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**RESISTANCE TO EXTINCTION AS A FUNCTION OF
DIFFERENTIAL LEVELS OF DRIVE AND EFFORT-
FULNESS OF RESPONSE.**

**The Ohio State University, Ph.D., 1966
Psychology, experimental**

University Microfilms, Inc., Ann Arbor, Michigan

RESISTANCE TO EXTINCTION AS A FUNCTION OF
DIFFERENTIAL LEVELS OF DRIVE AND
EFFORTFULNESS OF RESPONSE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

By

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* * * * *

The Ohio State University
1966

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ACKNOWLEDGMENTS

The author is grateful to his adviser, Professor Raymond C. Miles, for his continuous encouragement and support which made this study possible. He has been a 'guru' in the true sense of the word.

The author is also indebted to Professors Delos D. Wickens and Reed Lawson, members of the reading committee, for their valuable and helpful comments concerning the early draft of this dissertation.

Finally, I would like to express my deepest gratitude to the many people who contributed to my graduate career and made this one of my most cherished and valuable experiences.

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Factor Underlying Emotionality Produced by Septal Lesion and Infantile Stimulation. Psychol. Rep. (in press)

with D. R. Meyer and M. J. Lopoplo,
"Learning and Transfer as a Function of Differential Levels of Incentive
in the Monkey" J. Exp. Psychol (in press)

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INTRODUCTION

According to Hullian learning theory (1943, 1952), extinction of a learned response is explained on the basis of the two separate constructs of reactive inhibition (I_R) and conditioned inhibition ($S|_R$). Reactive inhibition is produced because "...whenever any reaction is evoked in an organism there is left a condition or state which acts as a primary negative motivation in that it has an innate capacity to produce a cessation of the activity which produced the state" (Hull 1943, p. 278). Conditioned inhibition is assumed to be a habit of not responding which is reinforced by the reduction of reactive inhibition. Since the summated inhibitory potential subtracts from the $S E_R$ (the strength of the tendency to respond), experimental extinction occurs when the summated strength of these two inhibitory potentials (I_R) becomes equal to or greater than $S E_R$.

Though both I_R and $S|_R$ are inhibitory potentials and diminish $S E_R$, these two mechanisms are assumed to have differential characteristics, namely:

1. $S|_R$ involves the whole neural receptor-effector mechanism of habit, whereas I_R involves only the effector portion of this mechanism.

2. I_R manifests the phenomenon of spontaneous dissipation as a function of time, whereas $S|_R$, being a habit, does not (Hull 1943, pp. 284-285).

3. The amount of I_R generated is a function of the amount of work (W) required to perform the responses. Hull states: "the net amount of functioning inhibitory potential resulting from a sequence

of reaction evocations is a positively accelerated function of the amount of work involved in performance of the response in question" (Hull 1943, p. 279). No such relationship was assumed for sl_R .

An implication arising from the last differential characteristic of l_R and sl_R is that one can increase total inhibitory potential ($\dot{l}_R$) by requiring more effort to make responses. Furthermore, since inhibitory potential subtracts from the total effective reaction potential ($s\bar{e}_R$), those responses involving greater effort or work would presumably extinguish more quickly than those responses requiring less effort.

A dramatically opposed relationship between work and resistance to extinction is predicted by Lawrence and Festinger's (1962) theory of Cognitive Dissonance. They state: "If an organism continues to engage in an activity while possessing information that, considered alone, would lead it to discontinue the activity, it will develop some extra attraction for the activity or its consequences in order to give itself additional justification to engage in the behavior" (p. 156). The development of extra attraction "...occurs primarily because the pressures to reduce dissonance result in the animal's discovering new aspects of the situation that serve as satisfiers for the variety of other motivations it has at the time" (Lawrence and Festinger, 1962, p. 48).

The degree to which extra attractiveness becomes attached to the environmental stimuli is a positive function of dissonance intensity and the total number of dissonance-arousing occasions. Hence,

according to cognitive dissonance theory, when an organism obtains an "insufficient reward" following an expenditure of energy, he will either discontinue his effortful activity or attribute additional value or "extra attraction" to the activity or to other aspects of the goal situation.

On this basis, if a response requires greater effort it will produce more dissonance and the animal will discover more extra attractions than an animal making a response requiring less effort. Furthermore, since those stimuli which possess added attractiveness serve to maintain responding in extinction, an animal which develops more extra attractions will be more resistant to extinction. Thus, while Hull's theory predicts that increased effortfulness in making a response will lead to reduced resistance to extinction, cognitive dissonance theory predicts increased resistance to extinction as effort in response increases.

Review of the literature

According to a recent review (Lewis, 1965), the literature on effort can be divided into two main issues: Will an organism choose a response requiring more effort, if given a choice; and, what will be the effect of greater effort on the strength of instrumental responses? The present review is concerned with the latter issue.

In an early study, Mowrer and Jones (1943) confirmed Hull's prediction by obtaining a perfect negative relationship between effort during extinction and resistance to extinction. However, Mowrer and Jones did not control for habit strength during the acquisition pro-

cedure. Animals received 180 reinforced trials on the light bar during training, as compared with only 80 trials on the heavy bar. Controlling for frequency of reinforcement during acquisition, Applezweig (1951) confirmed Hull's prediction, but the study was confounded by a rather severe selection of Ss for one of the groups. For example, under 50 gms force condition only those animals were assigned who could respond to that force without any training on a lighter weight. This resulted in the rejection of a large number of subjects under the heavy effort condition, while under the low effort conditions few or none were rejected.

The study reported by Capehart, Viney and Hulicka (1958) is more methodologically sound than the abovementioned studies in that the subjects were randomly assigned to experimental conditions and the frequency of reinforcement during acquisition was controlled. However, although these authors confirmed Hull's prediction, Quartermain (1965), using their design, was unable to find any difference in the number of responses during extinction as a function of the effort required in depressing the bar. The studies differed in that Quartermain gave more reinforced trials to the subjects than did Capehart et al. That the number of reinforcements may be a crucial variable is clearly shown in a study by Young (1965) who did not find any relation between different amounts of effort and resistance to extinction under continuous reinforcement. However, for partially reinforced groups the form of the function was different for less trained animals and highly trained animals.

Other studies which do not support Hullian theory are reported by Lawrence and Festinger (1962). In summary, some of the studies testing the effect of effort on extinction support Hull, others support cognitive dissonance theory, and some support neither. Table I summarizes the experiments reported concerning the effect of effort on extinction. The studies are in chronological order and the inconsistent results are obvious.

TABLE I
Studies Concerning the Effect of Effort on Resistance to Extinction

Mowrer and Jones	(1943)	Bar pressing	Different Weights	Hull supported
Solomon	(1948)	Jumping apparatus	Different Distance	Hull supported
Applezweig	(1951)	Bar pressing	Different Weights	Hull supported
Maatsch et al	(1954)	Bar pressing	Different Weights	No relationship
Stanley & Aamodt	(1954)	Bar pressing	Different Weights	Hull supported
Aiken	(1957)	Maze	Different Pressure	Hull supported
Capehart et al	(1958)	Bar pressing	Different Weights	Hull supported
Lawrence & Festinger	(1962)	Maze	Different Slopes	Cognitive-Dissonance
Quartermain	(1965)	Bar pressing	Different Weights	No relationship
Young	(1965)	Bar pressing	Different Weights	No relationship

It is possible to explain the inconsistent results reported in the area on the basis of the differential experience Ss received during initial training. In all the studies reported except the studies of Applezweig (1951) and Capehart et al. (1958), the following procedure for training was used. Initially, all animals were trained using light weight; from this group only those animals which were assigned to greater force condition were shifted to the heavy weight. Thus, while the animals working on greater effort have training on both light and heavy weight conditions, animals working with less effort have training under only one weight condition.

Another factor which may explain the inconsistent results obtained on the effect of effort on extinction is suggested by Maatsch, Adlerman, and Denny (1954). They propose that experiments involving the bar-pressing response may be confounded because of the contribution of the operant level of a given bar weight to the measures of resistance to extinction. "The lighter weight bar during extinction could allow more for an indiscriminate recording of tangential responses (aggression, operant level, random exploratory behavior) than heavier bars" (p. 47). There are no reported studies which control for the operant level for different bar weighting. Furthermore, there is no information concerning the question of how different drive levels interact with varied effortfulness of response during acquisition and extinction.

The purpose of the present investigation is to ascertain how the effect of effort will vary along the dimension of drive, while controlling for habit strength, differential experience and operant

level. The effect of differential drive level and effortfulness will be assessed using a factorial design. A free operant procedure in a modified Skinner box will be employed.

METHOD

Apparatus

The equipment consisted of three identical operant conditioning chambers constructed of clear $\frac{1}{4}$ in. plexiglass, each surrounded by a sound-insulated enclosure. The chamber (12 in. high x 12 in. long x 95 in. wide) was equipped with a retractable lever ($\frac{3}{4}$ in. wide x $\frac{1}{4}$ in. thick) which was located $4\frac{1}{4}$ in. above the floor, 3 in. from a side wall, and protruded into the box $\frac{1}{2}$ in. The bar was adjustable so as to require 11-, 22-, or 44gms force to depress fully. A food cup (1 in. diameter) was attached 2 in. above the floor and 2 in. beneath the bar. A 3 in. exhaust fan was mounted on the side of the box and in addition to producing masking noise drew air from a 2 in. aperture located on the side wall of the chamber. All E-controlled events were operated by an electronic programming device and bar presses were automatically recorded on counters.

Subjects

The Ss were 108 male Long Evans hooded rats, 200-225gms in weight upon receipt at the laboratory.

Procedure

Upon arrival at the laboratory, Ss were placed in individual cages and kept on an ad libitum food and water schedule for four days. On the fifth day, all animals were placed on 2-hr. daily feeding schedules (9 a.m. - 11 a.m.). After the feeding schedule, all food was removed from the cages. Water was available in the cages at all times. This feeding schedule was maintained throughout the

experiment. Also, starting on the fifth day all animals were handled for 5 min. a day following the feeding period. All the animals were adapted to the handling and feeding schedule until the tenth day. On the eleventh day, animals were randomly assigned to experimental conditions. The design was a 3×3 factorial incorporating 11-, 22-, or 44 gms required force on the bar and 4-, 10-, or 20 hrs of food deprivation. Each group consisted of 12 animals.

Starting on the eleventh day, operant rate of responding under each experimental condition was obtained for three days (11th, 12th, 13th). In all groups, bar weight was pre-arranged according to experimental conditions. Each animal was placed in the Skinner Box for 15 min. each day and the number of bar presses were recorded. Each bar press produced the sound of the food delivery mechanism; however, no food was delivered.

On the fourteenth day, immediately before the daily feeding period the animals were placed in the Skinner Box and were magazine trained. Initially, the food cup contained four free pellets. After the animal consumed the pellets, magazine training started on a VI-30 sec. schedule. Experimental periods were 15 min. in length and continued for three days (14th, 15th, and 16th days).

On the seventeenth day, using the method of approximation, all Ss were conditioned to press the bar. All animals, regardless of their experimental conditions, worked under 23-hr. food deprivation in the pre-training period and were trained in the following manner. All Ss started with the 11gms force required to press the bar and were

permitted 15 reinforced trials. Second, all Ss were shifted to the 22gms bar weight and were permitted to make 15 reinforced responses. Finally, all Ss were shifted to the 44gms bar weight and were again permitted 15 trials. Thus, regardless of the experimental condition, each subject received 15 reinforcements under each of the effort level conditions before starting acquisition trials.

After pre-training, animals were trained under the appropriate experimental conditions every day for a total of eight days. Daily experimental sessions consisted of 60 bar presses. The bar was never retracted except following the last bar press of the experimental session. The time interval recorded began when the animal was placed in the box and ended when the bar was retracted. At the end of the eight-day training period, each animal had received a total of 480 reinforcements under appropriate experimental conditions.

Extinction was begun on the day following the completion of acquisition trials. During extinction, the stimulus conditions were exactly the same as during operant level testing. Extinction sessions were 15 min. in length and continued for four days.

The experiment was conducted in a series of four replications.

RESULTS

The total responses made by each S in three days of operant level testing (Appendix I) were subjected to an analysis of variance, the results of which are summarized in Table 2. As evident, effort levels are significant at the .05 level of confidence. However, drive levels do not contribute to any significant differences in operant level responding. Figure 1 shows the operant level of responding for different bar weighting, disregarding drive levels. Operant responding is significantly higher for 11 and 22gms than for 44gms. Operant level responses do not significantly differ for 11 and 22gms bar weighting.

Before the data obtained for the four days extinction session (Appendix II) were analyzed, a product moment correlation was computed between animal's operant level of responding and the extinction responses. This information was necessary to ascertain if the magnitude of extinction responses made by an animal is some function of its' operant level of responding. The obtained relationship is non-significant ($r = .06$) and hence it can be inferred that the operant level of responding does not determine the total number of responses made by an animal in extinction. The raw scores upon which the correlation was computed are shown in Appendix III.

A Fmax test (Winer 1962) on the extinction data indicated heterogeneity of variance at the .05 level of significance. However, on the suggestion that F tests are robust and not so sensitive to the homogeneity assumption (Winer 1962) and the fact that the number of subjects used was large ($N = 108$), extinction data were subjected to an analysis of variance. The results of the analysis are summarized

TABLE 2

Analysis of variance of operant level of responding for different levels of drive and effortfulness of response.

<u>Source of variation</u>	<u>SS</u>	<u>df</u>	<u>Ms</u>	<u>F</u>	<u>P</u>
drive	114.056	2	57.03	1.25	NS
effort	318.500	2	159.25	3.50	.05
drive x effort	233.944	4	58.49	1.00	NS
error	4489.167	99	45.35		
TOTAL	5155.667	107

FIGURE 1

Mean operant level responding for different effort levels for three days. The drive levels are not included. (see results)

in Table 3. As evident from the table, drive effect is significant beyond the .01 level of confidence, while the effort and drive effort interaction is significant at the .05 level. Graphic representation of the extinction data is presented in Figure 2.

Multiple comparisons among the means of different experimental conditions were obtained using the Newman-Kuels method (Winer 1962). The results are reported in Table 4. The results indicate that:

1. Animals working under high drive (20-hr. food deprived) made significantly more responses for 11-, 22-, and 44gms than animals working under medium drive (10-hrs. food deprived) or low drive (4-hrs. food deprived). Similarly, animals working under medium drive made significantly more responses for each effort level than low drive animals.

2. If extinction responses for different effort levels are compared within a drive level, animals working under medium drive made significantly different responses for each effort level. These animals made maximum extinction responses for 22gms bar weighting, followed by 11gms and 44gms, respectively. For low drive state, extinction responses for 11gms and 22gms do not significantly differ. Similarly, for high drive state extinction responses for 11gms and 44gms do not significantly differ.

3. Extinction responses on 11gms for animals working under medium drive state do not significantly differ from 44gms extinction responses of low drive animals. Furthermore, there were no significant differences among 11 and 44gms extinction responses of the animals

TABLE 3

Analysis of variance of extinction responses.

<u>Source of variation</u>	<u>SS</u>	<u>df</u>	<u>Ms</u>	<u>F</u>	<u>P</u>
drive	198280.07	2	99140.00	28.50	.001
effort	25716.96	2	12858.48	3.70	.05
drive x effort	35674.93	4	8918.73	2.56	.05
error	344267.67	99	3477.45		
TOTAL		107

FIGURE 2

Mean extinction responses for four days of testing under different drive and effort levels.

TABLE 4
Multiple Comparisons among Means using
Newman-Kuels Method

	1	2	3	4	5	6	7	8	9
	22g.10h	11g.4h	44g.4h	11g.22h	44g.10h	11g.20h	44g.20h	22g.10h	22g.20h
1	---	47	514	605	969	1183	1198	1249	1932
2		---	467	558	922	1136	1151	1202	1885
3			---	91	455	669	684	735	1418
4				---	364	578	593	644	1327
5					---	214	299	280	963
6						---	15	66	749
7							---	51	734
8								---	683
9									---

1 2 3 4 5 6 7 8 9

Means underlined by the same
line do not significantly differ
from each other.

working under a high drive state and the 22gms extinction responses of animals working under a medium drive state.

DISCUSSION

The results show that animals working under high and medium drive state make maximum extinction responses for 22gms, while animals working under low drive state make maximum extinction responses for 44gms. The most clear and significant effect of effort is shown by animals working under medium drive state. These animals make significantly different extinction responses for each effort level.

Thus far, no reported study has obtained this kind of relationship between the effort variable and extinction responses. Hence, before any theoretical explanation of the present results is attempted, it will be necessary to investigate the factors which might have contributed to the results obtained in this investigation.

If the drive variable is not considered, studies reported on the effort variable and extinction responding can differ from the present investigation and from each other in regard to the following factors:

1. Spacing of effort levels. Some studies have investigated a closely spaced effort variable while others have used highly dispersed levels. For example, Young (1965) investigated 11-, 22-, and 44gms force levels, while Mowrer and Jones (1943) investigated 5-, 40.5-, and 80gms.

2. Number of reinforcements used during acquisition.

3. Method of training. In some studies (Mowrer and Jones, 1943) all the Ss experience every effort level in acquisition (differential method), while in others (i.e., Applezweig, 1951) only one level is experienced (absolute method). The training method has been shown to be an important factor in studies investigating the effect of the amount

of primary reinforcement and the strength of secondary reinforcement (e.g., Lawson, 1957). Hence, it is reasonable to assume that the training procedure may contribute to different results in the effort studies.

4. Combination of the above-defined factors.

If the effect of closely spaced effort levels vs dispersed levels is considered, one finds that all the operant studies which have demonstrated a negative relationship between effort and resistance to extinction have used highly dispersed effort levels. Specifically, Mowrer and Jones (1943) used 5-, 40.5-, and 80gms weight; Capehart et al (1958) used 5-, 40-, and 70gms; while Applezweig (1951) used 10-, 20-, 30-, 40-, and 50gms weight. Relevant information related to these studies is summarized in Table 5.

TABLE 5

Summary of Operant Studies showing Negative Relationship between
Effortfulness of Response and Extinction

Investigator	Effort level used	No. of reinforcements in acquisition	Training Procedure
Mowrer and Jones	5-, 40.5-, and 80gms	280	differential
Capehart et al.	5-, 40-, and 70gms	90	differential
Applezweig	10-, 20-, 30-, 40-, and 50gms	50	absolute

Regarding the Applezweig (1951) study, however, if only the closely spaced effort levels are considered the obtained relationship between effort and extinction responding is similar to the results of the present investigation. Specifically, Applezweig reports extinction responses for 10-, 20-, and 30gms weight as 55, 74, 45, respectively; whereas the responses for 10-, 30-, and 50gms weight are 55, 45, and 89.

The problem remains to explain how close vs dispersed spacing of effort levels can contribute to different results. A possible function of spacing of effort levels in the studies using differential method of training can be shown by considering the properties of habit strength (s_{HR}). According to Hull each s_{HR} will have an excitatory gradient; the shape of the gradient being a function of the number of reinforcements. Furthermore, if two s_{HR} are similar, the excitatory potentials may overlap -- a device used by Spence to explain the transposition phenomenon. Keeping this in mind, let it be assumed that bar pressing under different conditions constitutes different habits. If force required to press the bar is closely spaced, the resulting habits will be very similar and the excitatory gradients may resemble the hypothetical curves shown below.

Hence, under this situation $S_{R_2}^H$ will have greater strength as a result of the overlapping gradients of $S_{R_1}^H$ and $S_{R_3}^H$ (shaded areas in diagram). However, this kind of overlap is not probable if the different S_R^H s are based on dispersed effort levels (e.g., 5-, 40-, 70gms - Capehart et al, 1958).

If such speculation is sound, under closely spaced effort levels one should obtain greater resistance to extinction for the medium effort level; whereas under a highly dispersed effort level the strength of the medium effort level should not be affected. However, in the present investigation, though increased resistance to extinction is found for the medium effort level, the differential method was not used. Although the animals did have experience with all the effort levels (15 reinforcements at each effort level in pre-training), it does not seem probable that the effect of pre-training was influential after 480 reinforcements in acquisition. Furthermore, although Young (1965) used the same effort levels as used in the present investigation, he did not obtain similar results under continuous reinforcement conditions.

The discrepancy in the obtained results of Young's study and the present investigation could be due to the different number of reinforcement in acquisition. Young gave 960 or 1920 reinforcements, while in the present investigation 480 reinforcements were given. However, it is difficult to speculate as to how a different number of reinforcements could have contributed to the different results of these studies.

Regarding the effect of the drive variable, the present results cannot be completely accounted for by the existing theoretical models. For example, according to Hullian formulation there should be no interaction between the drive and effort variables. Since drive is multiplied to reaction potential, similar functions should be obtained under different drive states. However, the results show an interaction effect between the drive and effort variable.

Cognitive dissonance theory does predict different effects of the effort variable under high and low drive states. Lawrence and Festinger (1962) state "...if the dominant motivation is strong, there is considerable dissonance but poor dissonance reduction; if the dominant motivation is weak, there is less dissonance but good dissonance reduction" (p. 117). Animals working under low drive state do behave differently than animals working under medium and high drive states. Animals under low drive make the maximum number of extinction responses under 44gms weight, thus supporting cognitive dissonance theory. However, cognitive dissonance is not supported by the extinction behavior of the animals working under medium and high drive state.

It is possible that Hullian prediction will be supported only under relatively high drive states when effort levels are dispersed; while for low drive, a function predicted by cognitive dissonance will be obtained. The aforementioned speculation seems probable because of the results obtained in the present investigation.

APPENDIX I

Accumulated number of responses for three days of operant level testing under different levels of drives and effortfulness of response. N=108

Effortfulness of Response

<u>Drive levels</u>	<u>11 gms.</u>	<u>22 gms.</u>	<u>44 gms.</u>
20 hrs.	12	4	4
	10	8	0
	10	2	4
	7	3	2
	17	17	6
	14	6	1
	6	9	5
	14	4	3
	12	6	7
	1	3	14
	3	26	3
	21	11	0
10 hrs.	5	2	0
	31	2	2
	5	19	3
	11	4	13
	12	18	1
	12	3	1
	10	12	34
	13	17	4
	5	19	2
	11	12	3
	14	20	7
	23	6	1
4 hrs.	16	4	3
	4	5	10
	7	9	4
	5	1	15
	3	12	3
	3	13	0
	10	3	26
	4	12	2
	11	11	8
	5	2	1
	3	10	8
	9	11	12

APPENDIX II

Accumulated number of responses for four days of extinction as a function of differential drive and effortfulness of response. N=108

Effortfulness of Response

<u>Drive levels</u>	<u>11 gms.</u>	<u>22 gms.</u>	<u>44 gms.</u>
20 hrs.	188	377	243
	292	247	285
	195	246	292
	197	240	270
	315	268	230
	227	428	257
	423	439	295
	341	425	277
	231	279	208
	344	358	273
	172	305	292
	233	295	251
10 hrs.	145	448	242
	155	191	285
	326	286	282
	175	242	238
	314	264	189
	189	191	203
	142	262	268
	195	239	185
	169	195	189
	368	390	369
	144	201	206
	258	315	288
4 hrs.	189	144	211
	196	197	201
	177	142	198
	146	127	214
	143	200	231
	149	138	168
	133	142	237
	193	149	168
	195	189	251
	159	149	170
	198	195	251
	144	203	189

APPENDIX III

Correlation between operant level and number of responses made in extinction.

<u>Operant level</u>	<u>Extinction</u>	<u>Operant level</u>	<u>Extinction</u>	<u>Operant level</u>	<u>Extinction</u>
12	197	5	175	16	146
10	315	31	314	4	143
10	227	5	189	7	149
7	188	11	145	5	180
17	292	12	155	3	196
14	195	12	326	3	177
6	423	10	142	10	133
12	341	13	195	4	193
14	231	5	169	11	195
1	195	12	368	5	159
3	172	14	144	3	198
21	233	23	258	9	144
4	240	2	242	4	127
2	268	2	264	5	200
8	428	19	191	9	138
3	377	4	448	1	144
17	247	18	191	12	197
6	246	3	286	13	142
9	439	12	262	3	142
6	425	17	239	12	149
4	279	19	195	11	189
3	358	12	390	2	149
25	305	20	201	10	195
11	295	6	315	11	203
4	270	0	238	3	214
0	257	2	189	10	231
4	230	3	203	4	168
2	243	13	242	15	211
6	285	1	285	3	201
1	292	1	282	0	198
5	295	34	268	26	237
7	277	4	185	2	168
3	208	2	189	8	251
16	273	3	369	1	170
3	292	1	206	8	251
0	251	7	288	12	189

N=108

Product moment correlation (r) = .06 NS

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