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A Q-Sort Historical Analysis or the Learning Theories of Clark L. Hull and B. F. Skinner

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A Q-SORT HISTORICAL ANALYSIS
OF THE LEARNING THEORIES OF
CLARK L. HULL AND B. F. SKINNER

by

Keith V. Syrja

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
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Keith V. Syrja

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Introduction

Principles of Behavior, 1943, and Behavior of Organisms, 1938, were selected as representative works in psychological history for Clark L. Hull and B. F. Skinner, respectively. Both were published at relatively the same time period. Each reflected the author's views of a system of psychology. There were of course differences. Whereas Behavior of Organisms marked a culmination of Skinner's experimental studies into a general theory from which he latter began to disengage, Principles of Behavior marked the beginning of Hull's attempt to quantitize a complete theory of psychology using behavioral postulates in a hypothetico-deductive approach.

Before beginning this analysis the question do both these men (Hull, Skinner) actually have what can be considered as a theory of behavior, must be examined. While Hull's system is quite obviously theoretical in nature, Skinner's position is sometimes regarded as too positivistic to be considered as an actual theory. However, using the criterion of Modern Learning Theory, Skinner's Behavior of Organisms is deemed to be sufficiently theoretical for its analysis. In Modern Learning Theory the term theory "denotes a conceptual apparatus mediating

scientific explanation and prediction in an empirical area." This is the function of any scientific theory although its form may differ to the extent that any one dimensional outline as put forward in Modern Learning Theory cannot be strictly adhered to for all theories.

In this study then, both theories are examined. The results of this study hopefully reveal to some extent how these theories as they were formulated at these earlier times are still remembered and regarded today. Despite changes in these theories this subjective analysis will attempt to discover how proponents of the present day theories regard the earlier theories.

The first hypothesis tested was that a group which had been exposed to both theorists in their courses would be able to identify Hullian statements more correctly than would a group which had been exposed in their courses only to Skinnerian theory. The second hypothesis tested was that a group which had only been exposed to Skinnerian theory would judge Hullian statements as being less valid.

Procedure

Subject Information

The subjects used comprised two groups. The first group included both sophomore and junior level undergraduate psychology students from Kalamazoo College. The second group consisted of an equal number of graduate psychology students at Western Michigan University. A total of ten subjects were used. Subjects in the Kalamazoo College group had all taken one learning theory course which included sections on both Hull and Skinner, and also other related courses. Two subjects (#3 and #5) had even read parts of Principles of Behavior. The Western Michigan University subjects had taken a course in learning theory, but it was strongly oriented toward operant conditioning as were their other related courses. These subjects knew very little about Hullian theory.

Method

Each Q-sort Statement was typed separately on a slip of paper. The slips were thoroughly shuffled and given to the subject. As an aid in helping the experimenter classify these statements, a number from a random number list was assigned to the back of each slip. There

were a total of eighty statements, forty each of Hull and Skinner. About half of the statements of both theorists consisted of laws, principles, and theorems formulated in Hull's Principles of Behavior and Skinner's Behavior of Organisms. In one task the subject placed these slips in three piles, either "Skinner," "Hull," or "Don't Know," depending on whether he felt the statement to be that of Skinner, Hull, or that he wasn't sure. He was allowed to change his placements if he wished after he had sorted the statements.

Each subject also performed a validity task on these same statements, placing them in three piles: "Valid," "Invalid," or "Don't Know," depending on whether he felt the statement was currently either scientifically valid, invalid, or that he wasn't sure. Again, he was allowed time to change his selections if he so desired.

The experimental design counterbalanced both tasks. Half the subjects initially did the validity task followed by the statement identity task while the tasks were reversed for the other subjects.

This study was originally conceived as a Q-sort analysis whereby subjects would use a forced frequency sorting procedure. Such a design permits the dependency factorial analysis typical of Q-sort studies. Such a Q-sort forced frequency approach was found to be not

feasible for this study so an alternative design and analysis of results was devised. The subjects tested with a forced frequency design stated that it was impossible to make such discriminations, especially for the Hullian statements in the case of the Western Michigan University subjects. Even if such discriminations were possible, many subjects regarded most statements as valid rather than invalid in the validity task. Likewise, in the identity task most statements might be sorted into the "Skinner" pile, for example rather than the "Hull" or "Don't Know" piles. If this is how a subject actually wanted to sort the statements, he would be unable to do so in the forced frequency procedure. Such a design would therefore distort his actual sorting behavior. The present design eliminates this distortion.

The data for each subject was collected and compiled as subject data sheets by the experimenter. These data sheets separated the identity task statements as follows: statements placed in the "Hull" pile were separated into correct (the statement was a Hullian statement) and incorrect (the statement was actually a Skinner statement) categories. Likewise, there were Skinner correct and incorrect statement separations. The "Don't Know" pile was separated into Hull and Skinner statements. The validity task likewise involved separations of the "Valid"

pile into Hull and Skinner statement groups, similarly the "Invalid" and "Don't Know" piles into Hull and Skinner statement groups.

The mean data sheets were next compiled from the subject data sheets. The procedure used was to count the number of statements in each of the above described categories of the subject data sheets. Then the mean for all ten subjects in each category of both tasks was determined and also the means for both groups. Thus the means for both groups or all ten subjects as a whole could be compared.

A subject correct/incorrect ratio was also compiled for the identity task while a valid/invalid ratio was similarly compiled for the validity task. These ratios formed from the mean data sheet consisted of taking the number of correct statements and dividing by the number of incorrect statements in the identity task for each subject and analogously taking the number of valid statements and dividing by the number of statements termed invalid. One subject did not consider any statement invalid and therefore he did not have a valid/invalid ratio. The rationale for these ratios was to examine more closely how well the subjects actually differentiated between the two theorists (a low correct/incorrect ratio would show less differentiation than a high correct/incorrect ratio), and to show the extent to which they felt

each theorist's statements were valid (a low validity ratio would reveal little confidence in the theory while a high validity ratio would reveal much confidence in the respective theory). Finally a ratio totals table was compiled which compared the above ratios for both the Kalamazoo College group and the Western Michigan University group and also the overall values for all subjects. From this table a comparison of both groups could be made.

Although the above procedures give information pertinent to this study regarding any differences in theoretical orientation between the two groups, another procedure was used to analyze each particular statement. This latter procedure is closer to what is considered as Q-technique as explained in The Study of Behavior, Q-Technique and Its Methodology by William Stephenson. A statement data sheet was compiled for each statement for both tasks for all subjects. A list of abbreviations characterized each category. Thus HC referred to a "Hull Correct" statement choice while HI meant "Hull Incorrect." For the validity task the abbreviation VH meant "Valid Hull" while IH meant "Invalid Hull." Similarly for Skinner there were VS and IS abbreviations. For both tasks DH and DS denoted "Don't Know Hull" and "Don't Know Skinner" respectively.

A statement data summary sheet for both tasks was then obtained from the statement data sheets. For each statement all the choices made by the subjects were totaled. A decision was made as to the final category in which the statement would be placed. For example if the results for T1 (the identity task was so labeled although, as explained earlier, the tasks were actually counterbalanced) for statement number 047 showed 2HC, 6SI, and 2DH choices by the ten subjects the statement was classified as an SI (Skinner Incorrect) statement, indicating that the majority of subjects thought this statement was a Skinnerian statement when it actually was a Hullian statement. In a similar manner all the statements were categorized for the validity task. If the statement had no clear majority choice for a given task it was categorized as a "split" statement. Numerous combinations, therefore, comprised the split statement category, but their common feature was that the subjects did not respond similarly to the given statement.

The statement summary tables were tabulated from the results of the statement data summary sheets for both tasks. All of the statements categorized as HC were therefore listed under the HC column. Similarly the other categories were listed under the HI, SC, SI, DH, DS, and split columns for task one and the VH, IH, VS, IS, DH DS, and split columns for task two.

Results

The original data was analyzed as subject data and statement data. The results of the subject data analysis is shown by Tables One and Two. In table one the mean amount of correctly placed Hull Statements in the identity task for the Kalamazoo College subjects (KC group) was 20.4 while the Western Michigan University subject group (WMU group) mean was 17.6. The mean for incorrect Hull statements in the KC group was 10.6 while the WMU group mean was 12.6. The KC group mean for correct Skinner statements was 23.6, while the mean for the WMU group was 20.6. The KC group had a mean of 15.6 for incorrect Skinner statements while the WMU group mean was 17.4. The means for Hull statements placed in the "Don't Know" pile were 4.0 and 5.2 for the KC group and the WMU group respectively. The "Don't Know" Skinner Statement means were 5.8 and 6.8 for the two groups.

For Hull and Skinner statements judged valid the Kalamazoo College group means were 26.2 and 25.4 respectively. The Western Michigan University group means for the same categories were 19.4 and 25.4 respectively. The KC group mean for the number of Hull statements judged

invalid was 8.4 while the WMU group mean was 13.4. The two group means for Skinner statements considered invalid were 8.6 and 8.2. The "Don't Know" classification means for the validity task were 5.4 and 7.2 for Hull statements and 6.0 and 6.4 for Skinner statements.

In table two the range for the correct/incorrect ratio is from 0.78 (WMU group, subject no. one) to 4.23 (KC group, subject no. two) for the Hull statements. The Skinner ratio ranged from 0.84 (WMU group, subject no. one) to 3.00 (WMU group, subject no. five). The cumulative group ratios for the Hull identity statements were 1.92 and 1.40 while the Skinner results were 1.51 and 1.18. The ratio totals for both groups for Hull and Skinner statements were 1.64 and 1.34 respectively.

In the validity task a wider ratio range resulted. The Hull statement validity ratio ranged from 0.50 in the WMU group to 8.25 in the KC group. The validity ratio for Skinner statements ranged from 1.20 in the WMU group to 11.00 in the KC group. The cumulative group ratios for the Hull validity statements were 3.12 (KC group) and 1.45 (WMU group). The cumulative group ratios for the Skinner validity statements were 2.95 and 3.10. Hull and Skinner validity ratio totals were 2.09 and 3.02 respectively.

Tables three and four show the results of the statement analysis for both tasks (see procedure). The

Table 1. Group Means

1. Identity Task	KC Group	WMU Group
Hull Correct	20.4	17.6
Hull Incorrect	10.6	12.6
Skinner Correct	23.6	20.6
Skinner Incorrect	15.6	17.4
Don't Know Hull	4.0	5.2
Don't Know Skinner	5.8	6.8
2. Validity Task	KC Group	WMU Group
Valid Hull	26.2	19.4
Invalid Hull	8.4	13.4
Valid Skinner	25.4	25.4
Invalid Skinner	8.6	8.2
Don't Know Hull	5.4	7.2
Don't Know Skinner	6.0	6.4

KC Group: Denotes Kalamazoo College subjects.

WMU Group: Denotes Western Michigan University subjects.

Table 2. Subject and Group Ratios

1. Correct/Incorrect			Subject No.				
			1	2	3	4	5
G1 Hull	(1.92)		1.77	4.23	1.15	1.88	1.85
G2 Hull	(1.40)		0.78	1.09	1.38	1.78	2.67
G1 Skinner	(1.51)		1.27	2.43	0.96	1.90	1.53
G2 Skinner	(1.18)		0.84	0.86	1.19	1.50	3.00
(G1 + G2) Hull	(1.64)						
(G1 + G2) Skinner	(1.34)						
2. Valid/Invalid			Subject No.				
			1	2	3	4	5
G1 Hull	(3.12)		4.83	3.22	8.25	3.50	1.12
G2 Hull	(1.45)		-	2.88	0.67	1.71	0.50
G1 Skinner	(2.95)		3.00	2.89	11.00	2.11	1.69
G2 Skinner	(3.10)		-	5.60	2.27	2.90	1.20
(G1 + G2) Hull	(2.09)						
(G1 + G2) Skinner	(3.02)						

statements are listed by their random number under each category (see appendix).

The HC, HI, SC, SI, DH, DS, and split categories of the identity task have 18, 6, 26, 14, 1, and 15 statements respectively. The VH, IH, VS, IS, DH, DS, and split categories of the validity task have 23, 5, 28, 2, 2, 2, and 18 statements respectively. Only three statements were split for both tasks: 073, 652, and 852.

In the identity task split statements some difference in responding between the two groups was found. Statement 587 showed one HI and four SC responses for the KC group while the WMU group had one SC and four HI responses. Likewise statement 652 had one DS, one HI, and three SC responses for the KC group while the WMU group responses were four HI and one SC.

Differences in responding by the two groups was also shown in the split statements of the validity task. Statement 054 responses were one IH, one DH, and three VH for the KC group while the WMU group responses were three IH and two DH. Statement 073 had KC group responses of three VH, one DH, and one IH while the WMU group responses were three IH, one DH, and one VH. Statement 128 had responses of three VH, one IH, and one DH for the KC group while the WMU group responses were three IH, one DH, and one VH. Statement 151 responses were four VH and one IH in the KC group and four IH and one DH in the WMU group.

Statement 508 had KC group responses of three IS and two VS and WMU group responses of three VS, one DS, and one IS. Statement 652 responses for the KC group were three VS and two IS while WMU group responses were three IS, one DS, and one VS.

In many statements the response pattern between the two groups was similar. There were, for example, several statements in which there was a unanimous response. These included statements 361 and 920 in the SC category, statement 559 in the HC category, and statement 484 in the SI category. For the validity task there was unanimous agreement for statements 728 and 918 in the VH category and for statements 037, 361, 364, 920, and 932 in the VS category.

Some of the statements in the other categories in both tasks however did show group differences. Despite this difference, however, these statements still had a majority response and therefore were placed in a definite category. In the identity task statement 542 in the HI category had KC group responses of two SC, two DS, and one HI while the WMU group responses were four HI, and one SC. In the SI category statement 045 had KC group responses of two HC, one DH, and two SI while the WMU group responses were four SI and one DH. In the same category for statement 147 the KC group had responses of four SI and one HC while the WMU group had responses of

Table 3. Identity Task Statement Summary

<u>Hull Correct</u>		<u>Hull Incorrect</u>	<u>Skinner Correct</u>			<u>Skinner Incorrect</u>	
054	431	278	008	269	597	045	484
060	444	542	035	361	645	123	532
062	559	638	037	385	679	147	570
128	766	711	039	462	783	151	635
152	812	935	129	471	785	153	728
328	827	943	138	493	887	179	758
333	871		159	508	920	435	859
351	905		182	539	930		
407	918		196	558			
<u>Hull Don't Know</u>			<u>Skinner Don't Know</u>			<u>Split</u>	
None			818			073	587
						104	652
						165	689
						169	852
						180	863
						308	932
						364	979
						569	

Table 4. Validity Task Statement Summary

<u>Valid Hull</u>		<u>Hull Invalid</u>	<u>Valid Skinner</u>		<u>Skinner Invalid</u>
045	635	153	008	493	539
062	689	180	035	542	935
104	728	308	037	558	
123	758	559	039	587	
152	766	570	129	597	
179	812		159	638	
407	827		165	645	
435	859		169	783	
444	863		182	785	
484	905		269	920	
532	918		361	930	
569			364	932	
			385	943	
			471	979	
<u>Hull Don't Know</u>		<u>Skinner Don't Know</u>	<u>Split</u>		
060		196	054	278	652
333		818	073	328	679
			128	351	711
			138	431	852
			147	462	871
			151	508	887

three DH, one HC, and one SI. Statement 435 showed responses of three HC and two SI for the KC group and five SI for the WMU group. Statement 532 similarly showed responses of two HC, one DH, and two SI for the KC group while the WMU group responses were five SI.

In the validity task group differences were shown in the VH category as the KC group responses for statement 569 were four VH and one DH while the WMU group responses were one VH, two DH, and two IH. In the VS category the clearest example of a group difference was statement 645 with KC group responses of three IS, one DS, and one VS and WMU group responses of five VS. In the DH category of task two statement 060 KC group responses were three VH and two DH and WMU group responses were two IH and three DH. For statement 333 there were KC group responses of two VH and three DH while the WMU group responses were three DH and two IH.

Discussion

In this study two hypotheses were formulated. The first hypothesis concerned the identity task. The author felt that the Kalamazoo College (KC) group would be able to sort out the Hull statements more correctly than the Western Michigan University (WMU) group. The results as stated earlier show that the mean score for the KC group was higher for the HC category than the WMU group. The mean number of incorrect scores for Hull statements was less for the KC group. The combination of these two facts as shown by the higher identity (correct/incorrect) ratio value of 1.92 best supports the hypothesis that the Kalamazoo College group did discriminate the Hull statements better.

Other identity ratio values showed some unexpected results. There was a low value of 1.18 for the WMU group identification of Skinnerian statements, but a higher value of 1.40 for the WMU group identification of Hullian statements. The historical nature of the statements was probably a major factor affecting these results. Unfamiliar data language terms in both theories made it harder to differentiate between them, and a discussion of the data language of both theories will be presented.

One WMU group subject remarked that he had placed a given statement in the "Hull" pile if he found data language terms in the statement with which he was unfamiliar. Using such a strategy if there were more such Hullian statements, then his identification ratio could be higher for Hullian statements than for Skinnerian statements.

The second hypothesis of this study was that the category with the lowest mean score for valid statements in the validity task would be the WMU group mean for sorting Hullian statements. The group means of 26.2 and 19.4 for the VH (valid Hull) category for the KC and WMU groups respectively and the fact that both groups had a mean of 25.4 for the VS (valid Skinner) category, supported this second hypothesis. The validity ratios of 3.12, 2.95, and 3.10 for the KC group Hullian statements, the KC group Skinnerian statements, and the WMU group Skinnerian statements, respectively, were nearly equal, showing no partiality in preference for the KC group. The KC group thus showed as much confidence in either theory as valid as the WMU group showed in the Skinnerian theory. The low ratio value of 1.45 for the WMU group Hullian statements is a further indication that the WMU subjects did not show much confidence in the Hullian theory.

The subject background, given earlier, was used in analyzing these different group responses. In both groups the cultural matrix (Kantor, 1969) of the subjects seemed to have a definite influence on their responses. The cultural matrix is a reference to the different learning situations of the two groups. The KC group was exposed to formalized instruction of both theorists. The WMU group was heavily exposed to the Skinnerian paradigm, but knew relatively little about Hull. Whereas no singular theory was stressed in the learning environment of the Kalamazoo College group the validity of the Skinnerian paradigm was espoused by a number of Western Michigan University professors. The statement form of each theory as presented in historical context in this study may have represented differences, however, in the theory with which these subjects were familiar. To aid in an understanding of this issue, a brief analysis of structure and content of both theories of this study follows.

Skinner's theory of learning conceptually evolved around a division of behavior into respondents and operants. The important difference between these two was the "elicited" behavior of respondents in contrast to the "emitted" behavior and effect of reinforcement of operants. His system was "based on the assumption that both behavior and environment may be broken into parts

which retain their identity throughout an experiment and undergo orderly changes" (Skinner, 1938). Skinner described his system as positivistic and descriptive. As such it was an inductive system. In Behavior of Organisms Skinner chose the reflex, a lawful correlation between a stimulus and a response. He then formulated laws of the reflex, many of them used as statements in this study.

Hilgard (1956) spoke of a "family resemblance" between the topics covered in these laws of the reflex and in Hull's postulates. For Skinner, however, these laws were defining principles and therefore weren't intended for usage in deducing behavior.

Because these laws were true at a general observation level they were unlikely to be found false. They provided, however, a framework for further specification and quantification, but were little used in discussing data from experiments (Hilgard, 1956). Verplanck (1954) similarly states that "many of Skinner's laws of behavior are exhibited as untestable," that the theory deals "only with part of the activities of organisms that obeys its laws, this is behavior."

Hull's theory, like Skinner's, was a behavioral theory avoiding notions of consciousness (Hilgard, 1966). He was able to see, however, that much of what is commonly

referred to as behavior seemed to be out of reach of other behaviorists. Because he did not believe in the ultimate results of Watson's strict S-R behaviorism Hull combined his interest in quantitative research using a hypothetico-deductive method with the concept of the intervening variable, a construct which is securely anchored antecedently by independent variables of the environment and also consequently by dependent variables. The intervening variables therefore, represented inferences as to what was happening within the organism.

Hull evolved a complete postulate set for Principles of Behavior, beginning with definitions of basic terms and postulates that were at least indirectly verifiable. The postulates were used with the definitions to develop the theorems and corollaries of the system.

In both books the position of both theorists with regard to neural explanations of behavior was similar. Each believed that psychology could best progress by developing its laws first on a molar basis (Skinner, 1938; Hull, 1943). Then a molecular neural study of behavior could use these laws for its subsequent development. Due to this view the neurological functions weren't stressed by either theorist at this time. Hull, however, did express his postulates in neural terms anticipating latter usage of these postulates when a theory of molecular behavior became possible.

Hull's formalized system began with a drive reduction reinforcement of stimulus-response connections which produced a gain of habit strength, the first intervening variable. Generalized habit strength occurred from direct reinforcement and generalization from other reinforcement. Reaction potential depended on interaction with drive and habit strength. Reaction potential reduced by reactive inhibition and conditioned inhibition became effective reaction potential which could be modified at any given instant by an oscillating inhibitory factor which results in momentary effective reaction potential. The response was evoked if this momentary effective reaction potential, the last variable of the intervening variable chain, surpassed the reaction threshold. Responses were measured by probability of reaction, latency of reaction, resistance to extinction, or amplitude (Hilgard, 1966).

Hull's 1943 theory thus formulated reinforcement as drive reduction due to need satisfaction. The incremental gains in habit strength due to learning could match the typical learning curve. Reinforcement and therefore learning was at its greatest when need reduction was great, when delay was short between response and reinforcement, and when there was little separation between the conditioned stimulus and the acquired response (Hilgard, 1966).

A comparison can be made of Hull's deductive theory with Skinner's inductive theory by analyzing the relationship of theory with data (Marx, 1970). Hull's deductive theory involved a two-way relationship with data. The above features of his theory were testable; new theorems could be derived from them and also from new data. The tool (heuristic) function of theory can thus be combined with the goal of theory development. However, Marx also sees disadvantages of a deductive theory. It induces a tendency toward personal involvement and the formalized theory becomes invested with too much authority, more than the actual facts behind the theory warrant. In contrast inductive theory involves a one-way relationship with data, proceeding gradually from an accumulation of empirical facts to generalized explanatory principles.

The analysis of both theories as given above revealed some of the data language terms used. Such data language, of course, is a part of the statements used in this study. As these theories developed, however, certain terms were considered not useful and were simply dropped from the theory. New terms or constructs might then be substituted or added. The obsolete data language terms may then be examined to find out the effects of the theoretical change.

An analysis of the data language used in the statements in this study produced a list of terms which well

represented both theories. Skinnerian terms included: operant, respondent, elicit, induction, topography, periodic, compensatory, reflex, reserve, and envelop. Hullian terms were: habit, reaction, potential, oscillation, aggregates, evoke, inhibition, and receptor. Mutual terms used by both theorists include: reinforcement, stimulus, response, extinction, and effector. The presence of certain of these terms in a statement would make it easy for subjects to differentiate between the two theorists. In certain cases where terms mutually used by both theorists formed part of the statement the task would be more difficult. In judging statement validity a subject familiar with the current paradigm of a theorist would be unfamiliar with any obsolete terms. Of the terms mentioned above three were considered as obsolete: reserve, reflex, and envelop. Since reflex is still used in speaking of respondent behavior, however, only reserve and envelop were considered truly no longer in use. The term reserve occurred in statements 138, 269, 539, 558, 652, 711, and 935; but, statements 138, 269, 539, and 558 were identified correctly (see table three). In addition, statement 269 was judged to be invalid (see table four). The term envelop occurred only in statement 818. In both tasks this statement was categorized as "Don't Know." The author suspects that this unfamiliar word was what prompted most subjects to place the statement

in the "Don't Know" category in both tasks.

It is not always easy to state why a subject would consider a statement invalid even in cases where data language terms are concerned. For example, in Hull's 1943 theory the term reinforcement referred to a drive reduction where the activity in escaping from a charged grid was reinforced because of the need to escape injury. He later changed to a drive-stimulus reduction theory where the reduction in pain (the stimulation consequence) was reinforcing instead of the escape from injury. Such a seemingly subtle change is important theoretically, however, and could persuade a subject to regard a statement from the 1943 theory as invalid.

Despite this problem an attempt was made to analyze the categories of tables three and four to determine if data language could explain the response patterns. For the HC category in task one it was found that all of the statements contained the Hullian terms stated earlier except for statement 328 which was a quantitative description of drive stimuli and statement 756 which discusses "organismic need." In the HI category all statements were found to be either quantitative, neurologically termed, or obsolete terms of reserve and reflex. One WMU subject remarked, however, that he felt that all statements in neural or quantitative terms were Hullian statements.

Other subjects felt that any simply stated general principle was a Skinnerian statement. These mistaken conceptions influenced their responses. In the SC category of the identity task the word operant occurred in statements 035, 138, 361, and 920. It was unanimously termed a Skinnerian statement for statements 361 and 920. Statement 035 had nine correct responses and one "don't know" response, while statement 138 had seven correct responses, but three incorrect responses. The obsolete term reserve, also a part of the statement, probably confused subjects even despite the presence of the term operant.

One other factor was found in analyzing these statements; this was the research topic. In a comparison of research areas covered by both books it is seen that the areas of classical and instrumental conditioning were covered in both books, but the topics of delay of reinforcement and generalization were Hullian areas of research while a Skinnerian area was periodic reconditioning. Both theorists conducted research on drive. In the SI category the identity task statements 123, 728, and 859 all concerned delay of reinforcement, while statements 045 and 635 concerned generalization. Although Skinner did research in these other areas latter, he had not done so at the time of Behavior of Organisms.

In the VH classification in the validity task a group difference for statement 812 including "receptor discharge" and "afferent impulse" phrases showed KC group responses of four VH and one DH while WMU group responses were one VH, two DH, and two IH. The lack of strong support for such neurological wording in the WMU group was thus shown. Both IS category statements contained the obsolete term reserve. In the DH category for the validity task statement 333 with the phrase "afferent neural impulses" showed group response differences of two VH and three DH for the KC group and two IH and three DH for the WMU group. In the DS category in the validity task were statement 196 with the term "submaximal" and statement 818 with the obsolete term "envelop."

The split statement categories for both tasks contained statements where an analysis of neither data language terms, research subject areas, or statement content was considered to sufficiently explain the different split responses. Statement 652, however, was an exception for both tasks. It contained the obsolete term "reserve." In the identity task the KC group responses were three SC, one DS, and one HI while the WMU group responses were four HI and one SC. In the validity task the KC group responses were three VS, and two IS while the WMU group responses were three IS, one

DS, and one VS. Other group differences in the split categories followed a similar pattern and explanation to that of other statements analyzed earlier by examples in the other categories.

The obsolete data language terms discussed in this study indicate a pattern of change in theory development. A structure of scientific progress has been advanced (Kuhn, 1962). "Normal science" is a steady advance in scientific fact-finding and theory development. At a certain point, however, a crisis occurs due to a failure of a theory or paradigm to explain important data. Then a revolution occurs, and a new theory or paradigm results. The new paradigm not only solves the problem, but creates a new viewpoint on which to continue research. Such revolutions are usually considered invisible, however, because all important data are soon conceptualized to fit the new paradigm.

Did Hull or Skinner experience such a crisis? Although not focusing on paradigm change this study showed that Skinner discarded such terms as reflex strength, reserve, and envelop while Hull changed his reinforcement concept to a drive-stimulus reduction. The author felt that each theorist did reach such a crisis point. Their paradigm changes, however, did not bring a revolution to psychology. Skinner ignored this crisis and withdrew into the development of a more

determinate paradigm within the same inductive framework while Hull tried to overleap this crisis and establish a behavioral theory on a still wider level.

Both theories can be regarded as similar despite methodological differences. Skinner's use of the terms reflex reserve and strength in his reflex laws revealed an intervening variable construct similar to those of Hull's theory. An underlying "state" was inferred from the concurrent strength changes of a group of different reflexes (Hull, 1943). The use of such terms in the statements of this study have been shown to produce confusion in the subjects regarding the identification of the theorist and the validity of the term. A revolution will probably have to occur in psychology before any type of intervening variable will be regarded as valid.

Stephenson (1967) has developed a concept of communication science which concerns the generation and propagation of scientific knowledge. This study has not only made use of the Q-sorting technique exposed by Stephenson but has focused on much of his communication-pleasure aspects of science (Stephenson, 1967), in terms of which this study could be summarized as a "play exercise" to find out the subjective viewpoints of subjects regarding the earlier learning theories of Hull and Skinner. This analysis has studied what

potential scientists feel about science; the results produce agreement with Stephenson that "complex schemata are at issue" (Stephenson, 1972).

Summary

This study was a subjective historical analysis of the learning theories of Clark L. Hull and B. F. Skinner using the Q-sort methodology of William Stephenson. The subjects comprised two groups of five subjects each. The first group was that of undergraduate psychology students at Kalamazoo College while the second group was made up of graduate students in psychology at Western Michigan University.

A list of eighty statements, the Q-sort, was taken in equal numbers from Skinner's Behavior of Organisms and Hull's Principles of Behavior. The subjects performed two tasks on these statements. In the identity task the subject was asked to sort out the statement into "Hull," "Skinner," or "Don't Know" classifications depending on whether he thought the statements to be that of Hull, Skinner, or that we wasn't sure. In the second validity task the subject was asked to sort the same statements into "Valid," "Invalid," or "Don't Know" classifications depending on whether he thought the statement to be valid, invalid, or that he wasn't sure.

Two hypotheses were formulated. The first hypothesis was that in the identification task the Kalamazoo College

group would be able to identify the Hullian statements more correctly than the Western Michigan University subjects. The second hypothesis was that in the validity task the WMU subjects would have the lowest mean score for valid Hullian statements. Both hypotheses were supported, particularly by the identity and validity ratios determined from the data. The different background of the subjects of each group was considered as explanation for the different group responses obtained.

An analysis of the statements revealed responses occurred due to data language difficulties with obsolete terms and misconceptions of research areas of both theorists and statement content. The final analysis of the benefits of the study as a "play exercise" of communication-pleasure and the generation of scientific knowledge was made.

APPENDIX

Appendix: Q-Sort Statement List

These statements are given in the random number sequence order used in this study, except that the statements are separated according to author. The number in parenthesis is the random number that was on the back of the statement slip. The page number from which the statement is taken is also given. For Hull statements the reference is Principles of Behavior while for Skinner statements the reference is Behavior of Organisms.

Hull Statements:

1. The reaction involved in the original conditioning becomes connected with a considerable zone of stimuli other than, but adjacent to, the stimulus conventionally involved in the original conditioning; this is called stimulus generalization. (045) P. 183. (No. 1.)
2. Experimental extinction effects are in some sense directly opposed to reaction potential rather than merely to habit strength. (054) P. 249.
3. The effective habit strength is jointly a negative growth function of the strength of the habit at the point of reinforcement and of the magnitude of the difference on the continuum of that stimulus between the afferent impulses in units of discrimination thresholds (j.n.d's). (060) P. 199. (Post. 5)
4. Habit strength is manifested in a measurable manner by the reaction latency, the length of time elapsing from the onset of the stimulus to the onset of the associated reaction. (062) P. 104.
5. Whenever conditioned reactions are evoked, whether reinforced or not, reactive inhibition is generated. (073) P. 290. (Cor. XII)

6. Experimental extinction does not necessarily abolish completely and permanently the reaction tendency extinguished. (104) P. 274.
7. When a reaction is reinforced after a short delay, the time required to execute the act will be less than that required to execute a comparable act which has had the same number of reinforcements but in which the delay of the reinforcements has been longer. (123) P. 148. (Cor. II)
8. The amplitude of the reaction evoked by two stimulus aggregates acting jointly will be less than will be the sum of the reaction magnitudes evoked by the respective stimulus aggregates acting separately. (128) P. 214. (Cor. I)
9. 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. (147) P. 278. (First Submolar Principle)
10. Secondary reinforcement differs from primary reinforcement in that the former seems to be associated with stimulation whereas the latter seems to be associated with the cessation of stimulation. (151) P. 97 (No. 4)
11. Organisms possess receptor effector connections which, under combined stimulation and drive, may evoke a hierarchy of responses that either individually or in combination are more likely to terminate the need than would be a random selection from the reaction potentials resulting from other stimulus and drive combinations. (152) P. 66. (Post. 3)
12. It is doubtful if true trace conditioned reflexes can be set up when the onset of the unconditioned stimulus follows the termination of the conditioned stimulus by more than about three seconds. (153) P. 177.
13. Primary reinforcement appears to be a native, unlearned capacity in some way associated with need reduction. (179) P. 97. (No. 1)

14. The organism will execute the correct one of several acts originally evoked by the situation more promptly, more vigorously, more certainly, and more persistently when a large amount of food is stimulating its receptors than when they are stimulated by a small amount. (180) P. 132.
15. All primary drives produce their effects by the action of various chemicals in the blood. (308) P. 251.
16. Associated with every drive is a characteristic drive stimulus whose intensity is an increasing monotonic function of the drive in question. (328) P. 253. (Post. 6)
17. All afferent neural impulses active in the nervous system at any given moment, interact with each other in such a way as to change each into something partially different in a manner which varies with every concurrent associated afferent impulse or combination of such impulses. (333) P. 47. (Post. 2)
18. The effective reaction potential, that reaction potential which is actually available for the evocation of action is the reaction potential less the total inhibitory potential. (351) P. 284.
19. The momentary effective reaction potential must exceed the reaction threshold before a stimulus will evoke a given reaction. (407) P. 344. (Post. 11)
20. When the reaction potentials to two or more incompatible reactions occur in an organism at the same time, only the reaction whose momentary effective reaction potential is greatest will be evoked. (431) P. 344. (Post 16)
21. If two or more behavior sequences, each involving a different amount of work, have been equally well reinforced, the organism will gradually learn to choose the less laborious behavior leading to the attainment of the reinforcing state of affairs. (435) P. 294. (Cor. XV)
22. Organisms will learn to react differentially to a given objective situation according to the drive active at the time, and to react differentially to a given drive according to the objective situation at the time. (444) P. 251. (Cor. XII)

23. Secondary reinforcement may be acquired by a stimulus from association with some previously established secondary reinforcement, as well as with a primary reinforcement. Transfer of this power of reinforcement may go on indefinitely, given the conditions of stable and consistent association. (484) P. 97. (No. 2)
24. Behavioral oscillation precludes the possibility of deductively predicting the exact momentary behavior of single organisms. However with knowledge of the history of the organism and a good understanding of the laws of behavior, it should be possible to predict within the limits imposed by the oscillation factor what the subject will do under given conditions. (532) P. 316.
25. Any effective habit strength is sensitized into reaction potentiality by all primary drives active within an organism at a given time, the magnitude of this potentiality being a product obtained by multiplying an increasing function of habit strength by an increasing function of drive. (559) P. 253. (Post. 7)
26. In the original simple conditioning or learning of an all-or-none type of reaction the maximal level of 100 per cent of reaction evocation may occur in the later stages of reinforcement even though the reaction potential may steadily increase through continued reinforcement. (569) P. 333. (Cor. II)
27. The greater the number of reinforcements, the greater will be the amplitude of the evoked reaction. The amplitude of the reaction is said to be an increasing function of the number of reinforcements. (570) P. 104. (No. 2)
28. Stimuli not involved in the original reinforcement but lying in a zone related to it become connected with reactions not involved in the original reinforcement but lying in a zone related to it; this may be called stimulus-response generalization. (635) P. 183. (No. 3)
29. Habit strength is an increasing function of the number of reinforcements up to some sort of physiological limit beyond which no more increase is possible. (689) P. 113.

30. With training organisms tend to choose that one of a pair of alternative acts which yields reinforcement with the lesser delay. (728) P. 151. (Cor. III)
31. The greater the number of reinforcements the greater will be the number of non-reinforced reactions required to produce a given degree of experimental extinction. (758) P. 107. (No. 2)
32. An organism will hardly survive unless the state of organismic need and the state of the environment in its relation to the organism are somehow jointly and simultaneously brought to bear on the movement producing mechanism of the organism. (766) P. 18.
33. Whenever an effector activity occurs in temporal contiguity with the afferent impulse, and this conjunction is closely associated in time with the diminution in the receptor discharge characteristic of a need, there will result an increment to the tendency for that stimulus to evoke that reaction. (812) P. 80. (Law of Primary Reinforcement)
34. Habit may be defined as the relatively permanent connection which reinforcement leaves within the organism between the receptor and the effector associated in the original reinforcement. (827) P. 117.
35. The process of primitive trial-and-error learning and conditioned reflex learning occur concurrently; very likely they are the same process differing only in the accidental circumstance that the first begins with an appreciable strength, whereas the second sets out from zero. (852) P. 386.
36. The coarser the ratio of the delay of reinforcement of two competing reactions, the less will be the training required to give the act involving the lesser delay a given degree of dominance. (859) P. 153. (Cor. VI)
37. The law of reinforcement will mediate the connections of the non-critical stimulus elements to the reaction quite as readily as those of the critical ones. (863) P. 258.

38. The number of reinforcements being constant, the stronger the relevant drive, the greater will be the number of unreinforced evocations which will be required to reduce the reaction potential to a given level. (871) P. 249. (Cor. IX)
39. Stimuli closely associated with the acquisition and accumulation of inhibitory potential become conditioned to it in such a way that when such stimuli later precede or occur simultaneously with stimulus situations otherwise evoking positive reactions, these latter excitatory tendencies will be weakened. (905) P. 282. (Cor. I)
40. The stimulus involved in the original conditioning becomes connected with a considerable zone of reactions other than, but related to, the reaction conventionally involved in the original reinforcement; this may be called response generalization. (918) P. 183. (No. 2)

Skinner Statements:

1. Prolongation of a stimulus or repetitive presentation within certain limiting rates has the same effect as increasing the intensity. (008) P. 13. (Law of Temporal Summation)
2. If the occurrence of an operant already strengthened through conditioning is not followed by the reinforcing stimulus, the strength is decreased. (035) P. 21. (Law of Extinction of Type R)
3. The response of one reflex may constitute or produce the eliciting or discriminative stimulus of another. (037) P. 32. (Law of Chaining)
4. The magnitude of the response is a function of the intensity of the stimulus. (039) P. 13. (Law of the Magnitude of the Response)
5. When two reflexes overlap topographically and the responses are incompatible, one response may occur to the exclusion of the other. (129) P. 30. (Law of Prepotency)
6. The reinforcement of an operant creates a single reserve, the size of which is independent of the stimulating field but which is differentially accessible under different fields. (138) P. 229. (Law of the Operant Reserve)

7. Both behavior and environment may be broken into parts which retain their identity throughout an experiment and undergo orderly changes. (159) P. 33.
8. A reflex strengthened by induction from the reinforcement of a reflex possessing a similar but not identical stimulus may be separately extinguished if the difference in stimuli is supraliminal for the organism. (165) P. 170. (Law of the Discrimination of the Stimulus in Type S)
9. Two or more responses which do not overlap topographically may occur simultaneously without interference. (169) P. 29. (Law of Compatibility)
10. The strength of a reflex declines during repeated elicitations and returns to its former value during subsequent inactivity. (182) P. 16. (Law of Reflex Fatigue)
11. In general the states of strength of the conditioned reflexes of an organism are submaximal with respect to the operation of reinforcement. (196) P. 117.
12. At the beginning of extinction the reserve and the rate are both maximal. As responses occur the reserve is drained and the rate declines. (269) P. 84.
13. The simultaneous elicitation of two responses utilizing the same effectors but in opposite directions produces a response the extent of which is an algebraic resultant. (278) P. 30. (Law of Algebraic Summation)
14. If the occurrence of an operant is followed by presentation of a reinforcing stimulus, the strength is increased. (361) P. 21. (Law of Conditioning of Type R)
15. To elicit a response the intensity of the stimulus must reach or exceed a certain critical value called the threshold. (364) P. 12. (Law of Threshold)
16. The stability of reflex strength under periodic reconditioning and the prolongation of the extinction curve following it are important properties of normal behavior. (385) P. 138.

17. The rapid compensatory increases in rate following periods of little or no activity during extinction differ from spontaneous recovery in that the factor responsible for the inactivity is not the absence of necessary external discriminative stimuli but either the prepotent activity of competing stimuli or an emotional effect. (462) P. 84.
18. The strength of a reflex may be increased through presentation of a second stimulus which does not itself elicit the response. (471) P. 16. (Law of Facilitation)
19. To make a discrimination is to accumulate slight differences which are in themselves properties of the original behavior of the organism. (493) P. 170.
20. In a chain of reflexes not ultimately reinforced only the members actually elicited undergo extinction. (508) P. 105. (Law of the Extinction of Chained Reflexes)
21. The time required to establish a relatively complete discrimination depends upon the initial reserve of the reflex to be extinguished. (539) P. 203.
22. A discriminative stimulus which brings about the emission of a response (which 'sets the occasion' for the response) differs quantitatively in its action from the eliciting stimulus and must be 'explained' by a different neural mechanism. (542) P. 430.
23. The most efficient means of building a reserve with a given number of reinforcements is to administer them periodically. (558) P. 137.
24. A dynamic change in the strength of a reflex may be accompanied by a similar but not so extensive change in a related reflex, where the relation is due to the possession of common properties of stimulus or response. (587) P. 32. (Law of Induction)
25. When two reflexes have the same form of response, the response to both stimuli in combination has a greater magnitude and a shorter latency. (597) P. 31. (Law of Spatial Summation)

26. Immediately after elicitation the strength of some reflexes exists at a low, perhaps zero, value. It returns to its former state during subsequent inactivity. (638) P. 15. (Law of the Refractory Phase)
27. When the lever has not been present prior to the day of conditioning, its movement may have an emotional effect, one result of which is a depression in rate. (645) P. 70.
28. The distinction between the weakening of a reflex through the exhaustion of a reserve and weakening through an emotional modification of the relation between reserve and strength is obviously the distinction between mere 'forgetting' or 'loss of interest' and an active 'repression.' (652) P. 160.
29. A respondent, then, regarded as a correlation of a stimulus and a response, and an operant regarded as a functional part of behavior are defined at levels of specification marked by the orderliness of dynamic changes. (679) P. 40.
30. The concept of a reserve demands a neural mechanism different in kind from the momentary excitability or conductivity of a center or the mere connection of pathways. (711) P. 430. (No. 7)
31. Special properties of conditioned reflexes arise under periodic reconditioning which have no counterpart in the original conditioning and extinction of a reflex. (783) P. 117.
32. The approximately simultaneous presentation of two stimuli, one of which (the "reinforcing" stimulus) belongs to a reflex existing at the moment at some strength, may produce an increase in the strength of a third reflex composed of the response of the reinforcing reflex and the other stimulus. (785) P. 18. (Law of Conditioning of Type S)
33. The slope of the envelop of the extinction curve gives the maximal rate of emission at any point. The significant deviations are below this envelop and suggest that incidental factors may change the proportionality in the direction of reducing the rate. (818) P. 84.

34. An interval of as little as two seconds between the reinforced response and the reinforcement may reduce the effect of reinforcement by one-third. (887) P. 70.
35. The strength acquired by an operant through reinforcement is not independent of the stimuli affecting the organism at the moment, and two operants having the same form of response may be given widely different strengths through differential reinforcement with respect to such stimuli. (920) P. 228. (Law of the Discrimination of the Stimulus in Type R)
36. The response may persist for some time after the cessation of the stimulus. (930) P. 13. (Law of After-Discharge)
37. The definition of conditioning given here is in terms of a change in reflex strength, but the act of reinforcement has another distinguishable effect. It establishes the potentiality of a subsequent extinction curve, the size of which is a measure of the extent of the conditioning. (932) P. 85.
38. A discriminative stimulus used as a reinforcement in the absence of ultimate reinforcement creates in another reflex a reserve just equal to that of the reflex to which it belongs. The present evidence is hardly capable of establishing the law very conclusively. (935) P. 105.
39. The strength of a reflex may be decreased through presentation of a second stimulus which has no other relation to the effector involved. (943) P. 17. (Law of Inhibition)
40. Two responses showing some topographical overlap may be elicited together but in necessarily modified forms. (979) P. 31. (Law of Blending)

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