the reduced nodality effects reported by Imam (2001, 2003) have been observed exclusively under this CTS-like protocol, one must wonder whether this training protocol contributed to the outcome.

In addition, most of the instances of nodality reported by Imam (2001, 2003) under this CTS-like protocol occurred when participants were required to respond quickly. Because response speeds usually vary with accuracy and because manipulating response speed may adversely affect performance accuracy (see Baron, Menich, & Perone, 1983; Imam, 2001), one might also wonder whether different protocols may engender differential effects on nodality with a speed contingency in effect. To explore this possibility, the present study included the speed-and-accuracy condition used previously by Imam (2001, 2003). A second rationale for assessing equivalence-class formation with the use of a speed contingency is that the accuracy performance often peaks, thereby establishing a ceiling effect that obfuscates assessment of further changes in performance that may occur with continued training and/or testing. For this reason, response speed serves as a useful measure because no such ceiling effect occurs.

Finally, comparisons of the differential effects of protocols have been mostly between groups (e.g., Fields et al., 1997; see Fields et al., 1993), thereby casting doubt about intersubject variations in preexperimental history (Sidman, 1960). In the present experiment, a within-participant comparison was used to explore whether the relatedness of equivalence-class members would vary under the different protocols.

In each condition of the present study, therefore, different sets of three 7-member equivalence classes were established under each of three protocols, with and/or without a speed contingency. Different sets of arbitrary shapes served as stimuli in each condition. The number of presentations of training and testing trials was equal across baseline and emergent relations in each condition within each protocol. Throughout, an LS training structure was used in each protocol.

METHOD

Participants

Three male and 1 female, English-speaking, American University of Beirut undergraduate students participated. The participants were between 19 and 21 years of age at the beginning of the study. Upon answering a bulletin board announcement for human participants in psychological research, they signed an informed-consent agreement specifying the frequency and duration of their participation in the experiment, as well as the method and time of payment.

Apparatus and Stimuli

A Macintosh® computer controlled experimental events and collected data using MTS software (Dube & Hiris, 1997). Sample stimuli always appeared at the center of the screen and the three comparison stimuli appeared randomly from trial to trial at the corners of the screen, leaving one position blank. Each location was a white square (4.7 cm by 4.7 cm) against a black background. Figure 2 shows the 2.5-cm by 2.5-cm stimuli used for each protocol under the accuracy-only (left) and the speed-and-accuracy (right) conditions. The letter and number designations of comparison stimuli and class membership, respectively, were unknown to the participants.

Procedures

A click on the computer mouse button registered responses on stimuli. The computer automatically recorded responses and their latencies. The computer also determined consequences for each response, maintained a record of participant earnings, and recorded class-consistent responses as correct and other responses as incorrect. The interval between responding to the sample and selecting a comparison stimulus defined latency (the experimenter later calculated the response speed as the inverse of the latency).

Pretraining. Before implementing any training procedures, a demonstration of the MTS procedure was conducted for one correct and one incorrect response, using upper- and lower-case English letters as sample and comparison stimuli, respectively. Participants then completed 24 trials using the remaining English letters. No special instructions accompanied the demonstration. As college students, participants were assumed to have a repertoire of identity matching, and therefore no test of reflexivity was conducted.

Matching to sample. Participants were trained and tested individually over many

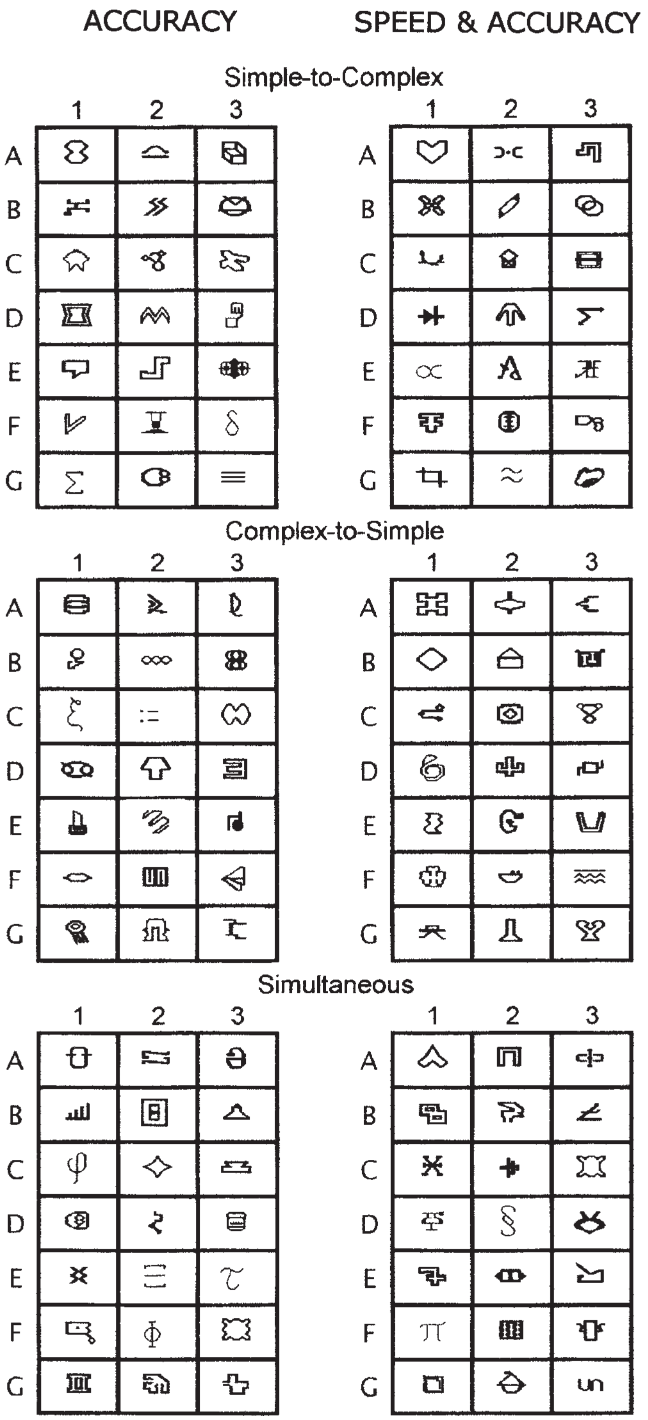


Fig. 2. Stimuli used in the accuracy-only (left) and the speed-and-accuracy (right) conditions under the simple-to-complex (top), complex-to-simple (middle), and simultaneous (bottom) protocols. The letters designate sets of sample and comparison stimuli and the numbers designate potential stimulus classes.

sessions using MTS procedures. A trial began when a sample stimulus appeared at the center of the screen. A mouse click on the sample stimulus produced three comparison stimuli at the corners. Any other response had no programmed consequence. The locations of the comparison stimuli changed randomly from trial to trial. Selecting the correct comparison on trials with feedback produced a 1-s display of the word ''correct'' and a tone, incremented a hidden counter, and started a 1.5-s intertrial interval (ITI). Selecting an incorrect comparison ended the trial, sounded a buzzer and darkened the screen for 1 s, and began the ITI. A mouse click on the blank stimulus location was considered incorrect, and a click during the ITI reset the ITI timer, ensuring that 1.5 s had elapsed without a response.

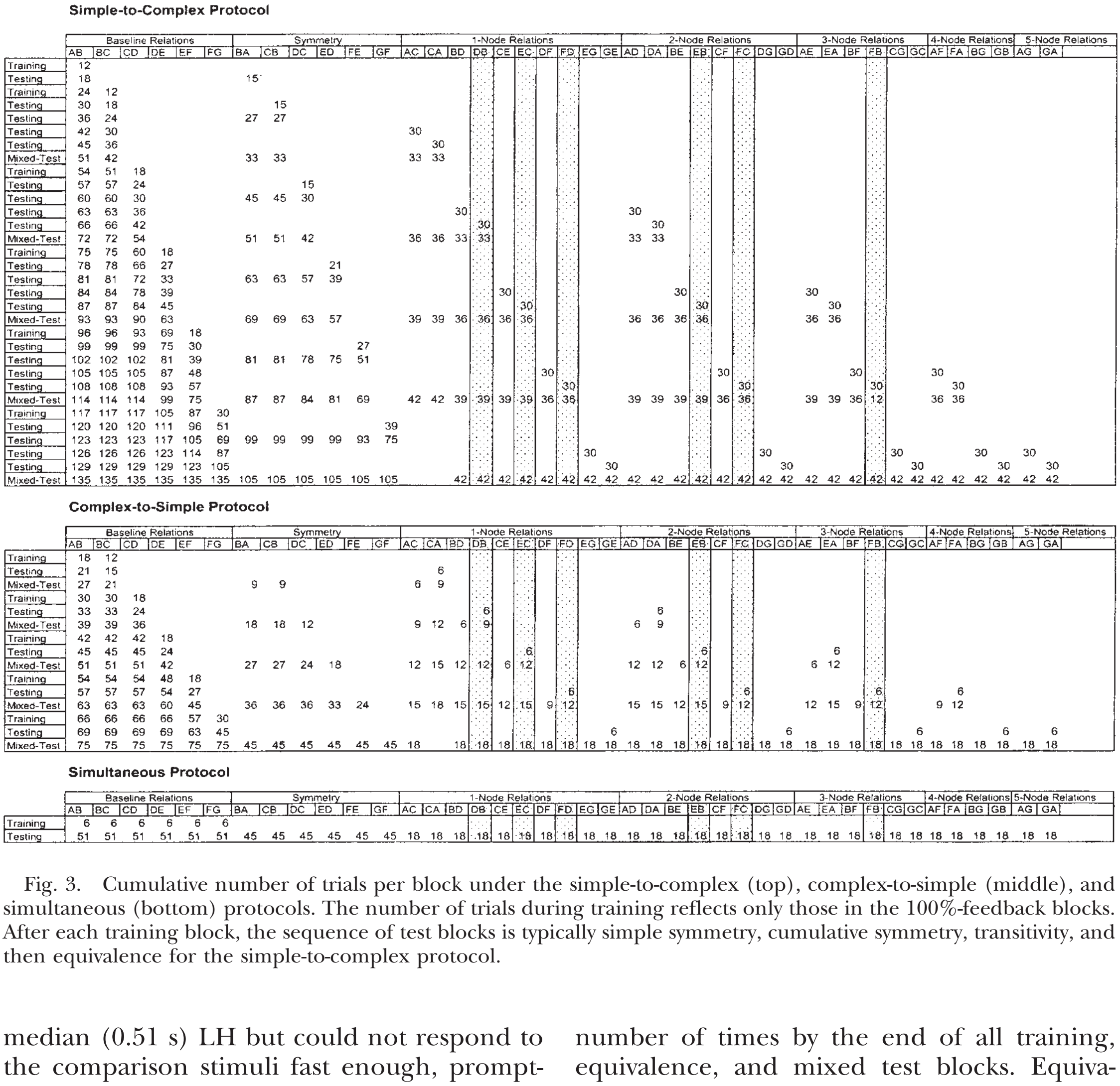
Training involved four levels of feedback (100%, 75%, 25%, and 0%). Training blocks with 100% feedback began with the following instructions: ''You will receive feedback for the next block of trials. In addition to 'Correct,' you will hear a tone for a correct choice, and you will hear a buzzer in addition to a black screen for an incorrect choice.'' With 75% and 25% feedback, participants were told at the beginning of each block, ''You will receive feedback for ONLY SOME trials in the next block of trials.'' During training blocks containing full or partial feedback, participants saw their earnings per block only at the end of each block. In 0% feedback and testing blocks, participants received no information about their earnings during or after the block. At the beginning of these blocks, they received the following instructions: ''In the next block of trials, you will be given no feedback regarding the accuracy of your responses. 'Correct' will not be displayed, you will hear no tone when you make a correct choice; you will hear no buzzer, and the screen will not turn black when you make an incorrect choice. You will not be told how many points you've earned, BUT I'll still keep track of your points and exchange them for money at the end of the study.''

Participants earned 31 Lebanese Lira (equivalent to $0.02) per point, and all earnings were held in reserve until the end of their participation. In addition, participants earned 4,500.00 Lira (equivalent to $3.00) for every hour of participation.

Training and testing. Six sets of conditional relations (A1B1, A2B2, A3B3; B1C1, B2C2, B3C3; C1D1, C2D2, C3D3; D1E1, D2E2, D3E3; E1F1, E2F2, E3F3; and F1G1, F2G2, F3G3) were trained in each condition. Participants Kim and Riz learned 36 different sets of conditional relations. Participants Ned and Ken learned only 12 sets of conditional relations.

The sequence of training and testing trials within a block was randomly determined. A training block consisted of different numbers of trial types distributed as shown in Figure 3 for each protocol. The number of training blocks implemented for each participant appears in Table 1. The criterion for advancing from one stage of training to testing under the STC and the CTS protocols was at least 90% correct, with only one error allowed per relation per block. The number of blocks completed by each participant to achieve the performance criteria on the 100% feedback of the first trained relations (AB under the STC protocol; AB and BC under the CTS protocol) determined the number of blocks used in the subsequent training blocks, across the four feedback levels, under each protocol. This meant that training on the subsequent relations did not have to meet the accuracy criterion to advance through the protocol, a necessary feature for maintaining the equality of number of trial types.

Under the speed-and-accuracy condition, in addition to class-consistent choices, to receive points for correct responses, participants had to select a comparison within an interval specified by a limited hold (LH) individually determined from the 0%-feedback level of the corresponding accuracy-only condition. Participants received no instructions on the speed contingency when the LH was introduced. If they asked if something was wrong with the computer upon instituting the speed contingency, they simply were told that the computer was fine and they were to figure out what to do. Table 1 shows the LH determined using the statistics indicated. For each speed condition, except for Riz's and Kim's STC conditions in which the mode was used, the median latency of the accuracy-only condition was used for each participant. The statistic used was the most representative of the range of latencies obtained under the criterion condition. Kim began the speed condition under STC with the



Simple-to-Complex Protocol

	Baseline Relations						Symmetry						1-Node Relations										2-Node Relations								3-Node Relations						4-Node Relations				5-Node Relations	
	AB	BC	CD	DE	EF	FG	BA	CB	DC	ED	FE	GF	AC	CA	BD	DB	CE	EC	DF	FD	EG	GE	AD	DA	BE	EB	CF	FC	DG	GD	AE	EA	BF	FB	CG	GC	AF	FA	BG	GB	AG	GA
Training	12																																									
Testing	18						15																																			
Training	24	12																																								
Testing	30	18						15																																		
Testing	36	24					27	27																																		
Testing	42	30											30																													
Testing	45	36												30																												
Mixed-Test	51	42					33	33					33	33																												
Training	54	51	18																																							
Testing	57	57	24						15																																	
Testing	60	60	30				45	45	30																																	
Testing	63	63	36												30								30																			
Testing	66	66	42													30								30																		
Mixed-Test	72	72	54				51	51	42				36	36	33	33							33	33																		
Training	75	75	60	18																																						
Testing	78	78	66	27						21																																
Testing	81	81	72	33			63	63	57	39																																
Testing	84	84	78	39													30								30						30											
Testing	87	87	84	45														30								30						30										
Mixed-Test	93	93	90	63			69	69	63	57			39	39	36	36	36	36					36	36	36	36					36	36										
Training	96	96	93	69	18																																					
Testing	99	99	99	75	30						27																															
Testing	102	102	102	81	39		81	81	78	75	51																															
Testing	105	105	105	87	48														30								30						30				30					
Testing	108	108	108	93	57															30								30						30				30				
Mixed-Test	114	114	114	99	75		87	87	84	81	69		42	42	39	39	39	39	36	36			39	39	39	39	36	36			39	39	36	12			36	36				
Training	117	117	117	105	87	30																																				
Testing	120	120	120	111	96	51						39																														
Testing	123	123	123	117	105	69	99	99	99	99	93	75																														
Testing	126	126	126	123	114	87															30								30						30				30		30	
Testing	129	129	129	129	123	105																30								30						30				30		30
Mixed-Test	135	135	135	135	135	135	105	105	105	105	105	105			42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42

Complex-to-Simple Protocol

	Baseline Relations						Symmetry						1-Node Relations										2-Node Relations								3-Node Relations						4-Node Relations				5-Node Relations	
	AB	BC	CD	DE	EF	FG	BA	CB	DC	ED	FE	GF	AC	CA	BD	DB	CE	EC	DF	FD	EG	GE	AD	DA	BE	EB	CF	FC	DG	GD	AE	EA	BF	FB	CG	GC	AF	FA	BG	GB	AG	GA
Training	18	12																																								
Testing	21	15												6																												
Mixed-Test	27	21					9	9					6	9																												
Training	30	30	18																																							
Testing	33	33	24													6								6																		
Mixed-Test	39	39	36				18	18	12				9	12	6	9							6	9																		
Training	42	42	42	18																																						
Testing	45	45	45	24														6								6						6										
Mixed-Test	51	51	51	42			27	27	24	18			12	15	12	12	6	12					12	12	6	12					6	12										
Training	54	54	54	48	18																																					
Testing	57	57	57	54	27															6								6						6				6				
Mixed-Test	63	63	63	60	45		36	36	36	33	24		15	18	15	15	12	15	9	12			15	15	12	15	9	12			12	15	9	12			9	12				
Training	66	66	66	66	57	30																																				
Testing	69	69	69	69	63	45																6								6						6				6		6
Mixed-Test	75	75	75	75	75	75	45	45	45	45	45	45	18		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Simultaneous Protocol

	Baseline Relations						Symmetry						1-Node Relations										2-Node Relations								3-Node Relations						4-Node Relations				5-Node Relations	
	AB	BC	CD	DE	EF	FG	BA	CB	DC	ED	FE	GF	AC	CA	BD	DB	CE	EC	DF	FD	EG	GE	AD	DA	BE	EB	CF	FC	DG	GD	AE	EA	BF	FB	CG	GC	AF	FA	BG	GB	AG	GA
Training	6	6	6	6	6	6																																				
Testing	51	51	51	51	51	51	45	45	45	45	45	45	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Fig. 3. Cumulative number of trials per block under the simple-to-complex (top), complex-to-simple (middle), and simultaneous (bottom) protocols. The number of trials during training reflects only those in the 100%-feedback blocks. After each training block, the sequence of test blocks is typically simple symmetry, cumulative symmetry, transitivity, and then equivalence for the simple-to-complex protocol.

median (0.51 s) LH but could not respond to the comparison stimuli fast enough, prompting the change to the mode shown in Table 1. Three blocks of 100% feedback were implemented for Kim under this condition, instead of the planned one block.

The objective of the present study was to balance the number of trials within protocols, not across protocols. During training blocks, trial types appeared an equal number of times by the end of all training blocks of the four feedback levels under each protocol as shown in Figure 3. Figure 3 shows that under the STC protocol (top panel), by the end of relational and mixed test blocks, symmetry (simple plus cumulative), transitivity, and equivalence trial types had all appeared an equal number of times, respectively. Under the CTS protocol (middle panel), trial types appeared an equal number of times by the end of all training, equivalence, and mixed test blocks. Equivalence blocks contained baseline and equivalence trials, but no symmetry and transitivity trials. Consequently, mixed test blocks contained less baseline and equivalence trials, which maintained equal number of trials for all relations under this protocol. When the number of trials in a block was too large under the STC and CTS protocols, the trials appeared in multiple blocks (e.g., the mixed test-5 trials were presented in five blocks).

Protocols. Participants received no instructions describing the differences among the three protocols. Training involved one set of stimulus relation at a time, in the order AB, BC, CD, DE, EF, and FG, under the STC protocol. The STC protocol began with AB training followed by BA symmetry. Following

Table 1

Sequence of conditions for each participant, showing the statistic used in the accuracy-only conditions to determine the limited hold for the speed-and-accuracy conditions, total number of sessions completed, the number of training blocks needed to achieve criteria under the first 100% feedback, and the total number of training trials completed to criteria with 100% feedback under the three protocols. The last column shows the percentage correct choices in the first 100%-feedback training blocks under each condition.

Participant	Sequence	Condition	Limited hold	Statistic	Number of sessions	Number of 100% training blocks	Total trials to criteria	Correct on first training blocks (%)
Kim	1	Accuracy; CTS	—	—	8	2	540	87
	2	Accuracy; STC	—	—	6	1	180	92
	3	Accuracy; SP	—	—	8	5	180	39
	4	Speed; STC	0.94 s	Mode	13	3	540	50
	5	Speed; CTS	1.82 s	Median	6	1	180	30
	6	Speed; SP	1.98 s	Median	7	5	180	47
Riz	1	Accuracy; STC	—	—	15	3	540	58
	2	Accuracy; CTS	—	—	6	2	540	67
	3	Accuracy; SP	—	—	5	10	360	36
	4	Speed; CTS	1.17 s	Median	15	3	540	37
	5	Speed; STC	1.2 s	Mode	10	2	360	76
	6	Speed; SP	1.58 s	Median	4	10	360	39
Ned	1	Accuracy; STC	—	—	10	3	540	75
	2	Speed; STC	1.83 s	Median	8	3	360	8
Ken	1	Accuracy; CTS	—	—	10	3	540	53
	2	Accuracy; STC	—	—	13	2	540	83

all subsequent training blocks that introduced new conditional relations, four phases were conducted in which tests for simple symmetry, cumulative symmetry, transitivity, or equivalence were conducted. The simple symmetry blocks consisted of the newest symmetry trials only, and the cumulative symmetry blocks included all preceding symmetry tests. The transitivity and equivalence test blocks contained only the newest transitivity and equivalence trials, respectively. Following this, a mixed test block was conducted that contained all the preceding trial types, including tests of baseline relations (see top panel of Figure 3).

As in the STC protocol, training in the CTS protocol involved one set of stimulus relation at a time, except that the AB and BC trial types appeared together in the first training block. Subsequent training blocks introduced a new conditional relation along with previously trained relations. The equivalence test blocks contained the newest equivalence trials and the requisite baseline trials. The mixed tests included all the preceding baseline, symmetry, transitivity, and equivalence trials, old and new. The sequence of blocks outlined in Figure 3 (middle panel) for the CTS protocol thus represents an abbreviated version of possible sets of blocks under this protocol. It presents the best-case scenario in which the participant passes all equivalence tests following each new conditional-discrimination training. This was the sequence followed for Ken in the accuracy-only condition and for Riz in both accuracy-only and speed-and-accuracy conditions because they achieved the 90% or more correct criterion in the first presentation of the equivalence blocks. Consequently, only the equivalence and mixed test blocks were implemented in these conditions for these participants. Kim failed to meet the criterion on the first CA equivalence, BA and CB symmetry, and the first mixed tests under the accuracy-only condition, but performed above 90% correct on all subsequent equivalence and mixed tests and was not exposed to other symmetry tests. In this case, to maintain an equal number of test and baseline trials, the final mixed test block contained extra trials (not shown in Figure 3) of the other relations for this participant.

In the SP, during training, all 18-baseline trial types from the AB, BC, CD, DE, EF, and FG relations were presented twice randomly in multiple blocks repeated until performance criteria were achieved (see Figure 3, bottom panel). The number of repetitions needed to achieve criteria under the 100% feedback determined the number of repetitions under the remaining feedback levels, regardless of performance. For this protocol, the number of blocks completed to criterion in the accuracy-only condition determined the number of blocks implemented in the speed-and-accuracy conditions for Kim and Riz. During testing, all relevant baseline, symmetry, transitivity, and equivalence test trial types were presented randomly in multiple blocks (15 in all; not shown in Figure 3) during which no feedback was provided even on baseline trials. Each baseline and symmetry relation appeared 45 times (15 per trial type) and each of the transitivity and equivalence relations appeared 18 times (six per trial type).

Sequence of conditions. As Table 1 shows, each participant experienced a different sequence of conditions during which different protocols, with and/or without the speed contingency, were implemented. Kim and Riz completed the accuracy-only condition before the speed-and-accuracy condition under each of the three protocols, but in a different order. Ned was scheduled to complete alternating accuracy-only and speed-and-accuracy conditions under the three protocols, but he withdrew from the study following the first two conditions with the STC protocol. Ken also terminated his participation after completing the first two conditions. This left only a comparison of STC and CTS protocols in the accuracy-only condition. Table 1 also shows the number of sessions completed by each participant under each condition. Within each session, participants completed multiple training and/or testing blocks. Sessions typically lasted from 35 to 65 min.

RESULTS

The 2 participants who completed all conditions under all protocols, Kim and Riz, took 4 and 5 months, respectively, to complete the six protocols. These participants completed each condition in between 6 to 13 (Kim) or 4 to 15 (Riz) sessions. Ned completed the accuracy-only condition in 10 sessions and the speed-and-accuracy condition in eight sessions under the STC protocol. Ken completed the accuracy-only conditions under the STC and the CTS protocols in 13 and 10 sessions, respectively.

A comparison of performance accuracy under each protocol indicated no marked difference in acquisition between the STC and the CTS protocols. Table 1 shows that in most conditions (10 out of 12 cases), participants achieved the accuracy criterion in two or three training blocks with the 100% feedback under these protocols, irrespective of the particular sequence of exposure to them. Kim's accuracy-only (STC protocol) conditions in which she required only one block was a notable exception. Under the SP, Kim and Riz achieved criterion performance in the 5th and 10th blocks of training, respectively, with 100% feedback.

Because the number of training blocks completed under the first 100%-feedback phase (e.g., AB training under the STC protocol) determined the number of blocks presented in subsequent baseline training (e.g., BC training under the STC protocol), performances under the latter blocks were not necessarily trained to the 90% accuracy criterion. Nonetheless, Table 2 shows that, with few exceptions, participants' accuracy in the 0%-feedback phase met the 90% accuracy criterion in at least one of the blocks implemented. Also, because training blocks with 100% feedback that determined subsequent training blocks contained different numbers of trials, the number of blocks completed to criterion seemed inappropriate for comparison of acquisition across protocols. Instead, the total number of trials in all training blocks (AB through FG) with 100% feedback was examined. Table 1 shows that the total number of trials completed in these criterion blocks under the various protocols varied unsystematically for individual participants.

Response accuracy and speed data from the equivalence trials in all the mixed test blocks under the CTS and the STC protocols and from all the tests of the SP were analyzed according to their nodal numbers to determine the effects of the three protocols on nodality. As described previously by Imam (2001) and Spencer and Chase (1996), when ABCDEFG classes were formed, an imbalance in the number of relations denoting each nodal number inherently obtained in the LS training structure that required equalizing the one-node, two-node, and three-node trials to minimize the differences across nodal numbers. Accordingly, one-node DB, EC, and FD,

Table 2

Percentage correct on training blocks with 0% feedback for each participant under the relevant accuracy and speed conditions of each protocol. The data are from the training blocks completed without accuracy criterion applied.

Training block	Kim		Riz		Ned		Ken	
	Accuracy	Speed	Accuracy	Speed	Accuracy	Speed	Accuracy	Speed
Simple-to-complex protocol								
AB-0%	100	100, 83, 92	100, 100, 100	100, 100	100, 100, 100	100, 100, 100	100, 100	
BC-0%	100	89, 78, 100	100, 100, 100	94, 100	94, 100, 94	100, 94, 94	100, 100	
CD-0%	100	83, 77, 87	100, 100, 100	93, 100	97, 100, 97	100, 97, 100	100, 100	
DE-0%	100	93, 87, 90	100, 100, 100	93, 90	100, 100, 100	90, 93, 80	100, 100	
EF-0%	100	94, 91, 85	100, 100, 100	85, 97	100, 100, 100	91, 82, 76	100, 100	
FG-0%	100	98, 93, 98	100, 100, 100	93, 93	100, 98, 98	84, 88, 75	100, 100	
Complex-to-simple protocol								
ABC-0%	77, 93	97	100, 100	100, 100, 97			100, 100, 100	
CD-0%	100, 100	93	100, 97	97, 97, 90			100, 100, 100	
DE-0%	100, 97	93	100, 100	97, 97, 100			100, 100, 100	
EF-0%	100, 100	100	100, 100	100, 100, 100			100, 100, 100	
FG-0%	100, 100	98	100, 100	95, 96, 100			100, 100, 100	
Simultaneous protocol								
Train-0%	100, 100, 100, 94, 97	89, 86, 89, 92, 89	100, 100, 100, 97, 100, 100, 100, 100, 100, 100	97, 94, 92, 100, 94, 94, 100, 100, 100, 100				

two-node EB and FC, and three-node FB equivalence trials (outlined shaded columns in Figure 3) were excluded from the analyses (see Imam, 2001; Spencer & Chase, 1996).

Table 3 presents the percentage of correct choices on the remaining equivalence trials (from the CA, DA, EA, FA, GA, GB, GC, GD, and GE relations) as a function of nodal number. In the speed-and-accuracy conditions, all errors were speed errors (i.e., the participant failed to make a response within the maximum latency period). The one exception was Ned; some of his errors were accuracy errors under the speed-and-accuracy condition of the STC protocol (see Table 3). No systematic trend in percentage correct as a function of nodal number was detected. In most cases, participants were at or near 100% correct regardless of the number of nodes. When exceptions occurred, they were confined to the speed-and-accuracy conditions when adding the speed contingency tended to increase errors. In spite of this increase in errors, no participant showed a systematic decline in accuracy as a function of nodal number.

A similar absence of nodality effect was observed in the response speed data. Figure 4 presents mean response speeds as a function of nodal number for all participants. For each participant, response speeds showed no systematic changes as a function of nodal number. To assess whether the response speed data shown in Figure 4 exhibited statistically significant effects of nodality within protocols, separate one-way analyses of variance (ANOVA) with posttest linear trends were conducted for each participant using GraphPad Prism® Version 4 for Windows (GraphPad, 2003). As shown in Table 4, no statistically significant effect of nodality ($p < .05$) was detected for any participant in any condition under the three protocols. Furthermore, the table shows that all of the negative trends accounted for a maximum of 1% of the variance. Finally, Figure 4 shows that response speeds were higher with than without the speed contingency for each participant under each protocol where such comparisons were possible.

Given that a within-participant design was used in the present study, to assess whether

Table 3

Percentage correct as a function of nodal number of equivalence trials for each participant under respective protocols with accuracy-only (Accuracy) and/or speed-and-accuracy (Speed) conditions.

Participant	Condition	Nodal number 1	2	3	4	5
Kim	Accuracy; CTS	100	100	100	100	100
	Accuracy; STC	100	100	100	100	100
	Accuracy; SP	100	100	100	100	100
	Speed; STC	79	63	46	88	83
	Speed; CTS	100	100	91	100	100
	Speed; SP	96	94	100	96	96
Riz	Accuracy; CTS	100	97	100	100	100
	Accuracy; STC	100	100	100	100	100
	Accuracy; SP	100	100	100	100	100
	Speed; CTS	89	78	67	83	94
	Speed; STC	88	88	88	88	92
	Speed; SP	94	92	97	97	94
Ned	Accuracy; STC	100	100	100	100	100
	Speed; STC	92 (50)[a]	71 (14)	71 (29)	75 (67)	75 (67)
Ken	Accuracy; CTS	100	97	100	100	100
	Accuracy; STC	100	100	100	100	100

Note: STC = simple-to-complex; CTS = complex-to-simple; SP = simultaneous protocol.
[a] Percentage of error due to speed errors (in parentheses).

any carry-over effects from protocol to protocol or from an accuracy-only to a speed contingency occurred, accuracy was examined in the first training blocks in each condition in terms of the cumulative number of correct choices (see Figure 5) and the percentage correct (see Table 1). These accuracy data revealed no carry over effects as new protocols and/or the speed contingency were introduced for each participant. Figure 5 shows that in every case the initial trials in the first training block contained errors for every participant.

DISCUSSION

The most significant finding of the present study is that the three protocols produced no differential effect on response speed and accuracy as a function of nodal number. Both measures tended to be flat as nodal number increased. The results thus replicate and extend previously reported effects of equal presentations of training and testing trial types during equivalence-class formation (Imam, 2001) or following response-speed transfer training (Imam, 2003). The implication of these results is that each protocol engendered equivalence classes whose members were equally related to one another, in agreement with a reinforcement contingency account of equivalence-class formation (Sidman, 1994), but contrary to an associative-distance account (Fields et al., 1993; Fields et al., 1990; Fields et al., 1995). The absence of nodal-number effects in the present study cast further doubt on the generality of the typical finding of unequal relatedness among equivalence-class members as a function of nodal number (e.g., Fields et al., 1995; Fields et al., 1997; Spencer & Chase, 1996). The present results thus do not support the claim by Fields et al. (1990) that ''... the relatedness of two stimuli that constitutes a derivative relation in an equivalence class should be an *inverse function* [italics added] of the number of nodes that characterize the relation'' (pp. 346–347; see also Spencer & Chase, 1996; Fields et al., 1993).

These results provide the strongest evidence to date contradicting the nodality effect and suggest it occurs when unequal training and testing trial types are used (e.g., Bentall et al., 1998; Imam, 2001; Kennedy, 1991; Kennedy et al., 1994; Spencer & Chase, 1996). By ensuring equal presentation of conditional discriminations in each protocol and by selecting, as Spencer and Chase (1996) did, only the most and the least trained relations for statistical analyses (see also Imam, 2001, 2003), the histories of reinforcement on baseline trials

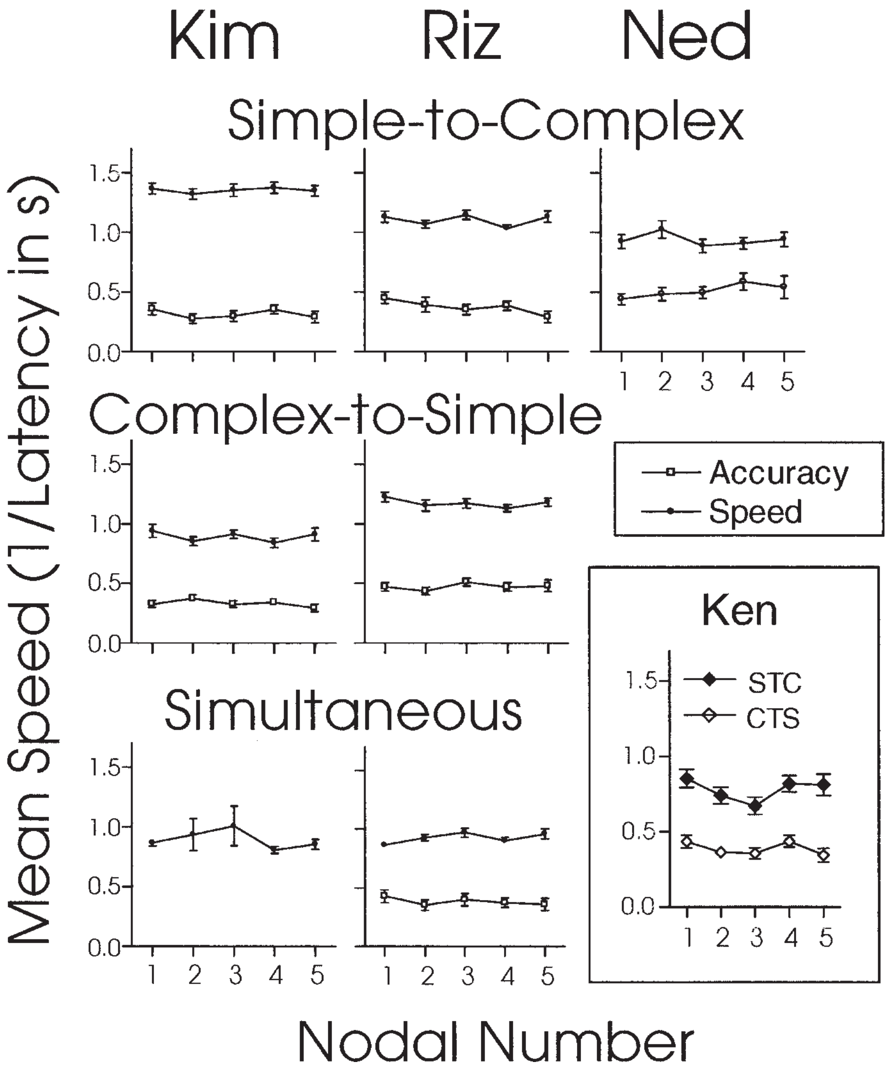


Fig. 4. Mean speed on correct choices on equivalence trials as a function of nodal number under the accuracy-only (open square) and the speed-and-accuracy (filled circle) conditions for Kim, Riz, and Ned, and under the STC (filled diamond) and CTS (open diamond) protocols for Ken. Error bars represent the standard deviation.

and the disparity of the number of emergent relations for each nodal number inherently present in the LS structure were controlled for in the present study. In so doing, contrary to the associative-distance view (Fields & Verhave, 1987) that goes beyond the role of the distribution of feedback among training trials to invoke nodal number, the nodality effect was completely absent in all cases in the present study. The results support, instead, the reinforcement-contingency explanation of equivalence-class membership, which predicts equality in response accuracy and speed as a function of nodal number based on equal histories of reinforcement (Saunders & Green, 1999; Sidman, 1994).

As noted in the introduction, of the various reports of the nodality effects to date, Fields et al. (1995) was an exception in presenting equal numbers of baseline and derived relations, using the SP. In the present study, however, the SP produced no effects of nodal number on either response accuracy or speed. One factor that may account for these divergent findings is that Fields et al. employed a two-comparison choice procedure, in con-

Table 4

Results of ANOVA and of posttest linear trend analyses of response speeds on equivalence trials as a function of nodal numbers for each participant under respective protocols with accuracy and/or speed-and-accuracy conditions.

		ANOVA				Linear trend	
Participant	Condition	df_b	df_w	F	η^2	Slope	η^2
Kim	Accuracy; CTS	4	242	0.83	.01	−0.009	.003
	Accuracy; STC	4	103	0.73	.03	−0.006	.001
	Accuracy; SP	4	319	2.31	.03	−0.010	.003
	Speed; STC	4	70	0.20	.01	0.002	.0002
	Speed; CTS	4	100	1.02	.04	−0.007	.002
	Speed; SP	4	199	0.55	.01	−0.015	.0008
Riz	Accuracy; CTS	4	157	0.58	.01	0.005	.001
	Accuracy; STC	4	103	1.07	.04	−0.033	.031
	Accuracy; SP	4	157	0.40	.01	−0.012	.003
	Speed; CTS	4	126	0.92	.03	−0.011	.005
	Speed; STC	4	90	1.57	.07	−0.003	.0006
	Speed; SP	4	149	1.94	.05	0.017	.014
Ned	Accuracy; STC	4	103	0.91	.03	0.03	.019
	Speed; STC	4	78	0.77	.04	−0.008	.002
Ken	Accuracy; STC	4	103	1.66	.06	−0.0003	.000002
	Accuracy; CTS	4	156	1.26	.03	−0.011	.004

Note: STC = simple-to-complex; CTS = complex-to-simple; SP = simultaneous protocol.

trast to the three-choice procedure of the present study. Kennedy (1991) showed that a three-comparison procedure reduced the nodality effect (Experiment 2) compared to a two-comparison procedure (Experiment 1). In the two-comparison procedure, participants tend either to select the correct comparison or to reject the incorrect comparison. In the context of nodality, as Sidman (1994) noted, adding new conditional discriminations by training increases the likelihood ''that some comparisons will be chosen by selection and others by rejection,'' leading to an ''increase [in] the variability among test outcomes as the number of nodes increases'' (p. 540).

Furthermore, the use of two-choice procedures in conditional discriminations carries with it the potential for misinterpretation of results, especially when using performance accuracy (Sidman, 1980). For example, suppose an experimenter arranges and expects exclusive selection of a horizontal line given a green hue and of a vertical line given a red hue (Scenario 1). Instead, the subject selects the horizontal line 75% of the time and the vertical line 25% of the time given green and reverses these selections given red (Scenario 2). Scenarios 1 and 2 differ only quantitatively. The overall accuracy in Scenario 2 is 75% correct, the same as if the subject always selects the horizontal line given green and the vertical and horizontal lines half the time given red (Scenario 3). With 75% accuracy under a two-choice procedure, it is unclear whether the subject's performance is under the control of contingencies arranged by the experimenter (line discrimination conditional on hue; Scenarios 1 and 2) or under a combination of line and position discriminations (Scenario 3; see Sidman, 1980, for further discussions). Performance accuracy of 1 of the 2 participants in the Fields et al. (1995) study on nodes one to three (Subject 478) was in the 75% range, as was that of the other participant (Subject 484) on node three. Which scenario applied in these cases? The absence of nodality in the present study in contrast to the Fields et al. study, therefore, may reflect the limitations that inherently accompany the latter's use of two instead of three comparisons.

Another factor that may account for the divergent findings is that Fields et al. (1995) used a ''zero-node'' designation for the symmetry relations and incorporated it as a nodal number. For the 2 participants who demonstrated equivalence in the Fields et al. study, however, if one excludes the symmetry relations, the reported nodality effect diminishes considerably, especially for Subject 478. In addition, the use of the zero-node designation is at best ambiguous conceptually. As Imam (2001) argued, the use of symmetry trials with this designation in defining nodal numbers is ill advised, principally because the

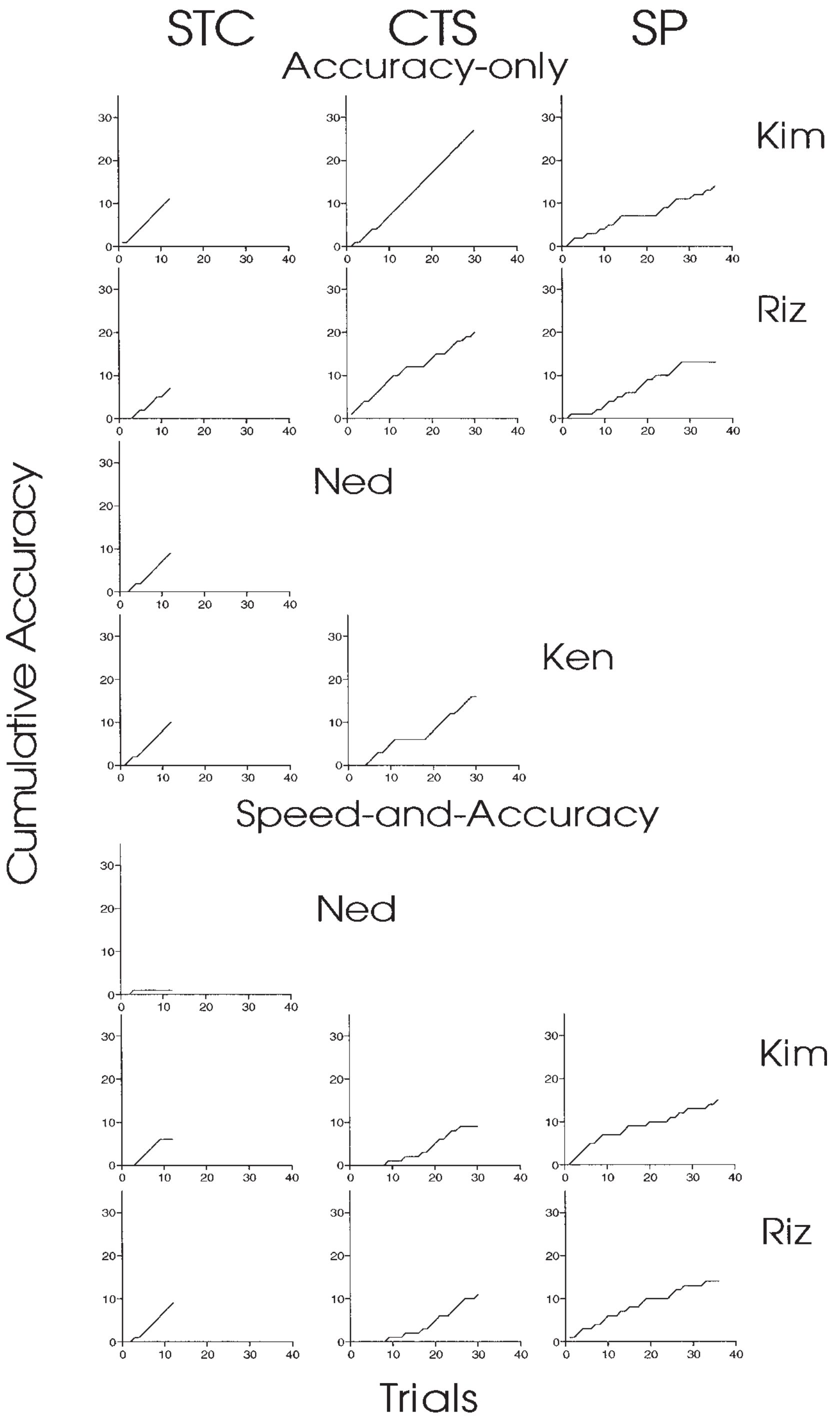


Fig. 5. Cumulative performance accuracy across trials in the first training block with 100% feedback presented to each participant under each relevant condition (see text for details). From trial to trial, each correct choice of a comparison added a step to the cumulative function and each incorrect choice added a horizontal step to the cumulative function.

definitions of nodes and singles provided in Fields and Verhave's (1987) associative-distance account of nodality do not allow for such designation. Considering BA and CB relations as zero nodes after AB and BC training is a misnomer, given that only B is a node, and A and C are singles—a single being a ''stimulus that is linked directly through training to only one other stimulus'' (Fields & Verhave, 1987, p. 320). Indeed, excluding the symmetry relations would either diminish or eliminate the nodality effect altogether in Kennedy's (1991) individual cumulative records in his Experiment 1 and Experiment 2, respectively. The present study did not include a zero-node designation. Thus the fact that Fields et al. used only two comparisons and included the zero-node designation in nodal numbers appears to account for the reported nodality effects, in contrast to the present study in which neither was applicable.

In the present study, both response accuracy and speed showed no nodality effect, unlike in the previous studies in which a few instances of nodality were observed, each in response speeds, under a CTS-like protocol (Imam, 2001, 2003). The latter cases, however, involved a trade-off between fast responding and accuracy (e.g., Imam, 2001), a by-product of adding the speed contingency (see also Baron et al., 1983). Adding the speed contingency in the present study tended to engender higher error rates compared to the corresponding accuracy-only contingency across the five nodal numbers, especially under the STC and SP protocols for Kim, under the STC protocol for Ned, and under all three protocols for Riz. Nevertheless, there was no nodality effect in these cases, and only Ned's STC speed-and-accuracy condition exhibited something suggestive of an accuracy–speed trade-off as shown in Table 3. Even then, it did not engender a decline in accuracy that would unambiguously support a nodality effect (cf. Imam, 2001); in fact, accuracy increased on nodes four and five, over nodes two and three. Although Fields et al. (1995) reported reaction time data, a direct comparison with the present results is limited because the data were from posttransfer tests (cf. Imam, 2003) and not, as in the present study, from tests for emergent relations during equivalence-class formation.

The general finding that the CTS protocol requires more blocks than the STC protocol (e.g., Adams et al., 1993) is only weakly supported in the present study. A comparison of the number of blocks completed to criteria under the two protocols showed that participants required only one or two more blocks between them. The present study confirmed, however, the finding that participants tend to learn more slowly under the SP (e.g., Fields et al., 1995; Fields et al., 1997) than under the other two protocols (see Adams et al., 1993; Saunders & Green, 1999). In the present study, the SP required the greatest number of blocks for Kim and Riz, who completed this protocol. The manner of exposure to the training and testing blocks provided under each protocol appears to influence this differential effect of the protocols on learning outcomes like the number of blocks completed (Fields et al., 1997). In the present study, however, the number of blocks completed to achieve criteria on the first block(s) of training (AB for STC, the AB+BC for CTS, and all relations for SP) determined the number of blocks used for the remainder of the relations trained within each protocol, a tactic adopted to achieve equality of various trial types and to ensure equal reinforcement history. Because the number of trials in each block varied as other, newer, relations were trained, considering only the number of blocks completed to criterion does not seem adequate for assessing the relative effects of the protocols on acquisition in equivalence-class formation. As such, the number of trials completed to criteria seemed more appropriate. As Table 1 shows, contrary to what might be concluded from relying on the traditionally used block data alone (e.g., Adams et al., 1993; Fields et al., 1997), the number of trials to criteria did not exhibit systematic variations as a function of any protocol or of whether or not the speed contingency was in effect. In other words, the number of trials completed did not follow the STC, CTS, SP order in difficulty of acquisition. Sometimes, the SP required the least number of trials (as with Kim; with and without the speed contingency), and sometimes, the STC protocol required the most number of trials (as with Riz; with the speed contingency). The lack of significant learning outcomes due to the protocols may be an artifact of the limitations, based on the initial training blocks, imposed on the later training blocks to maintain equality of trial types in the present study.

Finally, as noted in the introduction, previous comparisons of different protocols on equivalence outcomes were between groups; sometimes across different studies. The present study used a within-participant design to eliminate the intersubject variations in preexperimental history. Because the participants in the present study experienced exposures to multiple sets of stimuli in different conditions, the potential for carryover effects existed (Sidman, 1960). An examination of the first training blocks in each condition for each participant revealed, however, that no such carryover effect occurred; the initial trials in these blocks for each participant contained errors, as seen in Figure 5, and the percentage accuracy showed sufficient declines not to be indicative of such an effect (see Table 1).

To conclude, the results of the present study unambiguously show that regardless of any differences in learning outcomes the protocols may engender, they do not yield differential nodality effects in either response accuracy or speed when equal numbers of training and testing trials were presented. In replicating and extending the recently reported findings on the nodality effect (Imam, 2001, 2003), in contrast to other studies (e.g., Fields et al., 1990; Fields et al., 1995; Fields et al., 1997; Imam, 2001; Spencer & Chase, 1996; see Adams et al., 1993) in which such controls were absent, the present study provides some empirical support for Kennedy et al.'s (1994) observations that ''[f]rom an instructional perspective, if nodality effects are to be minimized, careful attention needs to be given to training methods'' (p. 680). In concert with their recommendations for further research, the number of stimuli used in the present study was as large compared to some (e.g., Kennedy, 1991; Spencer & Chase, 1996) but larger than most (e.g., Adams et al., 1993; Bentall et al., 1998; Fields et al., 1990; see Fields et al., 1993), training history was equalized in contrast to standard nodality research (Bentall et al., 1998; Fields et al., 1990; Fields et al., 1995; Fields et al., 1997; Spencer & Chase, 1996), and three different protocols were compared within participants (cf. Adams et al., 1993; Fields et al., 1997), precluding influences of preexperimental history on the outcome (Sidman, 1960).

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