DISCUSSION

The activity levels of extinction control subjects showed a clear invigoration, depression, and return to baseline in the present experiment. These activity changes were very similar to those noted in the original experiment (Klinger, Barta, & Kemble, 1974) and indicate that such cyclic activity changes are a replicable phenomenon during extinction. As before, these changes bore no discernible consistent relation to runway running speeds.

The data also clearly indicate that amygdaloid lesions abolish both the invigoration and depression of activity levels during extinction. The activity levels of these subjects were indistinguishable from those of subjects that were not extinguished. These data extend an earlier report (Henke & Maxwell, 1973) that amygdaloid lesions abolish frustrative response invigoration. In addition, the data suggest that these lesions also abolish the depressive reactions which follow invigoration during extinction. Such a suggestion is consistent with the rather sweeping attenuation in emotional reactivity which follows these lesions (e.g., Schreiner & Kling, 1956). The fact that both the invigoration and depression phases of the activity cycle are eliminated by amygdaloid lesions supports (though not conclusively) the conception that the cycle is mediated by closely related mechanisms.

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Comparable ratio indices of sequential consistency and subjective clustering in multitrial free recall

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Structurally comparable indices of clustering and sequential consistency are described. The former is the ratio index of subjective clustering, and the latter is the ratio index of repetition. Both indices are applicable to the same set of multitrial free-recall protocols, and it is suggested that they may be helpful in clarifying issues arising from contradictory results obtained in studies employing different free-recall paradigms. Correlational limitations of the indices are discussed.

Organization in the recall of "unrelated" word lists has generally been quantified in terms of the consistency of recall sequences on successive trials, following different random orders of presentation of the list items. The quantification of organization in the recall of categorized lists, on the other hand, has usually been based on the extent of clustering of category items in the recall protocol following a single presentation trial. It is frequently assumed (e.g., Shuell, 1969) that the same basic psychological processes are being tapped in these different paradigms, yet contradictory results have been obtained in developmental studies, depending upon whether an index of sequential consistency or a clustering index has been used. Laurence (1966) found no increase in sequential consistency with age, even though recall increased with age from 6 to 10 years, whereas other (e.g., Vaughan, 1968) have found both clustering and recall to increase with age. Discrepancies of this sort could be due to differences in the underlying probability models, or peculiarities of the mathematical

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structures of the indices used. Alternatively, it may be that indices of sequential consistency and of clustering are differentially sensitive to qualitatively different bases of organization. If there are developmental changes in the basis of organization, it is conceivable that indices of sequential consistency may be relatively more sensitive to those types of organization characteristic of younger children.

Problems raised by the occurrence of results which appear to be dependent upon the type of index employed, could be tackled using structurally comparable indices of sequential consistency and subjective clustering if these could be applied to the same set of recall protocols. The purpose of this paper is to describe a pair of such indices. They have been developed for use with unrelated lists, since it is in imposing an organization upon such lists that subjects are most free to express any qualitative differences in the bases of their organization. Since indices of sequential consistency cannot be applied to a single protocol, the indices to be described were designed for use in a multitrial free recall situation. As "unrelated" lists contain no experimenter determined units whose clustering in recall would indicate organization by the subject, subjective units established in a postrecall sorting task are used as individualized "categories," whose clustering in recall provides evidence of their actual utilization. In measuring subjective clustering, nonratio indices fail to take into account the maximum clustering possible in a protocol (Shuell, 1969). As this would have serious consequences in a situation in which the number and size of subjective categories varies between subjects, ratio indices were sought.

A RATIO INDEX OF SUBJECTIVE CLUSTERING (RISC)

Roenker, Thompson, and Brown's (1971) adjusted ratio of clustering (ARC) was adapted for use with unstructured lists by weighting ARC according to the proportion of items which were consistently grouped together by a subject in two consecutive postrecall sorts:

$$\text{RISC} = \frac{\text{ARC (number of items consistently grouped)}}{\text{(number of items in list)}} \qquad (1)$$

This gives an index with the same positive range (0-1) as ARC, but the upper bound can only be reached by a subject who has grouped all of the list items. The fewer the items grouped by the subject the smaller is his RISC score for a given proportion of clustering of those items in recall, as indicated by ARC.

The model upon which ARC is based makes the assumption (Bousfield & Bousfield, 1966) that at each stage of recall, all items remaining to be recalled are equally available and are chosen without replacement. Moely and Jeffrey (1974) have argued against this assumption. They claim that to consider which items are recalled, independent of the order of recall of these items, is theoretically incompatible with an age-related increase in recall, which they assume to be at least partly due to improved organization of the presented material. There are, however, difficulties with alternative models which assume that all of the items presented, or all items within categories represented in the recall protocol, are equally available during recall. Shuell (1966) has noted the incompatibility of these assumptions with such phenomena as the recency effect. Furthermore, there is some merit in eschewing an assumption that organization determines which items are recalled if you are developing an index of organization which may be used in the investigation of precisely this hypothesized relationship.

It was intended that the index should be applicable to the oral recall of young children, which is characterized by numerous repetitions. In checking well over a thousand protocols the author has yet to record an instance of an item being repeated in adjacent serial positions in recall. Bousfield and Bousfield's (1966) model was therefore modified, the new assumption being that at each stage of recall all items remaining to be recalled are equally available, with the exception of a repetition of the preceding item. The calculations for expected category repetitions, E(CR), and maximum category repetitions, MAX(CR), are consequently different from those used by Roenker et al (1971) in their solution of the basic formula for ARC, which is

$$\text{ARC} = 0(\text{CR}) - \text{E(CR)}/\text{MAX(CR)} - \text{E(CR)} \qquad (2)$$

The number of observed category repetitions, 0(CR), is given by the number of times within a recall protocol that an item from any subjective category is directly followed by any other item from the same category. The modified formula for E(CR) is

$$\text{E(CR)} = \left(\sum_{i=1}^{k} r_i^2 - \sum_{i=1}^{k} \sum_{j=1}^{r_i'} p_{ij}^2\right) \Big/ n \qquad (3)$$

where r_i' equals number of different items recalled in subjective category i; r_i equals total items, including repetitions, recalled in subjective category i; p_{ij} equals number of repetitions of item j in subjective category i; n equals total items recalled, including repetitions; and k equals number of subjective categories represented in the recall protocol. The modified formula for MAX(CR) is

$$\text{MAX(CR)} = \sum_{i=1}^{k} \text{MAX(CR)}_i \qquad (4)$$

where, if $\text{MAX}p_{ij} + (\text{MAX}p_{ij} - 1) \leqslant r_i$, then

$$\mathrm{MAX(CR)}_i = r_i - 1. \quad (5)$$

But, if $\mathrm{MAX}\ p_{ij} + (\mathrm{MAX}\ p_{ij} - 1) > r_i$, then (6)

$$\mathrm{MAX(CR)}_i = (r_i - 1) - [(\mathrm{MAX}\ p_{ij} + (\mathrm{MAX}\ p_{ij} - 1)) - r_i] \quad (7)$$

Equations 4 and 5 are equivalent to those used by Roenker et al. (1971), and Equation 6 is designed to take account of the possibility that there may be insufficient different items recalled within a subjective category i to be interpolated between all the repetitions of an item j, where this is the item with the greatest number of repetitions within the category i (i.e., $\mathrm{MAX}\ p_{ij}$). Given the modified assumption described earlier, such a situation would make the maximum possible number of category repetitions, $\mathrm{MAX(CR)}_i$, less than $r_i - 1$ by the amount indicated in Equation 6. For recall protocols containing numerous repetitions, RISC may be substantially overestimated if the modifications incorporated in Equations 3 and 6 are omitted.

A RATIO INDEX OF REPETITION (RIR) (8)

Equation 2 was adapted to provide a comparable measure of sequential consistency based on intertrial repetitions (ITR). The formula is

$$\mathrm{RIR} = [0(\mathrm{IRT}) - E(\mathrm{ITR})] / [\mathrm{MAX(ITR)} - E(\mathrm{ITR})]$$

The number of observed intertrial repetitions, 0(ITR), is given by the number of adjacent item pairs on trial $n - 1$ which are repeated as adjacent items on Trial n. Reversed-order repetitions are counted. An intratrial repetition of a pair can only count towards the 0(ITR) score if there is also an intratrial repetition of the pair in the other of the two successive trials under consideration. The formula for E(ITR) is the same as that provided by Bousfield and Bousfield (1966) except that a multiplication factor of 2 is applied to take account of reversed-order repetitions. The formula is

$$E(\mathrm{ITR}) = 2c\,(c - 1)/hk$$

where c equals number of items common to trials $n - 1$ and n (an intratrial repetition of an item only counts towards c if the same intratrial repetition appears in the other of the pair of trials); h equals total items recalled on Trial $n - 1$, including repetitions; and k equals total items recalled on Trial n, including repetitions. The formula for MAX(ITR) is

$$\mathrm{MAX(ITR)} = c - 1 \quad (9)$$

CORRELATIONAL DATA

Shuell (1969) has demonstrated a negative bias in correlations between recall and another ratio index of organization, the ratio of repetition. In order to investigate whether such a bias exists for RISC and RIR, a correlational analysis was carried out on data for 20 nine-year-old subjects, from a developmental study not yet reported. The subject means were also obtained for nonratio versions of the indices, i.e., nonratio index of subjective clustering (NRISC) = 0(CR) – E(CR), weighted according to the proportion of items grouped, and nonratio index of repetitions (NIRI) = 0(IRT) – E(ITR). Product moment correlations between recall and each of the four indices were calculated. Only that between recall and NRIR was significant in a one-tailed test, $r = .45$, $df = 18$, $p < .05$. This is in agreement with Laurence's (1966) result for children of the same age using a different nonratio index of sequential consistency. The difference between the coefficients obtained with RISC and NRISC was +.347, and that between the coefficients obtained with RIR and NRIR was +.503, the correlation between the nonratio index and recall being greater in each case. One-tailed tests of these differences indicated a low level of significance for the former, $t = 1.05$, $df = 17$, $p < .2$, and for the latter, $t = 1.50$, $df = 17$, $p < .1$. Taken together, these results are at least suggestive of a negative bias in the relationship between recall and the ratio indices, RISC and RIR. The failure to replicate Laurence's correlational result using RIR, followed by the successful replication of her result using a nonratio modification of the measure, emphasizes a need for caution in the interpretation of organization-recall correlations.

Since RISC, because of the introspective nature of the sorting task, cannot be assumed to sample equal proportions of the organization imposed by individual subjects, it is totally unsuited to correlational analyses involving the subject's scores on RISC and recall. This does not, however, affect its usefulness as an indicator of group differences, provided only that its sampling of the subject's organization is not systematically biased with respect to the independent variable.

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