

# Early Experience, Emotionality, and Exploration in the Rat: A Critique of Whimbey and Denenberg's Hypothesis

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Whimbey and Denenberg have suggested that emotionality and exploration are *orthogonal* or independent dimensions of behavior which can be affected to different degrees by stimulation during infancy. This paper suggests that the factorial structure of the data on which they based this hypothesis supports the viewpoint that the relationship between measures of fearfulness and exploration is *inverse*.

Denenberg and his associates have suggested: (1) that stimulation in infancy affects subsequent performance in adulthood on tests presumed to measure emotionality and exploratory behavior (Denenberg, 1967); (2) that amount of stimulation in infancy and adult level of emotional reactivity are inversely related (Denenberg, 1964, 1967); (3) that emotionality and exploration are *orthogonal* or independent dimensions of behavior which can be affected to different degrees by stimulation during infancy (Denenberg, 1967, 1969; Whimbey & Denenberg, 1966, 1967a, b). Two of these hypotheses will not be discussed here: the 1st, more general, hypothesis has received substantial confirmation (e.g., Scott, 1968); the 2nd hypothesis has been questioned by Goldman (1969) and Henderson (1969). This paper offers an alternative interpretation of the results obtained from an interesting and ingeniously designed study that appears to have been of critical importance in the formulation of the 3rd hypothesis—that emotionality and exploration are orthogonal dimensions of behavior. This hypothesis is of especial interest as several workers have suggested that a close relationship obtains between measures of emotionality and exploration (Gray, 1971; Halliday, 1966; Lester, 1967, 1968a; Montgomery, 1955; Russell, 1973).

Whimbey and Denenberg (1966, 1967a) subjected 16 groups of rats to various patterns of early experiences (e.g., early handling or not, free or restricted environment before and/or after weaning) and then tested them in adulthood on a battery of tests, including measures of exploration and emotionality. The mean scores for the 16 groups were intercorrelated, factor analyzed, and 6 orthogonal factors extracted. Although the primary purpose of this paper is to provide an alternative interpretation of the factorial structure, 2 methodological/statistical issues should be mentioned. The main factor analysis was carried out on 23 variables selected from an initial 46. The number of variables was reduced in order to avoid including several variables which measure the same thing. However, some measures were still disproportionately represented. For example, the final selection included 3 urination scores taken from 4 measurements in the same apparatus. Secondly, the ratio of observations (16) to variables (23) raises questions about the reliability of the factor loadings (see Cattell, 1966). Although the authors' use of group means instead of individual scores may have increased the reliability of the correlations (see King, 1970), this issue was not discussed. Therefore, the variables discussed here are those used by Whimbey and Denenberg in their interpretation.

The 2 factors to be discussed are those labeled "Emotional Reactivity" (ER) and "Field Exploration" (FE). Table 1 (taken from Denenberg, 1967) summarizes the tests that loaded on one or both of these factors. The investigators indicate that the 2 factors are clearly identifiable. The main reason for questioning the validity of their

*TABLE 1. Behavioral Measures and Factor Loadings for the Factors Labeled "Emotional Reactivity" and "Field Exploration" by Whimbey and Denenberg.<sup>a</sup>*

Age in days when measure obtained	Variable	Emotional reactivity factor	Field exploration factor
220	Emotionality rating	.697	.309
220-223	Open-field		
	Activity	-.028	-.840
	Defecation	.394	.436
224	Novel stimulus box		
	Time in stimulus half	-.529	-.188
	Number of crossings	-.418	-.636
225	Social stimulus box		
	Time in stimulus half	-.051	.234
	Number of crossings	-.228	-.777
226-230	Avoidance learning		
	Number of avoidances	.175	.005
	Defecation on Day 230	.743	.039
231	Consummatory behavior during day		
	Food	-.905	-.123
	Water	-.493	.012
233	Open-field defecation	.504	.424
70-73	Open-field activity <sup>b</sup>	-.330	-.651

<sup>a</sup>Taken from Denenberg, 1967; p. 178.

<sup>b</sup>This measure was obtained on litter-mates of the animals used in this study.

interpretation is that the factor labels appear to have been chosen quite arbitrarily. One of the factors was labeled "Field Exploration" because it is most heavily loaded by the activity measures. However, as activity scores have also been used as measures of fearfulness (e.g., Hall, 1941; King, 1970; Lester, 1968b), they are difficult to interpret—particularly in studies designed to elucidate the relationship between emotionality and exploratory behavior. For example, if we view activity as a measure of emotionality (perhaps reflecting "freezing behavior"), then the 2 factors might be interpreted as indicating that activity measures of emotionality tend to correlate more highly with one another than with other measures of emotionality (e.g., ratings and food consumption in a novel environment). In fact, the isolation of a relatively distinct field activity factor is not surprising in that tests which provide measures of the same thing (in this case ambulation in a novel environment) tend to come out as factors. This tendency was found to be particularly marked when the defecation and activity data from the open-field tests were subjected to an additional factor analysis in which the other variables were not included (Denenberg, 1969; Whimbey & Denenberg, 1967b).

Even if we accept the validity of activity scores of exploration, we have an additional reason for questioning the choice of factor labels: tests that were initially assumed to measure exploration and tests that apparently measure emotionality load on *both* factors. The ER factor loadings show that higher emotionality ratings and defecation are associated with lower consumption in a novel environment *and* with lower activity and a smaller amount of time in the more novel half of the novel stimulus box. Note that the latter variable is the only measure of exploration that is not entirely confounded by ambulation, and that its loading on the FE factor is very low. On the other hand, the FE factor loadings show that higher defecation scores (at 220-223 and 233 days) are associated with lower activity scores. Thus on *both* factors the polarities of the loadings indicate an *inverse* relationship between some of the measures of emotionality and some of the measures of exploration.

The 2 measures of exploratory behavior having the highest loadings on the ER factor were obtained from the novel stimulus box test. The apparatus used in this test consisted of a rectangular box: one half was empty and the other contained various novel objects. The rats were scored for the amount of time spent in the half of the box containing the novel objects and for the number of crossings made from one half to the other. In order to explain the loadings of these variables on the ER factor, Whimbey and Denenberg (1966, 1967a) suggest that the test measured fearfulness rather than exploration: one of the novel objects was a spinning pinwheel operated by an air hose from which the animals tended to run away and freeze after an initial approach. However, the factor loadings show that the less fearful rats (defined in terms of rating and defecation scores) were more active and tended to spend a greater amount of time in the novel half of the apparatus. *Why* this should have occurred was not discussed. In fact, this is precisely what might be expected if the fear-eliciting properties of novel stimuli have a greater inhibitory effect on the exploratory behavior of animals having higher basal levels of fearfulness (Gray, 1971; Montgomery, 1955; Russell, 1973). That the interpretation offered by Whimbey and Denenberg is probably mistaken is further indicated by the finding that "number of crossings" loads at least as highly on the FE factor as it does on the ER factor. This finding is clearly inconsistent with the hypothesis that FE and ER describe dimensions of exploration

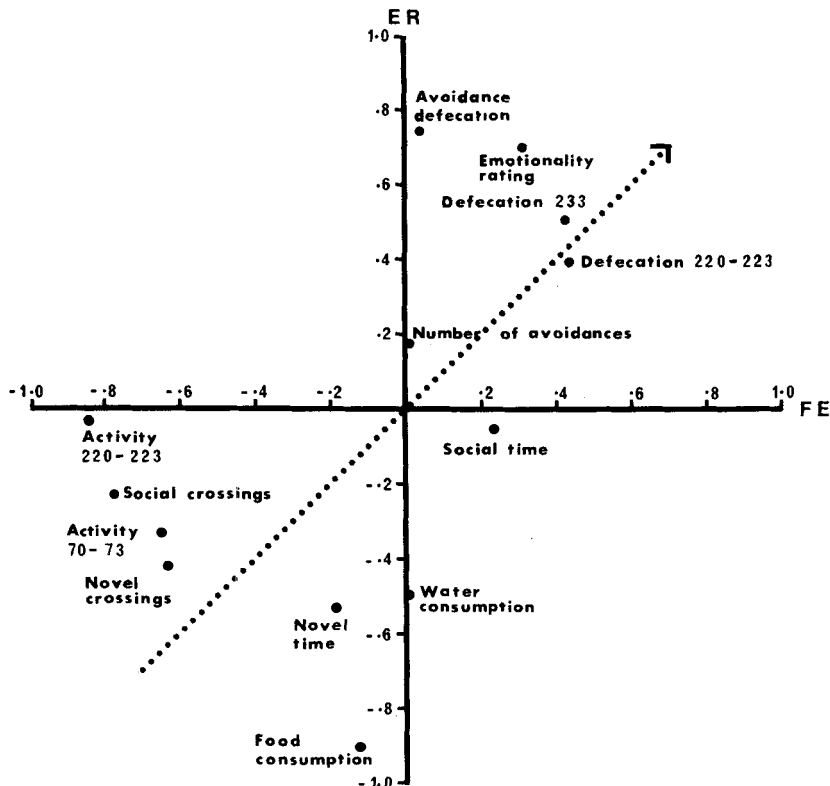


Fig. 1. Positions of the tests on the 2 factor axes.

and emotionality and that number of crossings is essentially a measure of emotionality.

Finally, Figure 1 shows that the tests tend to fall within 2 quadrants of the space defined by the 2 orthogonal factors discussed by Whimbey and Denenberg (1966, 1967a). Only 2 of the tests of emotionality/exploration fall in Quadrants 2 and 4. The positions of the test loadings relative to the vector lying midway between the primary reference axes (the dotted line in Fig. 1) appear to indicate a greater degree of association between the variables than that suggested by Whimbey and Denenberg. Higher emotionality ratings and defecation (Quadrant 1) are associated with lower food consumption in a novel environment, lower activity, and a smaller amount of time in the stimulus half of the novel stimulus box (Quadrant 3). This suggests that rotation to maximum oblique simple structure might provide a better description of the relationships between the variables. However, any reanalysis should take account of 2 methodological/statistical issues raised above (the selection of variables from the initial battery, the ratio of observations to variables). The 3rd issue (the ambiguity and relative preponderance of activity measures of exploration) can only be resolved by replications using other procedures.

An alternative interpretation of the factorial structure might take the following form. The 2 factors labeled FE and ER by Whimbey and Denenberg (1966, 1967a) describe *types of tests* that tend to cluster or have relatively high intercorrelations. The

tests of emotionality/exploration that utilize activity scores tend to have higher loadings on the factor that Whimbey and Denenberg have called the FE factor. On the other hand, the tests of emotionality/exploration that do not involve activity measures tend to have higher loadings on the factor that they have called the ER factor. However, on *both* factors the loadings indicate that some of the measures of emotionality are *inversely* related to some of the measures that are perhaps indicative of exploration. Furthermore, as most of the tests fall in 2 diagonally opposed areas of the space defined by these 2 factors, we may wish to describe the characteristics of a bipolar factor lying midway between the 2 axes. This factor is characterized by higher emotionality ratings and defecation at one pole and by lower food consumption in a novel environment, lower activity, and a smaller amount of time in the stimulus half of the novel stimulus box at the other pole. In general, if we accept the validity of the measures used, the factorial structure supports the viewpoint (Gray, 1971; Montgomery, 1955; Russell, 1973) that fearfulness inhibits exploration. Thus, the results of this analysis appear to indicate that adult levels of fearfulness, determined in part by experiences during infancy, exert a modulatory effect on exploratory behavior.

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