

## A critique of Nakagawa's (1993) "Relational rule learning in the rat"

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Nakagawa (1993) concluded that rats can use abstract concepts and relational rules. This was based on contrasting performances of two groups of rats in tasks where it was assumed that the controlling features of the stimuli were black visual patterns on white cards. However, the good performances can be explained by the rats' use of brightness cues with reinforcement contingencies that were consistent throughout pretraining and transfer training. The bad performances can be explained by the rats' use of brightness cues with unsignaled changes in reinforcement contingencies.

Nakagawa (1993) used matching-to-sample (MTS) and oddity-from-sample (OFS) procedures and concluded that rats "have the ability to learn the abstract concepts of matching and nonmatching" (p. 293) and to learn relational rules. Whether rats have such abilities is questionable (e.g., Thomas & Noble, 1988), and the performances of Nakagawa's rats can be explained by simpler processes.

Nakagawa assumed the controlling features of the stimuli were black visual patterns on white cards. Mackintosh (1974) discussed issues directly relevant to Nakagawa's research.

there are numerous ways in which the two cards differ; one has more white in the lower half than the other . . . [Mackintosh cited other examples which are less relevant but may apply to some of Nakagawa's stimuli]. . . Only extensive, and perhaps rather subtle tests will reveal which one or more of these features is critical (Sutherland, 1961b). We do not, in fact, know which are the features of visual forms that are responded to by animals. Since the pioneering work of Klüver (1933) and Lashley (1938), a certain amount of progress has been made (e.g., Sutherland, 1961a; 1969). Since the question at issue is largely perceptual, being one concerned with the nature of visual analysis, it is perhaps one not traditionally encompassed in the field of learning. Yet ignorance can be unfortunate. The problem becomes even more acute when experimenters set up studies of transfer between different discriminations designed to test theoretical analyses of the processes involved in transfer. Since a central question in such studies is whether transfer is based more on general or specific processes, e.g., whether animals learn something from one problem sufficient to benefit performance on any subsequent discrimination or whether they learn only to attend to specific dimensions, our nearly total ignorance of the dimensions along which stimuli actually

differ for a given animal, makes interpretation of some studies relatively uncertain (pp. 556-557).

McDaniel and Wall (1988) showed stimuli that must be used to control against brightness differences that can result from viewing small sections of black and white horizontal versus vertical stripes. Nakagawa used horizontal and vertical black and white stripes as pretraining stimuli as well as uniform white and black cards, which would likely promote the use of brightness cues. He provided close area matches for some of the patterns, but matching is minimally relevant when a rat can attend to sections of stimulus cards that yield brightness cues. His extensive pretraining gave the rats the opportunity to practice using brightness cues in conjunction with the reinforcement contingencies associated with the MTS or OFS procedures.

The difference between Nakagawa's Experiment 1 (hereafter, E1) and Experiment 2 (E2) was whether pretraining involved the MTS (E1) or the OFS (E2) procedure. The main independent variable was whether the rats were assigned to a "nonshifted" or a "shifted" group following pretraining. Nonshifted rats continued to be trained on transfer problems using the MTS (E1) or the OFS (E2) procedure. Shifted rats were pretrained with the MTS (E1) or the OFS (E2) procedure but were shifted between the two procedures on the transfer problems.

The main evidence cited for the rats' use of abstract concepts and relational rules was the significant differences between the groups on Trial 1 of the transfer problems, with nonshifted rats expected to perform better. Although it is not critical to the issue, since the simpler explanations also assume that the nonshifted rats will perform better, it is useful to reexamine the Trial 1 performances. The percentages reported for Trial 1 performances on the transfer problems in E1 (75% on the first two transfer problems and 88% on the last three) appear to be based on eight scores (one problem per transfer  $\times$  8 rats). Either 6 of 8 rats were correct on the first trial (75%) or 7 of 8 were correct (88%). On the basis of the

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binomial approximation (Meyer, 1976), 6 of 8 is not statistically significant ( $z = 1.06, p = .145$ ), but 7 of 8 is significant ( $z = 1.77, p = .038$ ).

If the rats used brightness cues, the transfer problems for the nonshifted rats required virtually no change from what they had learned to do to a stringent criterion in pretraining—that is, they could continue to respond to brightness differences among the stimuli according to the reinforcement contingencies associated with the MTS (E1) or the OFS (E2) procedure. The chance performances seen on Trial 1 of the first two transfer problems indicated disruption in performance as a result of introducing new cards. However, by Problem 3, the rats had learned that brightness-difference cues were reliably available. That they learned quickly to adjust to changes in brightness differences can be explained by stimulus generalization as opposed to learning a rule or a conceptually based response (see related discussion in Steirn & Thomas, 1990; Thomas & Lorden, 1993; Wilson, Mackintosh, & Boakes, 1985).

In E2, the rats in the nonshifted group performed better than chance on Trial 1 of the first transfer problem, suggesting that they were not susceptible to disruption by the new stimulus cards. There are at least two explanations that do not require using abstract concepts and relational rules. First, pretraining to criterion took a mean of 408 trials in E2 versus 180 trials in E1. Therefore, OFS was a more difficult procedure to learn; however, once learned, it might have been more resistant to disruption from the changes in brightness cues associated with new stimulus cards. Second, half of the rats in each experiment were pretrained on uniform black versus uniform white stimulus cards and half were trained on horizontal stripes versus vertical stripes. Nakagawa reported that the rats were assigned to the nonshifted and shifted groups by matching their performances from pretraining, but he did not report how many rats were assigned to the nonshifted and shifted groups as a function of being pretrained on the uniform cards or on the striped cards. Rats pretrained on the uniform cards should be more easily disrupted on the first transfer problem, because the change in the brightnesses would be greater following pretraining on the uniform cards versus the striped cards. If more rats in the nonshifted group had been pretrained on the striped cards in E2 than in E1, that could explain the significant transfer seen in E2 versus the chance performances seen in E1 on the first two transfer training problems.

The shifted groups' poorer performances on Trial 1 of the transfer problems are what one would expect to result from unsignaled changes in reinforcement contingencies associated with changing from the MTS to the OFS procedure (and vice versa), since this was equiva-

lent to unsignaled reversal learning. One would expect the rats in the shifted groups to err on Trial 1 of each new transfer training problem when there was no cue that the reinforcement contingencies had been reversed.

In conclusion, the nonshifted groups' better performances on Trial 1 of new transfer problems can be explained by their use of brightness cues in conjunction with reinforcement contingencies that were consistent throughout pretraining and transfer training. The shifted groups' poorer performances can be explained by their use of brightness cues in conjunction with unsignaled changes in reinforcement contingencies. Neither explanation requires the use of abstract concepts or relational rules. At best, Nakagawa's (1993) research was inconclusive, because the brightness-cue, reinforcement-contingency-based explanation and the abstract-concept, relational-rule-based explanation are confounded.

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