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DISCOVERY-ORIENTED BEHAVIOR AND PROBLEM SOLVING*[1,2]

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SUMMARY

Discovery-oriented behavior during the presolution stage of a problem-solving task was explored by videotaping and scoring the behavior of 60 male and female college students. They were presented with 14 different objects and told they would later have to suggest novel and useful combinations of three or more objects taken together. Behavioral variables that reflected touching and transformation of the objects were generated from the videotapes and correlated with number of solutions produced. Touching variables had high positive (significant) correlations with the criterion for females, but low positive (nonsignificant) correlations for males. Transformation variables had moderate negative correlations with the criterion for males (significant), but low negative (nonsignificant) correlations for females. Discovery-oriented behavior appears to be worthy of further study in the problem-solving domain.

A. INTRODUCTION

In an investigation of the *process* of creative production Csikszentmihalyi and Getzels (1) investigated a dispositional variable they called *concern for discovery*. They measured it at the stage of problem formulation and at the stage of problem solution. Thirty-one male student artists were asked to select objects from a group of 27, create a display (problem formulation stage), and produce a still life drawing (problem solution stage). The measures "number of objects manipulated" and "discovery-oriented behavior during selection and arrangement," which assess intensity of manipulation, correlated .52 and .58 with rated originality of the final production and .48

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[2] Requests for reprints should be sent to Thomas J. Bouchard, Jr., at the address shown at the end of this article.

and .44 with rated aesthetic value. These findings strongly support the authors' conclusion that discovery-oriented behavior during the problem formulation stage of the creative process is important.

We have attempted to create a laboratory analogue of the Csikszentmihalyi and Getzels situation and generalize some of their findings to a less select population and a different task. We have also included both male and female *Ss* in our study because sex differences are to be expected in studies of creative process (*cf.* 3, 4).

In our study *Ss* were exposed to 14 different objects and told they would later be asked to come up with as many novel and useful combinations of three or more objects as they could. Their presolution behavior was videotaped and scored on a variety of manipulatory variables. These variables were then correlated with number of solutions produced.

B. Method

1. *Subjects*

The *Ss* were 30 female and 30 male students from an introductory psychology course. They ranged in age from 18 to 27 years and were recruited to the experiment by offering them points for experimental participation (required of all introductory students).

2. *Procedure*

Each *S* was seated alone at a table on which 14 objects were arranged: a $12'' \times 12''$ square of aluminum foil, a 10″ white candle, a 12″ coil of wire, a ball of string, a $6'' \times 6'' \times 2''$ piece of styrofoam, a single-edged razor blade, a small spring, a cigarette lighter, a clip-type clothespin, a pushtop ballpoint pen, a ping-pong ball, a balloon, a clothes hanger, and a $12'' \times 2''$ piece of window glass.

A video camera was mounted facing the *S*, about six feet away from him. Written instructions were left on the table during the experiment. The same instructions were played to the *S* over a speaker. They were as follows:

> This is an experimental study of problem solving. There are a number of objects on the table. We would like you to pretend that you have found these objects in a junkyard. Your task is to think of as many novel and useful things that can be constructed out of any combination of three or more objects.
>
> You may do anything you want with the objects. You may assume that you have access to binding compounds, such as glue, tape, etc. Remember, come up with as many novel and useful things as you can, constructed with three or more objects.

> You will have 20 minutes in which to work. You will be told when your 20 minutes are up. At that time, you will be given 20 additional minutes to write down your solutions. Do *not* write until you are told to do so. You will be on closed circuit TV during the experiment.

After 20 minutes a voice over the speaker instructed the *S* to begin writing down his solutions. Only the first 20 minutes of the experiment were videotaped and scored for manipulative behavior.

A female *E* ran the female *S*s, and a male *E* ran the male *S*s. The taped instructions were in the appropriate *E*'s voice.

3. *Scoring*

The videotapes were used by a pair of judges to rate the manipulatory behavior of the *S*s. Scoring was carried out from two perspectives: manipulation of single objects and manipulation of multiple objects. Three categories were scored from each perspective. The categories were hierarchically arranged so that if a higher category was scored, it was implied that behavior in any category below it had occurred. Only the highest category into which a behavior could be classified was ever scored. Thus, the three categories were psychometrically independent. Scores in the superordinate groupings were also independent; for example, if a manipulation was scored in one of the multiple object categories, it was not scored in any of the single object categories. The ordering of the categories in each grouping represented a crude dimension of intensity of involvement with the objects.

4. *Categories*

a. Manipulation of single object categories. (*a*) *Touches*—a count of the number of times any of the objects was touched. (*b*) *Minor transformations*—scored whenever a manipulation effected a transient change in the object but did not alter its physical characteristics (examples would be lighting the lighter, snapping the clothspin, stretching the spring). (*c*) *Major transformations*—scored whenever a manipulation altered the physical characteristics of an object (examples would be punching holes into the styrofoam with fingers, disassembling the pen or clothespin, crunching the foil, breaking the wire).

b. Manipulation of multiple objects. (*a*) *Proximity*—scored when two objects were brought together in a nonpermanent manner to form a unit without altering their physical characteristics. (*b*) *Combination*—scored when two or more objects were brought together in a more or less permanent fashion, without altering their physical characteristics (examples would be

using the clothespin as a fastener, hanging the spring from some object, placing an object on or into another object so that it was stable but not changing the object, such as putting the candle into a ball of string). (*c*) *Transformation*—scored when two or more objects were brought together so that the physical characteristics of at least one object was altered (examples would be melting candle wax onto the glass, smoking an object with the lit candle, poking the candle or the glass into the styrofoam, using some object as a tool to hack at the styrofoam).

c. Criterion. The criterion variable was number of solutions produced. Solution quality was also analyzed in the following way: all solutions were typed on cards and coded to disguise the *S*'s sex and handwriting quality. They were rated by three raters on the following five-point scale: 1 = very poor; 2 = poor; 3 = ordinary; 4 = good; 5 = very good. Number of "good" ideas produced was determined by counting all ideas with a score of 7 or above (this level was used to insure a nonzero score for most *S*s). Number of "good" ideas correlated .74 (females) and .87 (males) with number of solutions produced. Therefore, only the simpler criterion was used.

Rater reliabilities of the various categories computed via the Spearman-Brown formula are given in Table 1.

C. Results and Discussion

The means, standard deviations, reliabilities, and correlations between categories and the criterion for each sex are given in Table 1. Also included are the sum of touches, proximity, and combinations and the sum of minor transformations, major transformations, and pair transformations because these variables cluster in both matrices. The first sum reflects total touching behavior, and the second sum reflects total transformation behavior.

The results are very simple. The touching variables correlated positively with number of ideas. The correlations were high and significant for females and low and nonsignificant for males, but still positive. The differences between the male and female correlations were significant ($p < .05$) for touches, proximity, and combinations. Thus there was a clear difference in the strength of the relationship for the two sexes. The transformation variables correlated negatively with number of ideas. The correlations were moderate and significant for males, low and nonsignificant for females, but still negative. There appeared to be a difference in the strength of the relationship for the two sexes, but none of the differences reached significance.

With respect to the touching variables, our results were similar to Csikszentmihalyi and Getzels (1) in that simple manipulation was positively

TABLE 1

MEANS, STANDARD DEVIATIONS, RELIABILITIES, AND INTERCORRELATIONS OF EIGHT MANIPULATION VARIABLES AND ONE CRITERION VARIABLE FOR MALES AND FEMALES

Variables	Females			Males			Variables								
	M	*SD*	Reliability	*M*	*SD*	Reliability	1	2	3	4	5	6	7	8	9
Touch variables															
1. Touches	18.38	13.02	.87	13.30	8.26	.48	—	.23	.45	.89	.17	—.03	.07	.11	.15
2. Proximity	7.17	7.39	.94	2.22	2.42	.52	.73	—	.24	.45	.21	—.14	.01	.07	.16
3. Combinations	8.07	6.53	.94	5.83	5.33	.91	.17	.40	—	.77	—.09	.01	.23	.12	.04
4. Sum of 1, 2, 3	33.62	21.80	—	21.35	12.55	—	.90	.89	.54	—	.12	—.04	.14	.14	.15
Transformation variables															
5. Minor transformations	4.03	2.42	.31	3.17	1.94	.54	—.17	—.03	—.14	—.15	—	.21	.30	.66	—.27
6. Major transformations	.77	.88	.56	.70	.92	.65	—.27	—.28	.01	—.25	.06	—	.52	.63	—.39*
7. Pair transformations	3.73	3.97	.92	4.12	3.01	.85	—.20	—.17	.22	—.11	.10	.40	—	.89	—.39*
8. Sum of 5, 6, 7	8.53	5.23	—	7.98	4.56	—	—.28	—.19	.11	—.19	.55	.50	.87	—	—.45**
Criterion															
9. Number of solutions	6.67	4.37	—	5.47	3.93	—	.60***	.62***	.27	.65***	—.05	—.14	—.17	—.17	—

Note: $N = 30$ for each sex, females in lower quadrant, males in upper quadrant.

* $p < .05$.

** $p < .01$.

*** $p < .005$.

related to productivity. Our results, however, were significant only for females. Csikszentmihalyi and Getzels used a highly selected group of male artists. The difference in results may have been due to a difference in the criterion, the task, or the populations studied. Perhaps their males were dispositionally similar to our females. This is a common finding in studies of creativity (2).

Much to our surprise the transformation variables correlated negatively with number of ideas generated. Since the correlations were significantly negative for the males, the results cannot be said to agree with those of Csikszentmihalyi and Getzels. Also, the correlations were all negative for both sexes—thus, the directional effect seems to be real. Again, the difference in results may have been due to task and population differences.

Our findings suggest that discovery-oriented behaviors are fruitful variables and can be studied in a laboratory setting as well as the field. Further research in both contexts is clearly called for. Some of it should be directed toward elucidating the causal status of the variables. We suggest, for example, that *S*s who are required to touch, manipulate, etc. be contrasted on appropriate dependent variables with *S*s who are not allowed to engage in these activities. Torrance (5, pp. 110-118) has obtained positive results with such a procedure using first, second, and third grade children.

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