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NODAL STRUCTURE AND THE PARTITIONING OF EQUIVALENCE CLASSES

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By definition, all of the stimuli in an equivalence class have to be functionally interchangeable with each other. The present experiment, however, demonstrated that this was not the case when using post-class-formation dual-option response transfer tests. With college students, two 4-node 6-member equivalence classes with nodal structures of A→B→C→D→E→F were produced by training AB, BC, CD, DE, and EF. Then, unique responses were trained to the C and D stimuli in each class. The responses trained to C generalized to B and A, while the responses trained to D generalized to E and F. Thus, each 4-node 6-member equivalence class was bifurcated into two 3-member functional classes: A→B→C and D→E→F, with class membership precisely predicted by nodal structure. A final emergent relations test documented the intactness of the underlying 4-node 6-member equivalence classes. The coexistence of the interchangeability of stimuli in an equivalence class and the bifurcation of such a class in terms of nodal structure was explained in the following manner. The conditional discriminations that are used to establish a class also imposes a nodal structure on the stimuli in the class. Thus, the stimuli in the class acquire two sets of relational properties. If the format of a test trial allows only one response option per class, responding on those trials will be in accordance with class membership and will not express the effects of nodal distance. If the format of a test trial allows more than one response option per class, responding on those trials will be determined by the nodal structure of the class. Thus, the relational properties expressed by the stimuli in an equivalence class are determined by the discriminative function served by the format of a test trial.

Key words: equivalence classes, nodal structure, nodal distance, response transfer, class bifurcation, transformation of function, discrimination based on trial format, keyboarding, college students

Fields and Verhave (1987) noted that an equivalence class containing N stimuli can be established by training many different sets of (N - 1) conditional discriminations, each of which creates a class with a unique training structure. For example, a 6-member class that is established by training the AB, BC, CD, DE, and EF conditional discriminations produces a class with the training structure A→B→C→C→E→F. The emergence of the class is evaluated with the presentation of the ordered pairs in the set that were not directly trained, each of which is called a derived or emergent relations probe. The emergence of an equivalence class is documented when class consistent selections are occasioned by all derived relation probes.

The emergent relations can be clustered into subsets based on the commonality of a sample stimulus or the commonality of a pair of comparisons. For example, the FA, FB, FC, FD, and FE relations share a common sample and vary in terms of comparisons. In these probes, the selection of all comparisons in a given class in the presence of the sample from the same class would demonstrate the *interchangeability* or *substitutability* of the comparison stimuli across the F*X* probes. Likewise, FA, EA, DA, CA, and BA share a common comparison and vary in terms of the sample stimuli. In these probes, the selection of the same comparison in the presence of the different sample stimuli from the same class would demonstrate the interchangeability or substitutability of the sample stimuli across the *X*A probes. Based on these performances all of the stimuli in an equivalence class are said to be interchangeable with, or substitutable for, each other (deRose, McIlvane, Dube, Galpin &

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Stoddard, 1988, Experiments 1 and 2; Mackay & Sidman, 1984; McIlvane & Dube, 2003; Sidman, 1994; Sidman & Tailby, 1982).

Once an equivalence class has been formed, it usually acts as a functional class or a function-transfer network (Goldiamond, 1962; Keller & Schoenfeld, 1950; Lea, 1984; Tonneau, 2002). That is, if one class member acquires a particular function, that function generalizes essentially completely to the other members of the same class but not to the members of other classes. This has been demonstrated with (a) discriminated operants of many different topographies, all established with positive reinforcement (Barnes, Browne, Smeets, & Roche, 1995; Fields, Adams, Verhave, & Newman, 1993; Rehfeldt & Hayes, 1998); (b) discriminative avoidance responses that were established with negative reinforcement (Augustson & Dougher, 1997); (c) classically conditioned responses that were established with aversive unconditioned stimuli (USs) (Dougher, Augustson, Markham, Greenway, & Wulfert, 1994; Green, Sigurdardottir, & Saunders, 1991; Roche & Barnes, 1997); (d) the combination of attractant and repellant functions acquired by class members that served as discriminative stimuli (S^Ds) for appetitive and aversive stimuli (Hayes, Kohlenberg, & Hayes, 1991; Barnes-Holmes, Keane, & Barnes-Holmes, 2000); (e) the combination of attractant and repellant functions acquired by class members that served as S^Ds and S^Δs (discriminative stimuli for the presence and **a**bsence of reinforcement) (de Rose et al., 1988); and (f) the extinction of a classically conditioned response that was established with aversive USs (Dougher et al., 1994; Dymond & Rehfeldt, 2000). These function transfer performances also demonstrate that the stimuli in an equivalence class act interchangeably.

These demonstrations of the substitutability or interchangeability of the stimuli in an equivalence class have led some to conclude that the stimuli in an equivalence class are equally related to each other (Sidman, 1994, 2000; Fields et al., 1993; Imam, 2001, 2006). In addition to interchangeability, however, the stimuli in an equivalence class may acquire other functional properties in which the stimuli in a class are differentially related to each other and appear to be determined by the nodal structure of the equivalence class or the nodal distance that separates the stimuli in the class.

This notion can be appreciated by considering the nodal structure of the equivalence class described, which is represented by A→B→C→D→E→F. This class contains four nodal stimuli (B, C, D, and E) and two singles (A and F) (Fields & Verhave, 1987). Each emergent relation is characterized by the number of nodes that separates any two stimuli in the training structure. For example, BA is a 0-node symmetrical relation because the B and A stimuli are not separated by any nodes. FD is a 1-node relation because the F and D stimuli are separated by one node. Likewise, BE, EA and AF are 2-, 3-, and 4-node relations because the stimuli in each relation are separated by two, three and four nodes, respectively. The number of nodes that separate two stimuli in an equivalence class is called nodal distance (Fields & Verhave, 1987; Fields, Verhave, & Fath, 1984) or nodal number (Sidman, 1994).

Fields and Verhave (1987) and most recently Fields and Moss (in press) noted the formal similarity of the nodal distance that separates the stimuli in an equivalence class with the number of explicit intervening nodes that separate the stimuli in serial lists (Ebbinghaus, 1913; Slamecka, 1985), and the number of implicit intervening nodes that separate the stimuli in a semantic memory network (Collins & Loftus, 1975; Collins & Quillian, 1969). After learning a serial list, new derived lists were constructed of nonadjacent words in the original list. The savings in the learning of the derived lists was an inverse function of the number of words that separated the words in the original list (Ebbinghaus, 1913; Slamecka, 1985). When the relations among the words in a semantic memory network were studied using sentence verification tasks, reaction time to statements was a direct function of the number of nodes that separated the stimuli in the network. In both cases, the performances were said to reflect the effect of *remote associations* between the stimuli in the list or the network (Lachman, Lachman, & Butterfield, 1979). Thus, Fields et al. (1984) and Fields and Verhave (1987) proposed that the responding produced by the stimuli in an equivalence class should also be an inverse function of nodal distance under appropriate conditions of testing.

The effect of nodal distance has been observed during the delayed emergence of multinodal equivalence classes. Specifically, the percentage of class-consistent comparison selections occasioned by the initial presentation of emergent relations probes was an inverse function of nodal distance (Fields, Adams, Verhave, & Newman, 1990; Kennedy, Itkonen, & Lindquist, 1994; Lazar, 1977). In addition, the serial order in which the emergent relations probes came to evoke class-consistent comparison selection was an inverse function of nodal distance (Fields et al., 1990; Kennedy, 1991; Kennedy et al., 1994). In 1-node 3-member classes (Bentall, Dickins, & Fox, 1993; Wulfert & Hayes, 1988), and 3-node 5-member classes (Bentall, Jones, & Dickins, 1998), the reaction times occasioned by emergent relations probes were a direct function of nodal distance that characterized each probe in the initial test blocks. Test repetition, however, diminished or eliminated the differential effects of nodal distance on reaction time. This transient outcome of nodal distance could mean that the effect of nodal distance was permanently lost once a class had formed. Alternatively, the transient outcome could mean that the effect of nodality was permanent and was overshadowed by the class-based sources of stimulus control.

This notion of permanent elimination is challenged by the results of seven studies which showed post-class-formation test performances that were correlated with nodal distance. Spencer and Chase (1996) found that response speed, the reciprocal of reaction time, was an inverse function of nodal distance in already established 5-node 7-member equivalence class that did not diminish with continued testing. Tomanari, Sidman, Rubio, and Dube (2006) also found that response speed after class formation was a stable and inverse function of nodal distance even though differential reinforcement contingencies were used to maximize response speed on all trials. In both of these experiments, then, class-based contingencies controlled the selection-based responding that documented the presence of an equivalence class, while nodal distance controlled the chronometric properties of comparison selection on a concurrent basis.

After the formation of equivalence classes, Pilgrim and Galizio (1996) found that reported reinforcer presentations were an inverse function of the nodal number that separated the stimuli in each relation. This occurred even though differential reinforcement was never provided on the emergent relations probes. In Experiment 3 of a study conducted by de Rose et al. (1988), a discrimination was established between an S^D denoted as A1 and an S^Δ denoted as A2. Thereafter, equivalence classes were established by training AB and DB conditional discriminations leading to the formation of equivalence classes that had the nodal structure A→B←D. In these classes, each A stimulus was 0 nodes removed from the B stimulus and was 1 node removed from the D stimulus. During post-class-formation discrimination tests that involved the simultaneous presentation of B1 and B2, B1 was selected on 11 of 12 test trials. In another test that involved the simultaneous presentation of D1 and D2, D1 was selected on 6 of 12 test trials. Thus, selection of the B and D stimuli that were in the same class as an A stimulus that functioned as an S^D was an inverse function of nodal distance.

The post-class-formation influence of nodal distance was further demonstrated in two additional studies that used testing strategies which pitted two response options from the same class against each other. Fields, Adams, and Verhave (1993) established two 3-node 5-member classes by training AB, BC, CD, and DE. After class formation, subjects were presented with conditional discrimination tests where the sample and both comparison stimuli on a trial were from the same class. Each comparison in a trial, however, was separated from the prevailing sample by a different number of nodal stimuli. For example, a trial might contain E1 as the sample with C1 and A1 as the comparisons. On such a trial, C1 was separated from E1 by one node while A1 was separated from E1 by three nodes. In such a test, C, the stimulus that was one node removed from the sample, was selected instead of A, the stimulus that was three nodes removed from the sample. On trials that contained comparisons with different nodal separations from the same sample stimulus, subjects routinely selected the comparison that was separated from the sample by fewer nodal stimuli. These results, then, support the view that the relational strength of stimuli in an equivalence class is an inverse function of nodal distance when within-class contingencies had previously established two response options per class. Similar results were obtained with a larger multinodal class by Alligood and Chase (2007).

Finally, Fields, Landon-Jimenez, Buffington, and Adams (1995) used a different post-class-formation within-class testing strategy. After the establishment of two 3-node 5-member equivalence classes with a structure represented as A→B→C→D→E, subjects were trained to make incompatible responses in the presence of the A and E stimuli in each class. Incompatible responses are those that cannot be emitted at the same time. Finally, all of the stimuli in both classes were presented alone and without feedback. Since a subject could make two different responses to the stimuli in a class, this evaluation procedure is referred to as a *dual-option response transfer test.*

In the Fields et al. (1995) study, reaction times were fastest for the A and E stimuli, slower for the B and D stimuli and slowest for the C stimuli. That is, reaction times increased systematically for the stimuli that were more nodally distant from A and E. These data demonstrated the post-class-formation steady-state chronometric effects of nodal distance. In addition, the response trained to the A stimulus in a class was emitted with decreasing frequency in the presence of the B, C, D, and E stimuli in the same class while the response trained to the E stimulus was emitted with decreasing frequency in the presence of the D, C, B, and A stimuli in the same class. These results showed the graded transfer of function that would be predicted by nodal distance.

In other cases, however, a different finding was obtained and suggested a second effect of nodality. Specifically, the A, B, and C stimuli evoked the same high degree of responding whereas a systematic decline of responding was occasioned by the D and E stimuli, respectively. The complete generalization of responding among the A, B, and C stimuli demonstrated emergence of a 3-member functional class: ABC. Such an outcome suggests that the nodal structure of an equivalence class induced a functional class that was a subcategory of the larger 5-member equivalence class. In addition, the decrement in responding occasioned by the D and E stimuli reflected the graded effect of nodal distance on the remaining stimuli in the class.

To summarize, the last seven studies showed that post-class-formation tests of different sorts produced responding that was correlated with nodal distance or nodal structure after the formation of equivalence classes. These results strongly suggest that nodal distance influences the relatedness of the stimuli in an equivalence class. The expression of responding that is correlated with nodality is dependent on the test type. Further, the effects of nodality can be overshadowed by class-based relations among the same stimuli under appropriate conditions of testing.

The Fields et al. (1995) study had two limitations. First, there was some cross-class and between-subject variation in the degree of generalization that occurred from the A and E stimuli to the B, C, and D stimuli. Thus, the sizes of the subcategorized functional classes were not precisely determined by nodal structure. Also it was impossible to determine whether the bifurcation of the basal equivalence class disrupted the integrity of the basal class because the authors did not present a final battery of emergent relations tests after class partitioning. These issues were addressed in the present experiment which began with the formation of two 4-node 6-member classes by training of AB, BC, CD, DE, and EF. Thereafter, incompatible responses were trained to the nodally adjacent C and D stimuli in each class. A test was then conducted to measure the generalization of the C- and D-based responses to the remaining stimuli in both classes. Finally, subjects were presented with another emergent relations test to evaluate the intactness of the 4-node 6-member equivalence classes after they had been partitioned into smaller functional classes.

Figure 1 illustrates six possible outcomes of the dual option response transfer test. Only five of them will be considered here because each provides a definitive evaluation of the effects of nodal structure and/or nodal distance on test performance. Graphic representations of each outcome are presented in separate panels of Figure 1.

Theoretical Outcome 1, displayed in the upper left panel, depicts the complete generalization of the C-based response to the B and A stimuli in the same class, and no generalization of that response to the D, E or F stimuli. In addition, the D-based response generalized completely to the E and F stimuli in the same

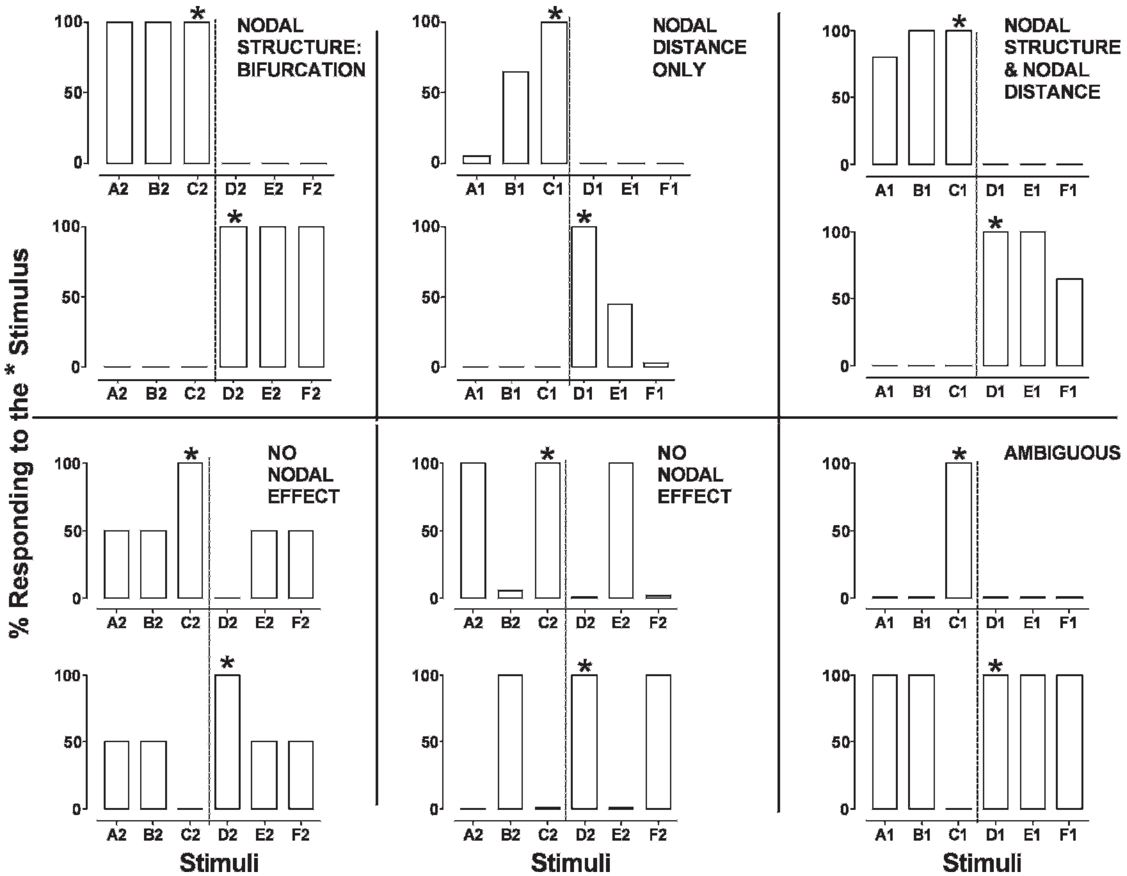

Fig. 1. Six theoretical outcomes of dual-option response transfer tests. Each graph lists the six stimuli in a class on the abscissa with an asterisk above the stimulus that has become an S^D for a particular response. The ordinate indicates the likelihood of occurrence of that response in the presence of the remaining stimuli in the class. The graphs in each section indicate a representative theoretical pattern of responding that would indicate the form of control listed as the caption for that section.

class and never to the A, B, or C stimuli in that class. These performances demonstrate the bifurcation of a multinodal equivalence class into two functional classes, ABC and DEF. Such an outcome would be in accordance with the binary effects of the nodal structure of an equivalence class. It would also demonstrate that membership in each bifurcated class was predicted precisely from nodal structure. Finally, the absence of a graded effect of nodal distance could imply that the binary effect of nodal structure overshadowed the graded effect of nodal distance.

Theoretical Outcome 2, presented in upper middle panel, depicts partial generalization of the C-based response to the B and A stimuli in the same class, and no generalization of that response to the D, E or F stimuli. In addition, the D-based response generalized partially to the E and F stimuli in the same class and never to the A, B, or C stimuli in that class. These performances demonstrate the bifurcation of a multinodal equivalence class into two classes that would be in accordance with the binary effects of the nodal structure of an equivalence class. It would also demonstrate the graded effect of nodal distance superimposed on the binary effect of nodal structure.

Theoretical Outcome 3, presented in upper right hand panel, depicts the complete generalization of responding from C to B and from D to E along with partial generalization of responding from C to A and D to F. The generalization of responding from C to B and D to E would reflect binary control by nodal structure, while the partial decrement in responding evoked by the A and F stimuli would reflect the graded effect of nodal distance. That is, the graded effect of nodal distance would suppress the binary effects of nodal structure for stimuli that are more nodally removed from the discriminative stimuli.

Theoretical Outcomes 4 and 5 show that nodal structure and nodal distance do not influence responding by the stimuli in an equivalence class. In Theoretical Outcome 4, lower left hand panel, the responses trained to the C and D stimuli are maintained. In addition, the C- and D-based responses generalize in essentially equal degree to the A, B, E, and F stimuli in a class. Since such generalization is unrelated to nodal distance that separates the A, B, E and F stimuli from the discriminanda, such an outcome would show that all of the stimuli in an equivalence class were interchangeable or equally related to each other.

In Theoretical Outcome 5, presented in the lower middle panel, the responses trained to the C and D stimuli generalize to the other stimuli in the class in a manner that is unrelated to nodal distance or structure. The generalization, however, is all or none to various A, B, E and F stimuli. In this example, the response trained to the C stimulus generalizes completely to A and E, while the response trained to the D stimulus generalizes completely to B and F. Further the stimuli to which the C- and D-based responses generalize would have to differ unsystematically across subjects.

To summarize, the dual-option response transfer test can give rise to a range of performances that can be used to definitively evaluate the predicted effects of nodal structure and nodal distance. Theoretical outcomes 1, 2, or 3 provide unambiguous support for the notion that relations among the stimuli in an equivalence class are determined by nodal structure and/or nodal distance in some combination. Theoretical outcomes 4 or 5 provide unambiguous evidence that the relations among the stimuli in an equivalence class are not influenced by nodal structure and/or nodal distance. Thus, these five outcomes of the dual-option response transfer tests provide for the experimental disconfirmation of the notion that nodality influences relations among the stimuli in an equivalence class.

As mentioned above, the dual-option response transfer test can also give rise to other outcomes, each of which gives rise to a number of conflicting interpretations. As such, these outcomes cannot be used to evaluate the effects of nodal structure on the strength of relations among the stimuli in an equivalence class. One such outcome is illustrated in the lower right section of Figure 1 and will be considered when discussing the outcome of the experiment.

Method

Subjects

Fifteen undergraduate students from Queens College participated in the experiment. They were naive about the nature of the research and received course credit for participation.

Apparatus and Stimuli

The experiment was conducted on IBM-compatible personal computers and software developed to study equivalence classes and response transfer. Each subject sat in a cubicle at a table facing a computer monitor. The table also had a QWERTY keyboard in front of the monitor. All stimuli were presented on the monitor. Responses involved pressing specific keys on the keyboard, and were automatically recorded by the computer. The 12 nonsense syllables that were used as stimuli in the experiment and their corresponding letter–number designations in Class 1 were: A1 = QIJ, B1 = TUW, C1 = COH, D1 = MEP, E1 = RAB, F1 = LYK; in Class 2, they were: A2 = VIF, B2 = KUY, C2 = XOL, D2 = GEZ, E2 = NAS, and F2 = PYT.

Procedure

Phases of the experiment. The entire experiment consisted of nine serially introduced phases. Phase 1 involved preliminary training which taught the subjects how to respond during the trials presented in the experiment. Phases 2 and 3 involved training and testing for equivalence class formation. Phase 4 involved the training of different responses to one member of each equivalence class. Phase 5 evaluated the generalization of those responses to the other members of each equivalence class. Phase 6 used an emergent relations test to evaluate the intactness of the equivalence class after generalization testing. Phase 7 involved the training of different responses to two other members of each equivalence class. Phase 8 involved testing for the generalization of these responses to the other class members. Finally, Phase 9 used an emergent relations test to evaluate the intactness of the equivalence classes after testing for the bifurcation of classes in the previous phase.

Phase 1: Preliminary training. Each trial began with the presentation of a sample stimulus. Pressing the space bar on the computer keyboard produced two comparison stimuli which were located below and to the sides of the sample stimulus. The comparisons remained on along with the sample until the subject pressed the 1 or 2 key which corresponded to the positions of the comparisons on the left and the right, respectively. A correct response produced the feedback message "RIGHT" on the monitor and an incorrect response produced the feedback message "WRONG" on the monitor. Either feedback message was terminated by pressing the Enter key. A second press on the Enter key started the next trial with the presentation of a sample stimulus.

In this phase, each subject was trained to emit the keyboard responses required to complete a conditional discrimination trial. A trial contained one sample and two comparison stimuli that are common words, where the sample (e.g., the written word QUEEN) was semantically related to the positive comparison (e.g., KING) but not to the negative comparison (e.g., MUD). The subject was prompted by written instructions on the screen to press certain keys to select one comparison, and to proceed to the next trial, the prompts were gradually faded. The subject moved onto the next phase when 100% accuracy was achieved in a block with no prompts.

Phase 2: Baseline training. The subjects were taught the 10 conditional discriminations, A1–B1, B1–C1, C1–D1, D1–E1, E1–F1 for Class 1, and A2–B2, B2–C2, C2–D2, D2–E2, E2–F2 for Class 2, using trials that are enumerated in Table 1. For example, in an A1–B1 conditional discrimination trial, A1 was presented as a sample, and B1 and B2 were presented as a positive comparison and a negative comparison, respectively. Each sample was presented on two trials in the block. On each of those trials, each comparison was presented once in each comparison position on the monitor. The left/right positional presentation of comparisons was randomized in a block.

All of the trials listed in Table 1 were presented in a training block in a randomized sequence without replacement. As can be seen, the trials needed to establish each of the conditional discriminations were presented the same number of times in the training block. The block was repeated until all trials occasioned correct responses; i.e., the mastery criterion for a block was 100% class-consistent selection.

As long as performance within the block remained at 100% accuracy, the percentage of trials in a block that produced informative feedback was then reduced from 100%, to 75%, to 25%, and finally to 0% in successive blocks. The subject moved onto the next phase when 100% accuracy was achieved in a block with 0% feedback. The percentage of feedback remained the same for consecutively presented blocks until the mastery level of responding was attained. Once attained, that percentage was shifted as described above. Thus, the number of blocks of exposure at a given feedback percentage could vary across subjects.

All of these baseline relations were trained at the same time, through the repeated presentation of a block of training trials that contained the same number of trials for each relation. In addition, the relations were presented in a randomized order throughout training. Thus, number of trial presentations and serial order of trial presentation could not be correlated with nodal distance. As a result, any outcome of a subsequent test that is correlated with nodal distance cannot be attributed to either of these training variables; rather, they could only be attributed to nodality (Buffington, Fields, & Adams, 1997; Fields et al., 1995; Spencer & Chase, 1996).

Phase 3: Emergent relations test 1. Subjects were presented with all baseline conditional discriminations, symmetry probes, one-, two-, three-, and four-node transitivity and equivalence probes under extinction conditions in the same test block. Four trials were presented for each baseline conditional discrimination and probe: each sample was presented on two trials, and the positions of the comparison stimuli were reversed across trials. All of these

Table 1

Symbolic representation of stimulus triads used in the training and the testing blocks. Sa = sample stimulus; Co+ = positive comparison stimulus; Co- = negative comparison stimulus. Each Sa/Co+/Co- triad appeared twice, once with the Co+ on the left and once on the right, yielding a total of 20 trials in the training block and 120 trials in the testing block.

		Sa	Co+	Co-	Sa	Co+	Co-
Training		A1	B1	B2	A2	B2	B1
		B1	C1	C2	B2	C2	C1
		C1	D1	D2	C2	D2	D1
		D1	E1	E2	D2	E2	E1
		E1	F1	F2	E2	F2	F1
Testing	Baseline review						
		A1	B1	B2	A2	B2	B1
		B1	C1	C2	B2	C2	C1
		C1	D1	D2	C2	D2	D1
		D1	E1	E2	D2	E2	E1
		E1	F1	F2	E2	F2	F1
	0 nodes						
		B1	A1	A2	B2	A2	A1
		C1	B1	B2	C2	B2	B1
		D1	C1	C2	D2	C2	C1
		E1	D1	D2	E2	D2	D1
		F1	E1	E2	F2	E2	E1
	1 node						
		A1	C1	C2	A2	C2	C1
		B1	D1	D2	B2	D2	D1
		C1	E1	E2	C2	E2	E1
		D1	F1	F2	D2	F2	F1
		C1	A1	A2	C2	A2	A1
		D1	B1	B2	D2	B2	B1
		E1	C1	C2	E2	C2	C1
		F1	D1	D2	F2	D2	D1
	2 nodes						
		A1	D1	D2	A2	D2	D1
		B1	E1	E2	B2	E2	E1
		C1	F1	F2	C2	F2	F1
		D1	A1	A2	D2	A2	A1
		E1	B1	B2	E2	B2	B1
		F1	C1	C2	F2	C2	C1
	3 nodes						
		A1	E1	E2	A2	E2	E1
		B1	F1	F2	B2	F2	F1
		E1	A1	A2	E2	A2	A1
		F1	B1	B2	F2	B2	B1
	4 nodes						
		A1	F1	F2	A2	F2	F1
		F1	A1	A2	F2	A2	A1

trials were presented in a randomized sequence without replacement in a test block. The test block was repeated up to five times or until class-consistent comparisons were selected on at least 95% of the trials in a block. This performance demonstrated the emergence of two 4-node 6-member equivalence classes.

Phase 4: Single-option discrimination training. After subjects formed two 4-node 6-member equivalence classes, subjects were trained to make different responses in the presence of one member of each of the equivalence classes. Both responses involved the use of the same manipulandum, in this case, pressing the J key on the computer keyboard. Reinforcement was provided for pressing the J key seven times followed by the enter key in the presence of the C1 stimulus, and the J key three times followed by the enter key in the presence of the C2 stimulus. Thus, reinforcement was provided for FR-7 and FR-3 response units in the presence of the C1 and C2 stimuli, respectively (Mechner, 1994). To facilitate acquisition, instructions were presented on the monitor that indicated the available response strings that were eligible for reinforcement. Thereafter, all training was done on a trial and error basis.

Training was conducted in blocks of eight trials each that contained equal numbers of the C1 and C2 stimuli, all of which were presented in random order without replacement. All trials in a block received differential feedback until all trials occasioned the correct responses. Then, the percentage of trials in a block that occasioned feedback was reduced on a block by block basis from 100% to 75% to 25% to 0% as long as 100% accuracy was maintained at a given level of feedback. Failure to achieve the mastery level of accuracy resulted in a step increase to the last used feedback percentage.

The FR-based responses and corresponding ratio values were used in the present experiment because the results of prior experiments had shown that discriminations that used similarly defined responses were acquired with little training and were maintained with very high accuracy under extinction conditions (Belanich & Fields, 2003; Fields et al., 1995). Different keys of the computer keyboard were not used as the responses because they could be construed as comparison stimuli in a trial (Fields, Tittelbach, et al., 2007). Under those circumstances, instead of forming a simple discrimination between a class member and an operant, a subject would be selecting among comparison stimuli and forming a conditional discrimination between two stimuli. Thus, the subsequent measure of response transfer would not show response transfer; rather, it would show the expansion of each 6-member equivalence class to a 7-member equivalence class. This interpretive problem was avoided by use of one manipulandum (the J key) and defining each response as a separate FR which was terminated by pressing the ENTER key.

Phase 5: Single-option response transfer test 1. Each of the 12 stimuli in the two 6-member equivalence classes was presented one at a time, in a random order, without replacement in a single test block. All trials were presented in the absence of feedback, or extinction. This test block was repeated eight times to allow the performances to stabilize if necessary and to provide enough repetition to ensure reliability of test performances occasioned by each stimulus. Thus, each stimulus in each of the equivalence classes was presented eight times.

Phase 6: Emergent relations test 2. The emergent relations test described in Phase 3 was repeated after the first response transfer test to assess the intactness of the two 6-member equivalence classes.

Phase 7: Dual-option discrimination training. Subjects were trained to make different responses to the C and D stimuli in each equivalence class. Reinforcement continued to be presented for the emission of the FR-7 response in the presence of C1 and the FR-3 response in the presence of C2, as in Phase 5. In addition, reinforcement was presented for the emission of an FR-5 response in the presence of D1 and an FR-9 response in the presence of D2. All trials in a block received differential feedback until all trials occasioned the correct responses. Then, the percentage of trials in a block that occasioned feedback was reduced on a block by block basis from 100% to 75% to 25% to 0% as long as 100% accuracy was maintained at a given level of feedback. Failure to achieve the mastery level of accuracy resulted in a step increase to the last used feedback percentage.

Phase 8: Dual-option response transfer test. At the completion of dual-option discrimination training, subjects were reexposed to the response transfer test described in Phase 5.

Phase 9: Emergent relations test 3. After the second response transfer test, subjects were presented with the emergent relations test described in Phase 3. This test was conducted to assess the intactness of the two 6-member equivalence classes after testing for the bifurcation of each of these classes.

RESULTS AND DISCUSSION

The experiment is divided into many phases, each of which provides information that is relevant to the overall intent of the experiment. To help with the integration of the diverse sets of information, the results obtained in each phase will be described and interpreted in the same section. The general implications of the totality of the results will be considered in the General Discussion.

Baseline acquisition. Of the 15 subjects, 12 acquired all of the baseline conditional discriminations in a median of 10.5 blocks with a positively skewed range that varied from 3 to

36 blocks. The conditional discriminative performances were maintained during feedback reduction. Thus, subjects completed feedback reduction in three blocks, which was the minimum.

Emergent relations test 1. Figure 2 provides a detailed view of the performances of each subject in the experiment. Each set of bars in a panel is for a different test block. The bars in each set indicate the percentage of class-consistent comparison selections for the baseline, symmetry, 1-, 2-, 3-, and 4-node probes. Data for successive test blocks are presented from left to right in a panel. The data for the subjects who did and did not form equivalence classes are presented in the panels on left hand and right columns, respectively.

First, the data in Figure 2 were considered in terms of percentage of trials in a test block that occasioned class-consistent responding without consideration of performances occasioned by different emergent relations probes in each block. Of the 12 subjects, only Subject 2753 responded in a class-consistent manner to all probes, thereby showing the immediate emergence of the equivalence classes. For the 11 remaining subjects, the first test block did not occasion a mastery level of class-consistent comparison selections. Three of these 11 subjects (2708, 2714, and 2715) were not exposed to additional test blocks because they ran out of time. For 3 of the 8 remaining subjects (2711, 2747, and 2749), the probes presented in the second test block occasioned very high levels of class-consistent comparison selections which documented the delayed emergence of two 4-node 6-member equivalence classes.

For the 5 remaining subjects (2744, 2746, 2754, 2713, and 2716), the emergent relations probes presented in the second test block did not occasion high levels of class consistent responding, which documented the failure of equivalence class formation. Two of these 5 subjects who did not form classes by the second test block ran out of time (2 hours) and did not continue to participate in the experiment. The 3 remaining subjects of the 5 who did not show class formation in the second block (2744, 2746, and 2754) were then exposed to one or two more test blocks to determine whether additional testing would result in the delayed emergence of the equivalence classes. In each case, mastery levels of responding did not emerge with test repetition. In addition, there were no systematic changes in overall accuracy of responding with extended exposure to the test block. These data then suggest that test repetition beyond two blocks does not induce the delayed emergence of equivalence classes.

To summarize, 8% of subjects (1 of 12) showed the immediate emergence of equivalence classes, and 25% of subjects (3 of 12) showed the delayed emergence of the equivalence classes. Of the 8 subjects who were exposed to at least two test blocks, 38% (3 of 8) showed the delayed emergence of equivalence classes.

Second, the data in Figure 2 were used to consider the performances produced by each type of probe presented during each emergent relations test. Subject 2753 responded at the mastery level to all baseline and emergent relations probes presented in the first test block. These data demonstrated the immediate emergence of the two 4-node 6-member equivalence classes. For Subject 2749, the baseline relations and 0-node symmetry probes always occasioned class indicative comparison selection. The 1-and 2-node probes occasioned the same level of class consistent responding. That level, however, was lower than that occasioned by the baseline and symmetry probes. The 3- and 4-node probes occasioned the same level of responding. That level, however, was lower than that occasioned by the 1- and 2-node probes. These data, then, showed no disruption of baseline performance with the introduction of the emergent-relations probes and a modest nodal distance effect. In the second test block, all probes occasioned mastery levels of class-indicative comparison selections which documented the rapid albeit delayed emergence of the equivalence classes.

For Subjects 2711 and 2747, the baseline probes occasioned performances that were lower than those measured at the end of training. At that time, the baseline trials maintained 100% accuracy in the absence of any differential feedback. For Subject 2711, the symmetry probes occasioned the same level of responding as the baseline probes. For subject 2747, the symmetry probes occasioned a lower level of responding than the baseline probes. For both of these subjects, the 1- through 4-node probes occasioned similar

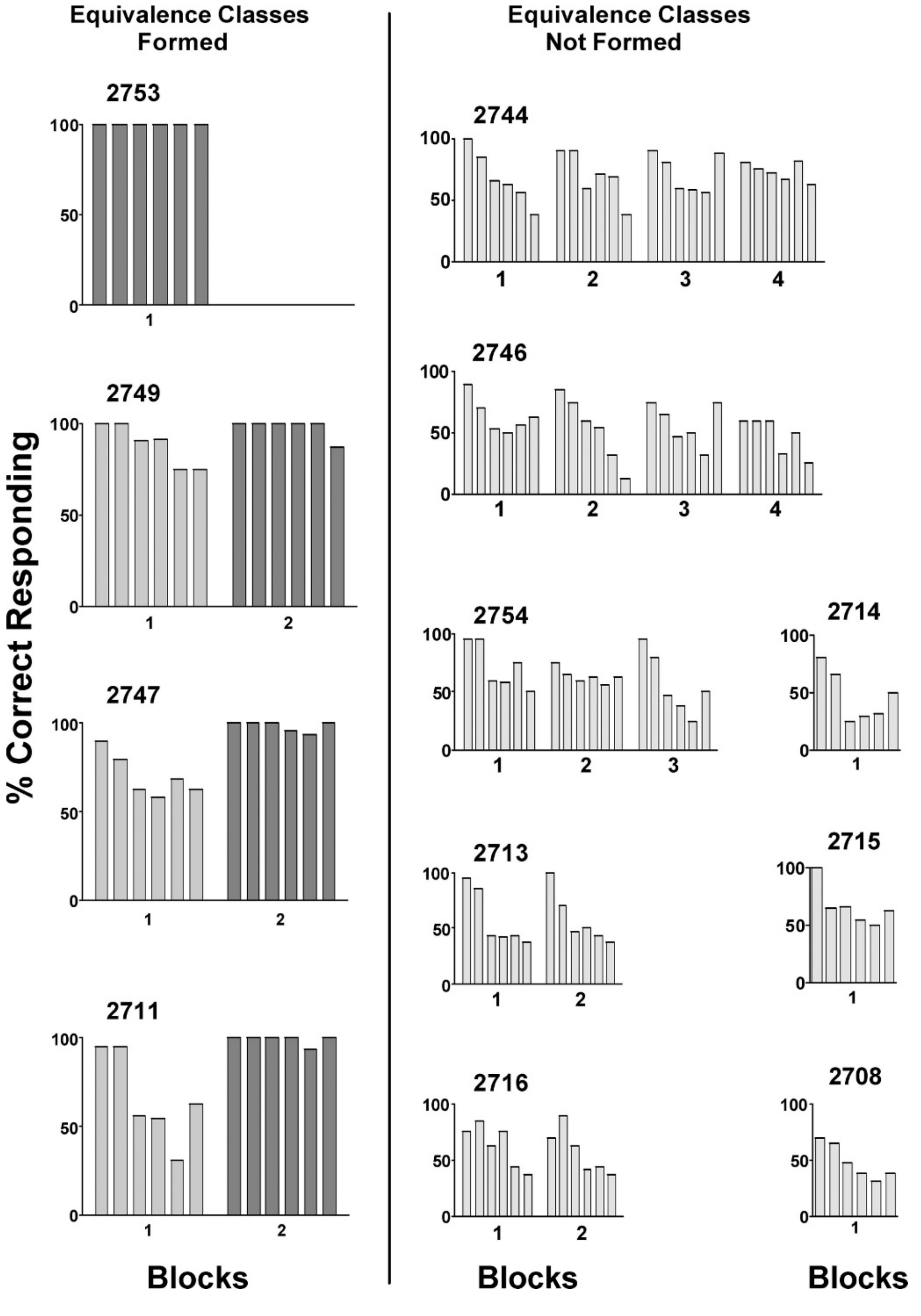

Fig. 2. Percentage of baseline, symmetry, 1-, 2-, 3-, and 4-node probe trials in each block that evoked class-indicative comparison selections during Emergent Relations Test 1. The panels in the left column are for the subjects who formed equivalence classes. The panels on the right hand side of the figure are for subjects who did not form equivalence classes. For a given subject, each set of bars is for one presentation of the test block. Within each block, the bars from left to right indicate the performances occasioned by the baseline, symmetry, 1-, 2-, 3-, and 4-node probes, respectively.

levels of class-consistent responding, all of which were lower than the performances occasioned by the 0-node symmetry probes. These data, then, were not correlated with nodal distance. When these subjects were reexposed to the test block, all probes occasioned class-consistent responding which documented the delayed emergence of the 4-node 6-member equivalence classes.

The panels on the right show the performances occasioned by each of the subjects who did not form equivalence classes. Prior to testing, the baseline trials maintained 100% accuracy in the absence of any differential feedback. The introduction of the test blocks resulted in a disruption in the accuracy of the baseline conditional discriminations on 85% of the baseline probe trials for 6 of the 8 subjects. The symmetry probes yielded lower levels of class-consistent responding than the baseline probe on 77% of the comparisons. One hundred percent of the 1-node probes yielded lower levels of class-consistent responding than the 0-node probes. Sixty-seven percent of the 2-node probes yielded lower levels of class-consistent responding than the 1-node probes. 61% of the 3-node probes yielded lower levels of class consistent responding than the 2-node probes. Finally, 55% the 4-node probes yielded lower levels of class-consistent responding than the 3-node probes. In general, there was a tendency for the selection of class-consistent comparisons to be inversely related to nodal distance. In addition, the disparity in responding between nodally adjacent probes diminished with an increase in nodal distance.

Single-option discrimination training. Each subject who formed the equivalence classes also acquired the discriminations of one response per class in one or two blocks of training. Thus, the C1 and C2 stimuli each came to evoke a different FR response. Mastery level performances were maintained with reductions in feedback and eventually in the absence of feedback.

Single-option response transfer test. Figure 3 depicts relative frequencies of C-based responses occasioned by each stimulus in both classes. For each subject, the response trained to the C1 stimulus was almost always emitted in the presence of the other stimuli in Class 1 and was never emitted in the presence of the Class 2 stimuli. Likewise, the response trained to the C2 stimulus was almost always emitted in the presence of the other stimuli in Class 2 and was never emitted in the presence of the Class 1 stimuli. Thus, the subjects discriminated between stimuli in the two equivalence classes and generalized among the members of each individual equivalence class. Each 6-member equivalence class, then, acted as a 6-member functional class.

Emergent relations test 2. Subjects were presented with emergent relations test 2 upon completion of the single-option response transfer test. As seen in Figure 4, each subject almost always responded in a class-consistent manner to all probes presented in emergent relations test 2. These results demonstrated the intactness of the basal 4-node 6-member equivalence classes after the single-option response transfer test and before dual-option discrimination training.

Dual-option discrimination training. Figure 5 shows the results of training new FR-based responses to the D stimuli in each of the 4-node 6-member equivalence classes while maintaining the C-based discriminative performances. When training of the D-based discriminations commenced, there was a decrement in the discriminative performances occasioned by the C stimuli. This was followed by a rapid recovery of the mastery level of discriminative responding. In the initial training blocks, the D stimuli evoked lower levels of accurate responding than did the C stimuli. Mastery levels of responding were achieved by the second training block, indicating a rapid acquisition of the D-based discriminations. The discriminative performances were maintained during feedback reduction and, eventually, in the absence of feedback.

Dual-option response transfer test. Each of the 4-node 6-member equivalence classes could give rise to two 3-member functional classes based on nodal structure. Specifically, equivalence class A1–F1 could be partitioned into the functional classes ABC–1 and DEF–1 and equivalence class A2–F2 could be partitioned into the functional classes ABC–2 and DEF–2. The results of the dual-option response transfer test are presented for each 6-member class in Figures 6 and 7.

The dual-option response transfer test was conducted in four blocks, each of which involved the presentation of two trials per stimulus. In some cases, the test performances

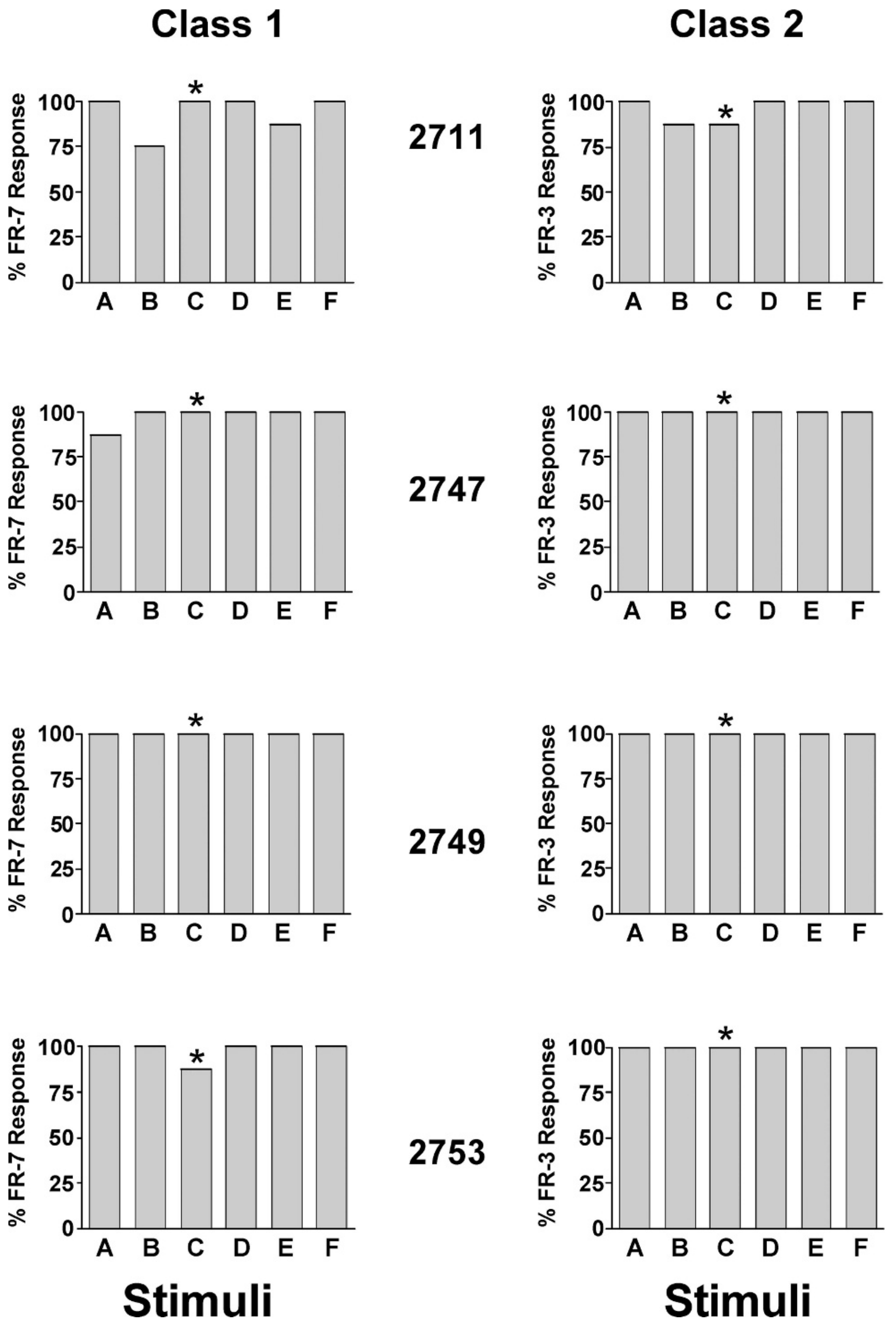

Fig. 3. Relative frequency of C-based responses occasioned by each stimulus in a class during the single-option response transfer test. Each panel is for a separate subject. The asterisk (*) indicates the S^D to which the C-based response was trained.

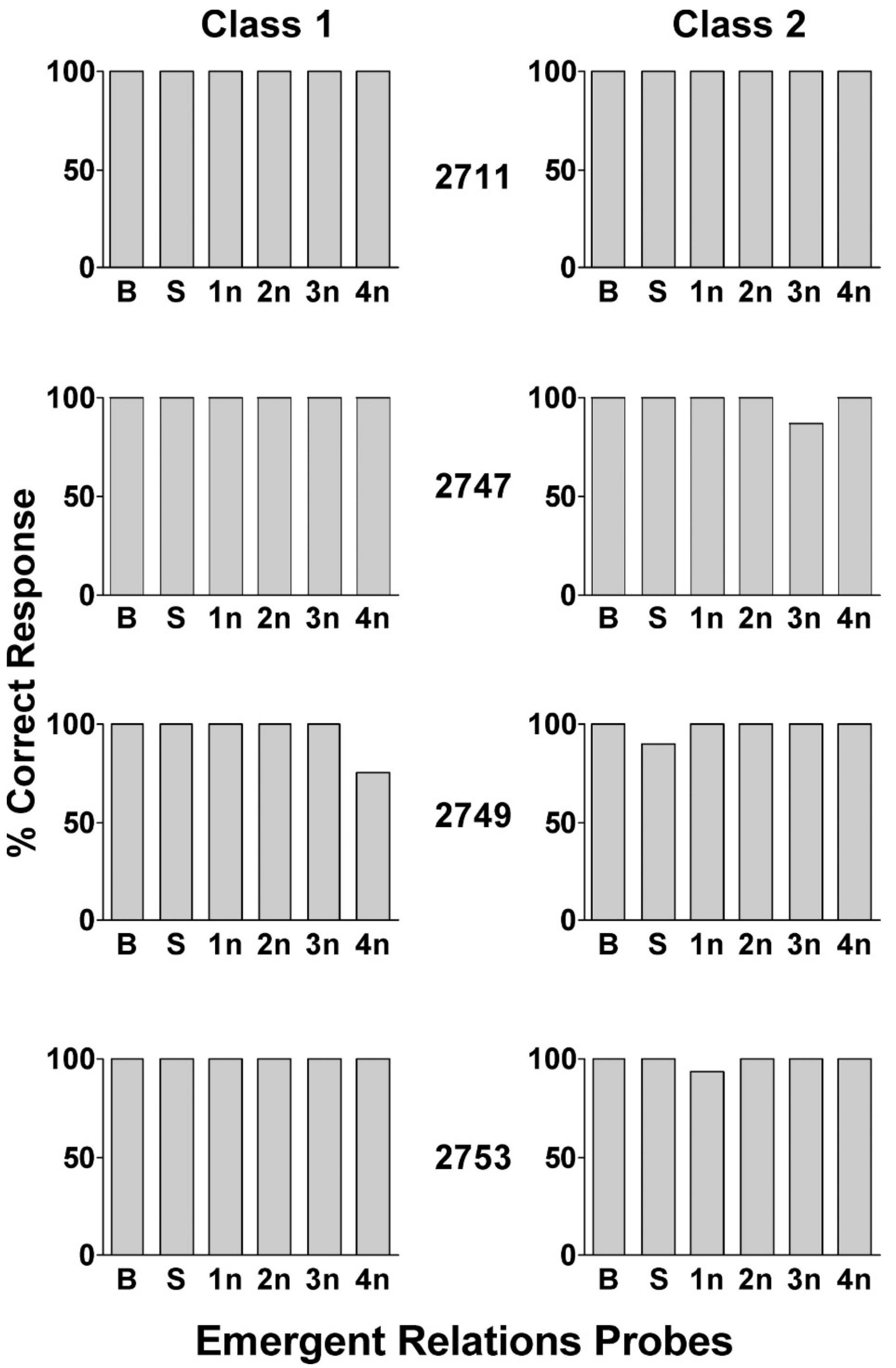

Fig. 4. Percentage of baseline (B), symmetry (S), 1-node (1n), 2-node (2n), 3-node (3n), and 4-node (4n) probe trials that evoked class-indicative comparison selections during Emergent Relations Test 2.

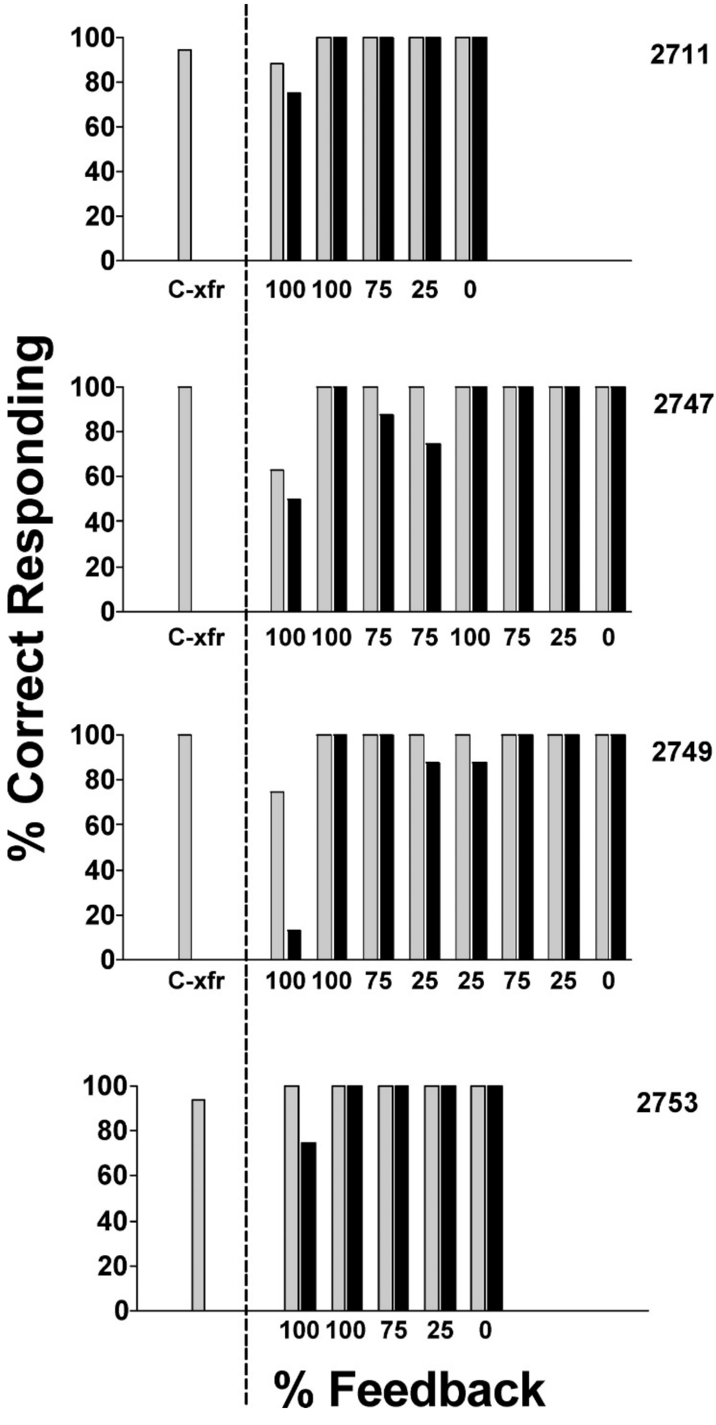

Fig. 5. The percentage of correct responding occasioned by the C and D stimuli during each block of dual-option discrimination training. The light bar to the left of the vertical line on each panel indicates performances occasioned by the C stimuli in the previous single-option response transfer test. In each pair of bars to the right of the vertical line, the dark bar indicates the performance occasioned by the D-stimulus during discrimination training, while the light bar indicates the performance occasioned by the C stimulus during discrimination training.

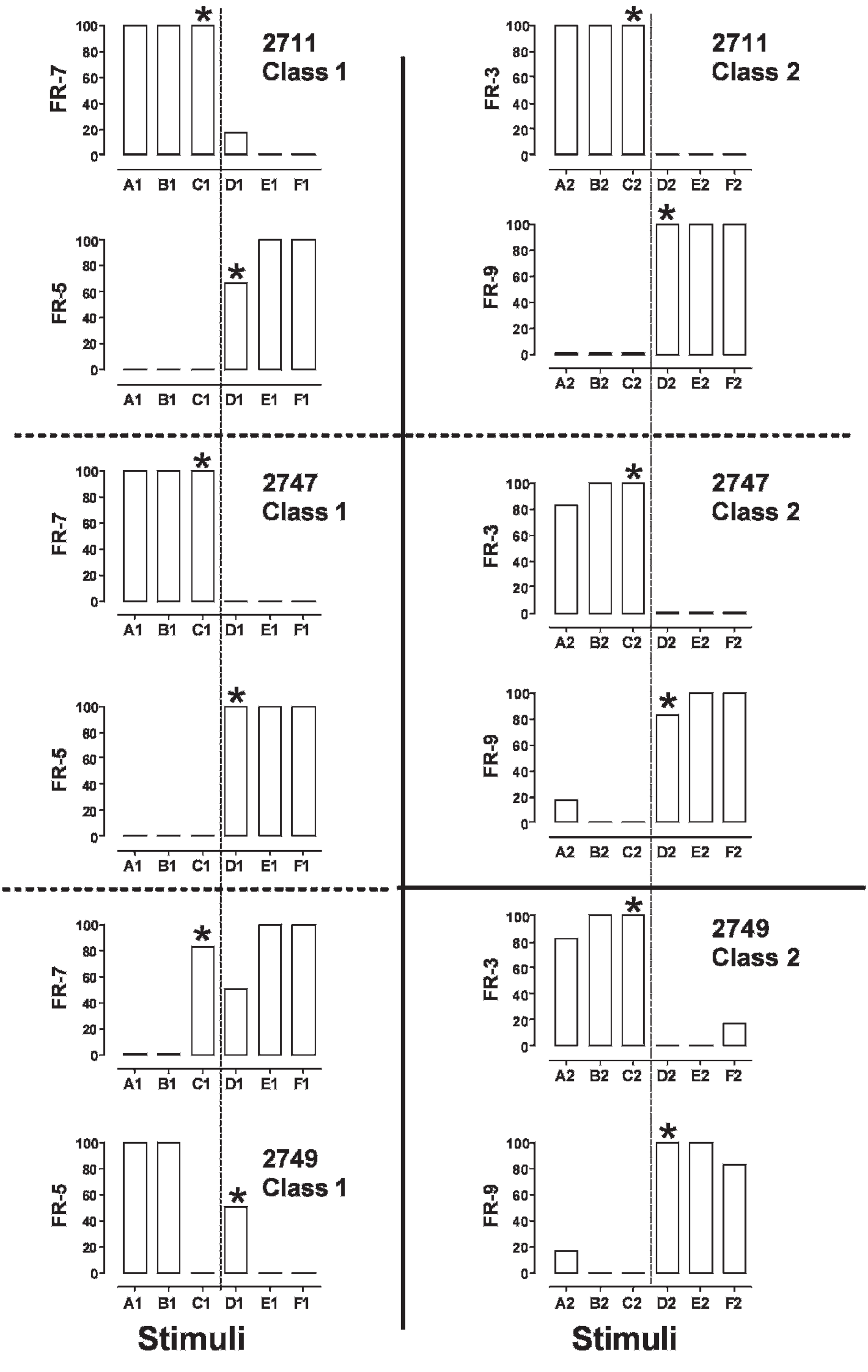

Fig. 6. Relative frequencies of responding in the presence of the A through F stimuli in each class during the last three of four test blocks conducted during the dual-option response transfer test. The figures in each row are for one subject. The figures in the left and right columns are for equivalence classes 1 and 2, respectively. Each of the six sectors in the figure contains two panels. The upper panel in each sector shows the generalization of the response trained to the C stimulus in a 6-member class. The lower panel in each sector shows the generalization of the response trained to the D stimulus in a 6-member class. Asterisks indicate the C and D stimuli that were used as S^Ds during dual-option discrimination training.

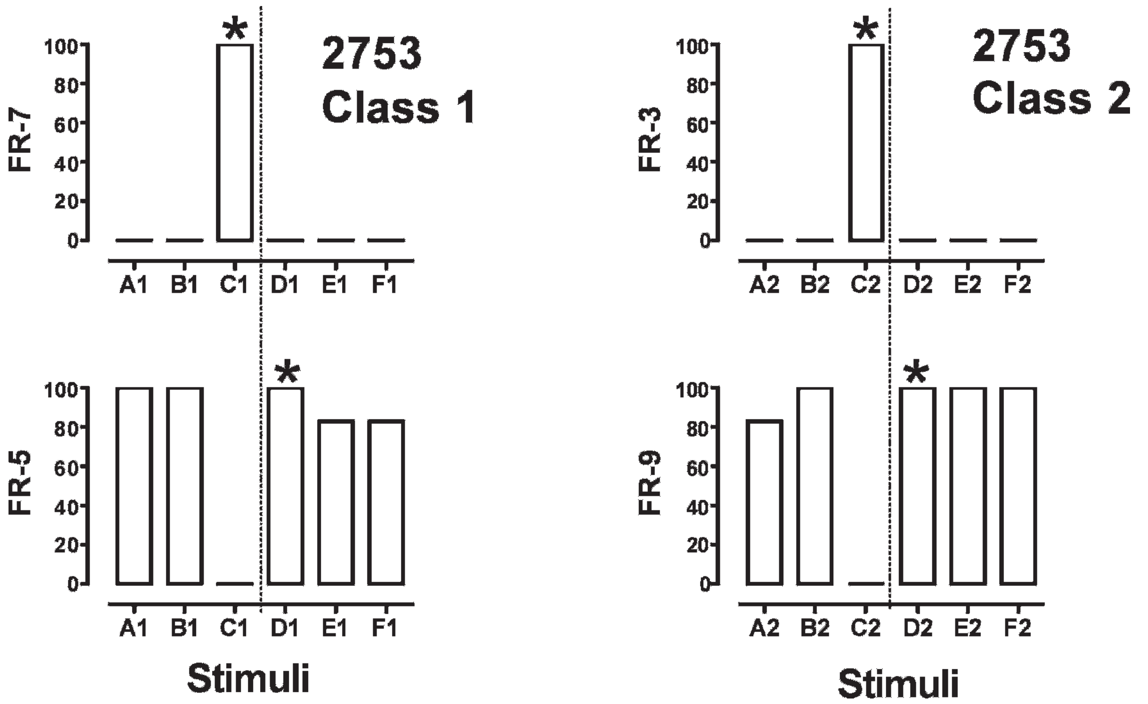

Fig. 7. Relative frequencies of responding to the A through F stimuli in each class during the dual-option response transfer test for Subject 2753. The format of the data are as described for Figure 6.

were stable across all four test blocks. In other cases, the performances occasioned on the first two trials were inconsistent, after which the test performances became stable. Therefore, data will be presented for the last three tests blocks (i.e., six trials per stimulus) for each subject.

Figure 6 illustrates the results of the dual-option response transfer test for 3 of the 4 subjects in the experiment. Data for each subject are presented in the same row, with the results for classes 1 and 2 in the left and right hand columns, respectively. For each class, the upper panel depicts the evocation of the response trained to the C stimulus in an equivalence class by all members of the same class, while the lower panel depicts the evocation of the response trained to the D stimulus in the same equivalence class. Each panel is referred to as a case that can be used to evaluate the effects of nodal structure or distance on the responding produced by the stimuli in a 4-node 6-member equivalence class.

One type of outcome was observed in 10 cases: The C-and D-based responses in Classes 1 and 2 for Subjects 2711 and 2747, and Class 2 Subject 2749. In 7 of these 10 cases, the response trained to the C stimulus generalized completely to the B and A stimuli but not to the D, E, or F stimuli, or the response trained to the D stimulus generalized completely to the E and F stimuli but not to the C, B, or A stimuli.

In the remaining 3 of the 10 cases, the response trained to C generalized completely to B, somewhat less to A, and minimally to the D, E or F stimuli, or the response trained to D generalized completely to E, somewhat less to F, and minimally to the C, B, or A stimuli.

In the seven cases mentioned above, each ‘‘parent’’ 6-member class was bifurcated into two 3-member functional classes (ABC and DEF) where their membership was precisely predicted by nodal structure. In the three remaining cases, generalization from C to B or D to E was binary, in accordance with nodal structure, and occurred to the stimuli that were nodally closer to the class member that had been used as a discriminandum. In addition, the modest decrement in generalization from C to A or D to F occurred in the stimuli that were more nodally distant from the class member that had been used as a discriminandum. These performances also documented the bifurcation of each parent 6-member classes into two 3-member functional classes where membership of the functional classes was precisely predicted by nodal structure: ABC and DEF. The decrements in responding from C to B and A or from D to E and F, however, reflected the graded effect of nodal distance which moderated the binary effect of nodal structure.

Class 1 for Subject 2749 (bottom left sector of Figure 6) showed a different outcome. Specifically, the response trained to the C1 stimulus was evoked by all of the presentations of the E1 and F1 stimuli but was not by the A1 or B1 stimuli. In addition, the response trained to the D1 stimulus was evoked by all of the presentations of the A1 and B1 stimuli but not by the E1 and F1 stimuli. Thus, the 6-member class was bifurcated into the two 3-member functional classes: CEF–1 and DBA–1. The basis for the reversal of the C and D discriminations is not known at this time and should be the subject of future research.

Figure 7 contains data for Subject 2753 who responded very differently from the others. For both classes, the response trained to a C stimulus continued to be produced by that stimulus while the response trained to the D stimulus was usually produced by the A, B, D, E and F stimuli. For each 6-member equivalence class, then, the C stimulus acted as free-standing discriminandum for one operant, while the remaining five stimuli acted as members of a functional class: either AB-DEF–1 or ABDEF–2.

Intactness of basal equivalence classes. For all subjects, during the dual option response transfer tests, the responses trained to the C1 and D1 stimuli were evoked by the A1 through F1 stimuli only, and never by the A2 through F2 stimuli. Likewise, the responses trained to the C2 and D2 were evoked by the A2 through F2 stimuli only, but *never* by the A2 through F2 stimuli. Thus, subjects continued to discriminate between the two 6-member classes. That finding, however, does necessarily imply that the underlying 6-member classes had remained intact after the dual-option response transfer test or had deteriorated as a result of the bifurcation of the stimuli in each of the 6-member classes.

Those possibilities were clarified with Emergent Relations Test 3, which followed immediately on the completion of the dual-option response transfer test, the results of which are shown in Figure 8. For each subject, class-consistent comparison selections were occasioned by virtually all of the baseline conditional discriminations and emergent-relations probes presented in the test block. These data demonstrated the intactness of the 4-node 6-member equivalence classes even though the stimuli in those classes produced differential responding that was in accordance with nodal structure in the immediately preceding dual-option response transfer test. The bifurcation of the classes did not result in the deterioration of the initial 4-node 6-member equivalence classes.

GENERAL DISCUSSION

This experiment reported two general findings: First, the use of the simultaneous protocol resulted in the formation of equivalence classes by relatively few subjects. Second, the results of the dual-option response transfer test showed the effects of nodal structure and nodal distance. Each of these findings will be discussed in order.

The simultaneous protocol and the effects of nodality. To evaluate the predicted effects of nodality on the relation among the members of an equivalence classes, it was necessary to establish those classes with a protocol that precluded other factors from being correlated with nodal structure. That was accomplished in the present experiment with the use of the simultaneous protocol to establish the equivalence classes (Buffington et al., 1997; Fields et al., 1995). In this protocol all baseline relations were trained at the same time, all training trials were presented in a randomized order, all baseline relations were presented an equal number of times during training, all emergent-relations probes were introduced immediately after the completion of training, and the order of presenting them was randomized in each test block. Since nodal structure could not be correlated with order of training, the frequency of stimulus presentation, or the order of introducing each type of emergent-relations probe, it would not be possible to attribute test outcome to factors other than nodal structure or nodal distance.

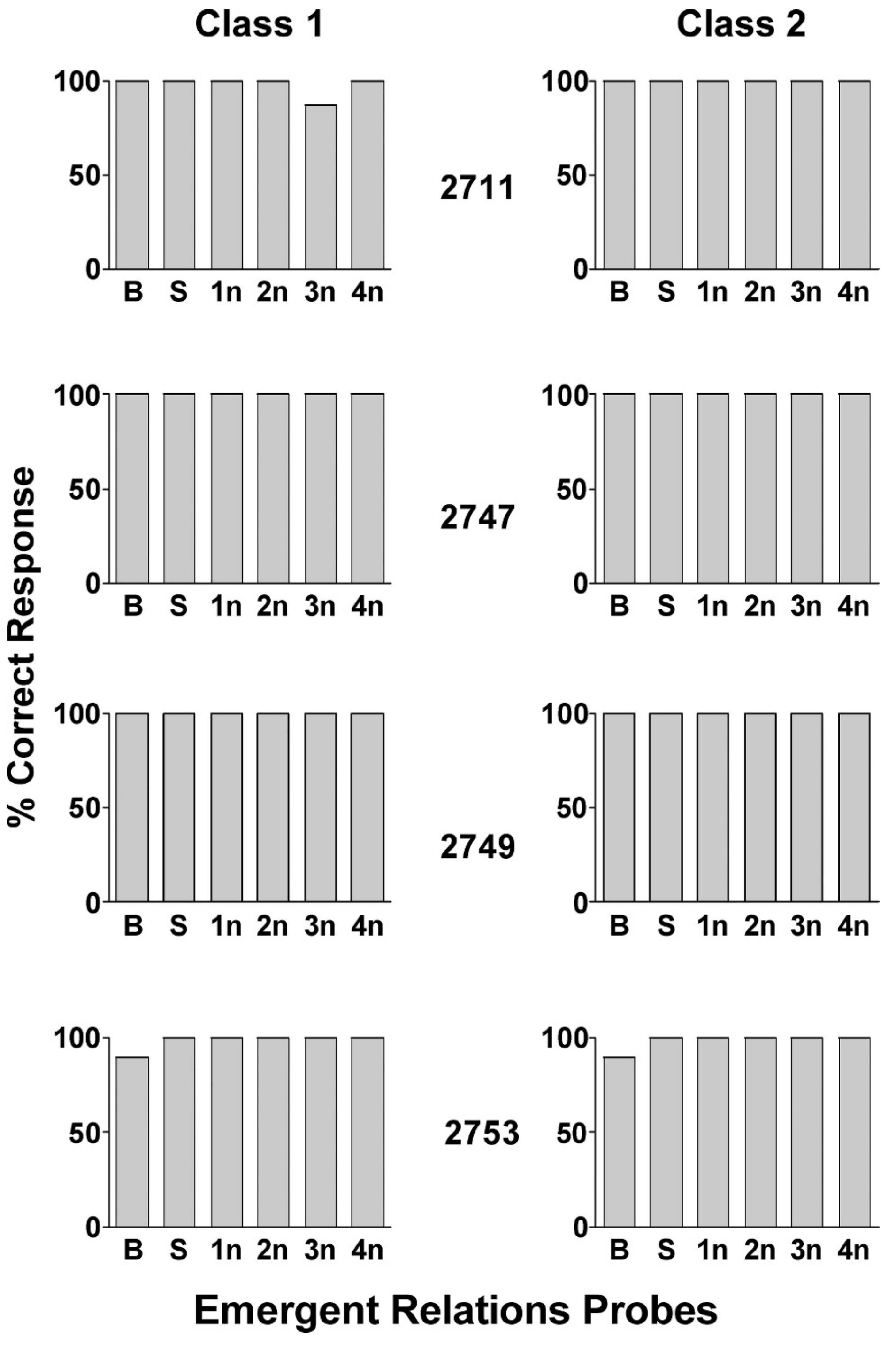

Fig. 8. Percentage of baseline, symmetry, 1-, 2-, 3-, and 4-node probe trials that evoked class-indicative comparison selections during Emergent Relations Test 3.

Notwithstanding the necessary use of the simultaneous protocol, a small percentage of subjects formed equivalence classes. Thus, the observed bifurcations could have occurred only for subjects who were able to form equivalence classes under the simultaneous protocol. Additional research will be needed to determine whether a larger segment of the population would also bifurcate class membership based on nodal structure. That could be evaluated by the using preliminary training procedures that increase the percentage of subjects who form multinodal equivalence classes under the simultaneous protocol (Fields et al., 2000; Fields et al., 1997), and then replicating the remaining components of the present experiment.

Nodal structure and relations among stimuli in equivalence classes. Each of 4 subjects formed two 4-node 6-member equivalence classes. Thereafter, a response trained to one class member generalized completely to the other class members. The interchangeability or substitutability of the stimuli in each class was documented by the terminal performances observed in the emergent-relations tests presented during class formation and the single-option response transfer test presented after single-option discrimination training. Because these performances were uncorrelated with nodal distance, they could be used to argue that nodal structure does not influence the relations among the stimuli in an equivalence class, as proposed by Sidman (1994) and Imam (2001, 2006).

Such an inference, however, was not supported by the results of the dual-option response transfer test. Specifically, after training subjects to make different responses to the C and D stimuli in each class, five of the eight 6-member classes were bifurcated into the two 3-member functional classes ABC and DEF, where class membership was precisely predicted by the nodal structure of the parent 6-member class. Such an outcome could not have occurred if relations among the stimuli in the 6-member equivalence classes had not been influenced by nodal structure.

With most of these classes, the dual-option response transfer test produced essentially complete generalization of the C-based response to the B and A stimuli and of the D-based response to the E and F stimuli. In a few cases, although complete generalization occurred to the stimulus that was nodally proximal to the discriminanda (B to A and D to C) there was a small decrement in responding to the stimuli that were nodally more distal to the discriminanda (A to C and D to F). In addition to demonstrating a binary effect of bifurcating multinodal equivalence classes in accordance with the nodal structure, these test performances also showed the graded effects of nodal distance. Thus, the binary effect of nodal structure was modulated by the graded effect of nodal distance. The variables responsible for the expression of the binary effect of nodal structure and the graded effects of nodal distance will be the subject of future research.

The bifurcation of each 6-member class into two 3-member classes could have resulted in the deterioration of the parent 6-member class. That, however, was not the case. After measuring the bifurcation of the classes, the subsequently presented Emergent Relations Test 3 produced responding that documented the intactness of the originally established 6-member equivalence classes. Thus, the performances produced by the dual option response transfer test and Emergent Relations Test 3 documented the coexistence of two properties acquired by the relations among the stimuli in an equivalence class: interchangeablity, substitutability or equal relatedness of the stimuli in an equivalence class and the differential relatedness of those stimuli based on nodal structure.

The results of the present experiment, then, obviate prior debates about whether the relations among the stimuli in an equivalence class are determined by the contingencies only or by nodality. Obtaining answers to the following questions would appear to be of more import: (1) What factors account for the imposition of equal and differential relatedness upon the stimuli in an equivalence class? (2) What factors account for the expression or nonexpression of nodal structure? The following are some potential answers.

The baseline relations that are trained as the prerequisites of an equivalence class impose a nodal structure among the stimuli in the potential class. That nodal structure imparts differential relational strengths among the stimuli in the class that are inversely related to the number of nodes that separate the stimuli in the class. Nodal structure, then, is a within-class variable that exerts permanent effects on relations among the stimuli in an equivalence class. At the same time, the contingencies used to establish the baseline relations reinforce the selection of stimuli from the same set and not from different sets. When viewed at the level of stimulus classes, these contingencies also have both between- and within-class effects. Between classes, the contingencies establish discriminations among different equivalence classes. Within classes, the contingencies reinforce substitutability of the stimuli in each class.

Responding that is indicative of interchangeability will occur when test trials signal control by the contingencies of reinforcement. In addition, control by these contingencies will overshadow the nodally determined differential relatedness among the stimuli in the class. On the other hand, differential relations among the stimuli in a class will occur when test trials signal control by a within-class variable such as nodal structure. Under those conditions, the control by nodal structure will overshadow the contingency-based substitutability of stimuli in the class.

It follows that the format of a test trial bears a formal similarity to the format of some training trial. As such, a test trial signals the contingencies present during training. On those trials that occasioned reinforcement of a single response in the presence of some stimuli in one class, the same single response option per class would be signaled during a test trial. Thus, the stimuli in the tests would occasion responding indicative of class membership and discrimination between classes. This was the case during emergent-relations tests, which contained one comparison that was from the same class as the sample. This was also the case during single-option response transfer tests that have been preceded with discrimination training in which a single response was reinforced in the presence of one stimulus in a class. In contrast, on those trials that occasioned reinforcement of at least two different responses in the presence of different stimuli in one class, the same dual-response option per class would be signaled during a test trial. Under those conditions, the stimuli in the tests would occasion responding that was in accordance with the nodal structure of the classes. Thus, the formats of test trials are discriminative for the expression or nonexpression of the effects of nodality.

Other parameters that can influence expression of nodality. In 3 of 8 cases, the dual-option response transfer tests produced responding that did not appear to be in accordance with the predictions of nodality. Specifically, for Subject 2749, the emergence of functional classes CEF–1, and DBA–1 might reflect an uncontrolled reversal of the discriminations trained to the C and D stimuli and subsequent generalization that is in accordance with nodal structure. Such an outcome might be avoided with a variation in dual-option discrimination training that would prevent such a C/D discrimination reversal.

For Subject 2753, during the dual-option response transfer test, the responses trained to the C stimuli continued to be evoked by the C stimuli, while the A, B, C, E, and F stimuli evoked the response trained to the D stimuli in each class. As discussed for Theoretical Outcome 5 in the introduction, a result such as this would contradict the predictions of nodal structure only if many other tests across subjects also produced similar outcomes. The above-mentioned performances were correlated with the order of training the C- and D-based discriminations. An outcome such as that seen for Subject 2753 might be avoided by the extensive overtraining of the C- and D-based discriminations prior to the dual-option response transfer test or by the omission of the single-option discrimination training.

The above-mentioned outcomes could be taken as evidence that contradicts the view that nodal structure influences relations among the stimuli in an equivalence class. We have argued, however, that these outcomes could reflect unintended effects of the training contingencies, which interfered with the expression of nodal structure. Until the effects of these alternatives can be ruled out, it would be premature to use these findings to support the notion that nodal structure does not influence the relations among the stimuli in an equivalence class.

To summarize, the relations among the stimuli in multinodal equivalence classes are influenced by the contingencies of reinforcement needed to form the classes, and by the nodal structure that is imparted to the stimuli by dint of the particular conditional discriminations used as the baselines for the class. The effects of nodality will depend on the discriminative functions served by the formats of the trials used to evaluate the emergence of the class and post-class-formation function transfer tests. The fact that some subjects did not show these effects suggests that as-yet-undiscovered contingencies of reinforcement also influence the expression of nodal structure on the performances seen in tests conducted after the formation of a multinodal equivalence class.

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