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RULE LEARNING AS A METHODOLOGICAL PRINCIPLE

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I.

The word "rule" plays an important role in modern research on the psychology of learning and thought. There have been attempts to define "problem solving" as the application of rules, and "learning" as the acquisition of rules. Whereas some authors consider rule learning as one form of learning[1], others are of the opinion that all human behavior is governed by rules[2]. The subsequent academic dispute[3] kindled mainly as a result of two questions:

- whether learning theory should predict behavior with the aid of deterministic statements or with the aid of probabilistic ones, and,
- whether explicit rules could be ascribed to all behavior patterns which are to be learned.

The discussion of these questions must necessarily remain unproductive as long as no agreement is met concerning the use of

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[1] Gagné (1969), for example, differentiates between 8 types of learning which are organized hierarchically: 1) signal learning, 2) stimulus-response learning, 3) chaining, 4) verbal-associate learning, 5) multiple discrimination, 6) concept learning, 7) principle learning and 8) problem solving.

[2] E.g. Scandura, 1973; Fillbrandt, 1975.

[3] Cf. Spada, 1976; as well as the discussion in Spada/Kempf, 1976.

terminology, and as long as the opponents cling dogmatically to pre-formed opinions which they consider to be unquestionable.

And so it is that Scandura[4], before introducing the term "rule", states that "rule-governed behavior" is given when it is possible to tell in advance what a subject's next response will be. At the same time, he asserts axiomatically that all human behavior is rule-governed: if a prediction of behavior is not possible then the observer has not yet detected the corresponding rules. A "rule" is then defined as a mathematical function whose domain is a set of stimuli and whose range is a set of responses[5].

Thus, the questions which were raised earlier are already settled for Scandura:

1. If rules are mathematical functions which pair every element of their domain (i.e. each stimuli to which they are applicable) with an element from their range (i.e. a response), then the prediction of behavior - which has been made possible because of rules - is necessarily deterministic. This is so because the range of rules, according to Scandura, is not constituted by response probabilities, but by the responses themselves.

2. If all behavior is rule-goverened, then - at least in principle - a rule should be able to be ascribed to all behavior patterns which are tc be learned (and if we are not successful in this today then this is only because we have not yet construed the appropriate rule).

A methodically executed attack against Scandura's position cannot, therefore, be launched from the angle of these questions, but must be aimed at opposing the introduction of the terms "rule-governed behavior" and "rule", and/or at the axiomatically phrased opinion that all human behavior is rule-governed.

Scandura's opponents have not yet made any such efforts. Instead, attempts are made to "settle" the first question by dogmatically contending the opposing standpoint[6], and the second

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[4] Scandura, 1973, p. 11.

[5] Scandura, 1973, p. 12.

[6] Scheiblechner expects (in Spada and Kempf, 1976, p. 25) "difficultues with the empirical basis" of deterministic theories, and considers this sufficient reason not to even attempt to enter into a discussion with Scandura.

question by providing counterexamples, i.e. by naming learning objectives for whose attainment one believes one can provide no rules. However, not even counterexamples are useful here because their cogency can always be rendered powerless by Scandura's stating that no suitable rules have yet been construed for these learning objectives. One, therefore, has to look for counterexamples for which there can be no rules, and hence one formulates learning objectives by means of a "terminology" which is so indefinite that a clear-cut decision as to whether or not certain behavior corresponds to the learning objective cannot be made. An example might be, for instance, the learning objective "to write in good scientific style"[7]. In the face of such vaguely formulated "learning objectives" one should certainly ask oneself how one can substantiate them at all (when it is not even clear what one is obliged to defend when one asserts that behavior correspond to the learning objectives). In particular for "good scientific style", the question arises, if it would not be better to teach people how to present their arguments meaningfully, at least in scientific texts - for this, and here I am getting ahead of myself, there are teachable rules.

When in the following, a critical reconstruction of Scandura's structural learning theory is tackled, this is done with a view to giving reason for the assertion that human behavior is rule-governed. In doing so, however, we will neither accept - sight unseen - Scandura's essentially behavioristic explanatory concept, nor his introduction of the term "rule". Nor will the conception that all human behavior is rule-governed be able to be sustained in quite this form. On the other hand, it will prove to be possible to give reason for declaring as much behavior as possible as rule-governed, and for formulating learning objectives in the form of rules. This, however, does not at the same time mean that teaching must limit itself to the specification of explicit rules or that it always should make use of the expressly specified rules. In the same way that we acquired the use of our mother tongue, i.e. through systematic practice - without, for instance, constantly having been made aware of predicate rules - we can also learn, e.g. wind surfing, without knowing the explicit rules to which we must adhere while executing this sport and which keep us from taking an involuntary bath. If we are familiar with these rules and we notice that someone who is trying to wind surf more or less regularly makes the same mistake, i.e. fails to observe the same rule, we would do well to point this out to him.

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7) Suppes (in Spada and Kempf, 1976, p. 46).

II.

We do, however, want to use another procedure when dealing with scientific language than when dealing with everyday language, and make clear the distinction which we make when using the word "rule". This has become necessary because the lack of uniformity in the use of the word has already become apparent[8], and because we too have already diverged from Scandura's definition when speaking of predicate rules. A predicate rule is neither a mathematical function, nor does it map stimuli on reactions. Similar to a mathematical function, a predicate rule is a transitional rule; one which permits or forbids the transition from one elementary statement to another[9]. Depending on whichever modality happens to be the case ("permits" or "forbids") we can write[10] a predicate rule in the form

$$x \varepsilon P \implies x \varepsilon Q$$

or in the form

$$x \varepsilon P \implies x \varepsilon' Q$$

and read these formulas as $x \varepsilon P$ permits $x \varepsilon Q$ or $x \varepsilon P$ permits $x \varepsilon' Q$ (equivalent to $x \varepsilon P$ "forbids" $x \varepsilon' Q$). In more detail: whoever has correctly ascribed an object with the predicate P may also ascribe the same object with the predicate Q (or deny it the predicate Q). To formulate this still another way: if the statement $x \varepsilon P$ can be defended, it is permissible (or forbidden) also to maintain $x \varepsilon Q$.

With the predicate rule we have provided a first example of a rule - whereby it must be kept in mind that this is a special kind of rule - which I would like to call a conditional rule or a transitional rule. Another example of such transitional rules are conditional norms[11], which we want to write in the form

$$A \implies !B$$

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[8] Cf. Scheiblechner's demand for probabilistic predictions of behavior and their incompatibility with Scandura's definition of "rule".

[9] For the introduction of the term "predicate rules" see Kamlah & Lorenzen, 1967, p. 73ff..

[10] The symbol ε stands for the copula is, the symbol ε' for is not.

[11] For the introduction of the term "norm" see Lorenzen, 1974, p. 22ff..

and which differ greatly from predicate rules: the transition does not take place from one statement to the next, but from one statement A to an imperative !B; the transition does not take place with the modality "permits", but with the modality "requires": if assertion A is true, one must act in such a manner that the assertion B becomes true.

I want to distinguish unconditional rules from transitional rules and point to unconditional rules such as, for instance, the first commandment from the Old Testament as an example. We write such an unconditional norm in the form

$$\Longrightarrow \; !B$$

in words: it is (under all circumstances) necessary to act in such a manner that the assertion B becomes true.

Further examples of rules are the dialogical defense rules for the logical particles [12], or the rules - often mentioned in literature of the theory of learning[13] - for the construction of numbers in the different number systems, e.g. the construction rules[14]

$$\text{(i)} \quad \Longrightarrow \quad |$$

$$\text{(ii)} \quad x \Longrightarrow x\,|$$

which give rise to the infinite series of ciphers |, ||, |||, ...

The first of these rules is an unconditional rule. It dictates the choice of a vertical line as the first cipher. The second is a conditional rule which dictates the transition from one cipher to the next by the addition of a further vertical line.

To conclude the exemplary introduction of the term "rule", I would like to mention some counterexamples. In order to emphasize - right from the beginning - the dissimilarities in the use of the word "rule" by other authors, I will choose such counterexamples which are numbered among the examples by other authors. E.g. the sentence "gas expands on heating"[15], which is not a

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[12] Cf. Kamlah & Lorenzen, 1967, p. ff.

[13] Cf. Scandura, 1973, p.

[14] Cf. Lorenzen & Schwemmer, 1973, p. 45.

[15] Cf. Gagné, 1969, p. 47.

rule, but a statement. When we incorporate such a sentence as truth (i.e. not needy of further examination) into our body of knowledge, we re-formulate it (by using prescriptive statements) into a rule, e.g. into the rule that maintaining this sentence is allowed. "Two wheels which are mounted on a common axis have a parallel direction of rotation"[16] is also a statement and not a rule. It too is formulated into a rule when we apply prescriptive statements to it (e.g. argumentation norms). The rule can be specified as: "It is allowed to maintain that two wheels, which are mounted on a common axis, have the same direction of rotation", or: "If two wheels are mounted on a common axis, it is permissible to maintain that they have the same direction of rotation".

III.

In order to arrive at a founded structure for a theory of learning from these initial terminological definitions, we must first critically examine the purpose for which we want to pursue the psychology of learning. For this we build around the distinction between practical and technical difficulties commonly made in constructive philosophy of science.

Practical difficulties (conflicts) arise when incompatible objectives are pursued; technical difficulties (deficiency situations) arise when no - or insufficient - suitable means are available for factually pursued objectives.

Constructive philosophy suggests the mastery of practical and technical difficulties as a first task for the cultural sciences (to which psychology is also numbered[17]), whereby the technical tasks are considered as being subsequent to the practical ones: the objectives must first be determined before suitable means for their attainment are sought. Hereby it is meaningful not only to do away with existing technical and practical difficulties, but to prevent them from developing.

The fact is that we cannot just vegetate and entrust the solving of the problems with which we are confronted to anonymous institution "science". We must face our problems on our own. The science can only be an aid to us when they do a part of the headwork which is necessary to solve the problems. I would, therefore, like to suggest that it be the first task of education to make

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16) Cf. Spada, 1976, p. 26f.

17) Cf. Schwemmer, 1975

everyone capable of solving existing everyday problems and of preventing future practical and technical difficulties through carefully planned action.

Subsequent to this, the task of the psychology of learning can be formulated as the setting up of a body of knowledge containing information on how what should be learned, can be learned. To work on this task it is first necessary to state what should be learned. Even though this has not yet been done in detail, several basic methodical suggestions for the procedure in the psychology of learning can, nevertheless, be founded on the basis of what has already been said.

IV.

For careful planned action in a given situation we need at least two types of sentences:

- sentences which prescribe what objectives are to be pursued in this situation, and

- sentences which describe what actions are appropriate in this situation to attain the objectives.

It would certainly be hopeless if one were to endeavor to tell each person in each situation what objectives he should pursue and what means are appropriate. That is, we cannot stand at a person's side - i.e. at the side of the subject of our educational efforts - in all situations in which he is to act and tell him what to do. Instead, the person must learn to make demands upon himself and act self-reliantly. If we, as educators, want to help him to act sensibly (and morally) we must teach him universal and general sentences

- that specific objectives should be pursued when a specific situational description fits the situation (knowledge of norms), and

- that specific actions definitely - or with a good chance - lead to the attainment of objectives when a specific situational description fits the situation (knowledge of means).

Norms are prescriptive sentences, as such, rules. Yet even knowledge of means implicitly dictates what means can be maintained as being appropriate in what situations and for what purposes (and, therefore, if they are not in opposition to a maxim which the person pursues in the situation, can be used). Making these implicit rules explicit is of great importance when giving

reason for what should be taught. For this we must compare the behavior patterns which have been made possible due to the knowledge to be taught, i.e. the behavior patterns which are possible because of the person's knowledge with the desired behavior patterns (which, in turn, are themselves in need of justification).

It is, however, not sufficient just to teach knowledge of means and norms. For their application, a person also needs sentences which describe what situation is given (situational knowledge). We must, therefore, also teach a person how he or she can come by such sentences - namely, founded situational knowledge. In other words: we must teach a person to present arguments for situational descriptions.

However, a person can also get into a new situation for which he knows no means (deficiency situation). We must, therefore, also teach a person how he can expand his knowledge of means. In other words: we must teach a person to present arguments for technical opinions.

Finally, a person can find himself in practical difficulties (conflicts). We must, therefore, teach him how to make objectives compatible. In other words: we must teach the person to present arguments with a view to the mastery of conflicts.

If we call presenting arguments in "inner speech" as a thought process, we thus must be concerned with the disciplining of speech and thought - for which there are rules, anyway (cf. "logic" etc.).

It cannot be concluded from education's "obligation to teach rules" (namely, the obligation to convey founded rules through teaching) that only rules should be taught, or that everything that should be taught should be taught by the explicit provision of rules. That this cannot be done is obvious from the impossibility of setting up a terminology exclusively by means of predicate rules and definitions (word replacement rules) etc., i.e. without learning at least some first words in an empragmatic way or by means of examples and counterexamples.[18)]

Similarly, it cannot be concluded from the fact that disciplined thought and speech comply to certain rules that they can be described down to the last detail as virtually mechanical adherence to rules. When a person presents arguments for maintaining $A \vee B$ (i.e. wants to defend an adjunction), and there exists no previous knowledge which of the two parts of the statements can

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18) Cf. Kamlah & Lorenzen, 1967; Janich, Kambartel & Mittelstraß, 1974, p. 50ff..

be defended easier, then no rule can be provided as to which of the two parts of the statement he should choose and defend. The person can still present desciplined arguments methodically by first choosing one part of the statement. If its defense does not succeed, he can take back the first step of the dialogue and, instead, try to defend the second part of the statement. If the person were to wait for a rule which dictates which part of the statement he or she should defend first, he or she would be behaving like Buridan's ass which turned out to be just that in the end - an ass.[19]

Hereby, it should not be ruled out that some people - with stereotype regularity - e.g. always try to defend the first part of the statement first. However, such behavior patterns only become a problem when one can give reason that in certain situations it would be better to first try to defend the other part of the statement, e.g. because the defense procedure is then less troublesome, or because one will be able to reuse parts of the defense procedure for the defense of later statements. However, this is then a situation in which there is indeed a founded rule as to how one should proceed.

If we want to make use of our body of knowledge to solve problems and if, in doing so, we do not always want to begin at the very beginning (which is advisable when one considers the limitation of our life span, and also because problems are often pressing), it is certainly sensible also to make use of such tenets which we - or others - were able to defend earlier (and to pass such tenets on through teaching), and avoid such tenets whose negation we - or others - were able to defend earlier (and to warn others about these tenets through teaching). As examples of such tenets, I already mentioned above the tenets which represent our knowledge of means. We can - if, and only if, we want to - teach these tenets as rules which prescribe that we may maintain certain tenets without carrying out our own individual defense procedure (as long as no founded doubts concerning the impartiality and correctness of the earlier defense procedure arise).

V.

We above already prescribed the psychology of learning with the task of setting up a technical body of knowledge concerning how what should be learned, namely, the mastery of technical and practical difficulties by means of carefully planned action, can be learned.

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[19] Buridan's ass was an ass who died of hunger in between two heaps of hay, because he could not decide, which of the two he should eat.

We can now subdivide this task as follows:

1. The task of deciding what knowledge should be taught

and

2. The task of determining how this knowledge can be acquired.

The psychology of learning has concerned itself very little with the first of these tasks until now. For its mastery we need predictions as to which the range of problem solutions is, which becomes possible because of the body of knowledge in question. Such predictions can, first of all, be made purely analytically. The question of what knowledge should be taught only becomes an empirical problem inasmuch as the predictions depend on what previous knowledge exists, and inasmuch as the existence of specific knowledge does not already guarantee that a person also makes active use of his knowledge. This is particularly connected to the question of the degree to which knowledge can be "theoretical" and still be relevant for action. The advantage of such "theoretical" knowledge consists in the fact that the range of problem solutions which becomes possible - principally - through the knowledge, becomes wider. Passing this knowledge on is justifyable only if this is not just "principally" the case, but factually.

In order to say what knowledge should be taught, we, therefore, need certain pragmatic values. Empirical laws of the nature that all children of a certain age group follow the same rules in their thought and actions[20] and only differ from each other as to which of these rules they have already learned[21] are unnecessary. We especially do not need such laws to explain why a certain person (a certain child) is able to solve some problems, but not others.

The same is true for the mastery of the second task of the psychology of learning, i.e. to determine how the knowledge to be taught can be acquired. This question too - contrary to its factural treatment in learning psychology and, over long stretches, in curriculum evaluation - only partially raises empirical questions. How, for instance, the body of knowledge to be taught can be set up step by step only needs justification through pragmatic values inasmuch as it is a question of deciding if the pupils can identify with the setup of the body of knowledge, what degree of detail is necessary when the teacher deals with the individual

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[20] Cf. Spada, 1976.

[21] Cf. Scandura, 1973.

steps, how the step by step expanded knowledge can (and must) be practiced, etc.

For the fulfillment of its tasks, learning psychology certainly also needs empirical methods, methods with which it can determine what technical and practical knowledge a person has at his fingertips at the moment - before the learning situation in order to determine the amount of previous knowledge (to determine what knowledge should be taught), and during or after the learning situation (to determine the amount of success in teaching and learning).

Hereby it is not just a question of the knowledge a person can reproduce upon questioning, but one of the knowledge which the person actively uses. When a body of knowledge to be taught is a knowledge of norms, the success of learning can only be seen when a concurrence exists between the norms to be learned and the maxims according to which the person actually acts.

Here we face the problem that we do not observe the knowledge that a person possesses, but derive it from the observed behavior of a person. This particular type of derivation shall be called an "interpretation", methodological rules for the justification of interpretations must be construed. Some first methodological rules for the justification of the interpretation of a person's knowledge of means will be sketched briefly in the following.

The suggestions made will show strong parallels to the basic conception of Scandura's theory of learning. They do, however, differ from them on two basic points:

1. Through the rejection of Scandura's behavioristic definition of the term "rule" as a pairing of stimuli and responses, and

2. Through the renunciation of the search for empirical laws of the type that all persons of one - as is said in psychology - "specific population"[22] (e.g. all children of one specific age group) proceed according to the same rules when solving problems and differ only in that some persons have not yet learned the one or the other rule.

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22) The use of the phrase "specific population" is problematic because the word "population" is used, on the one hand, in the sense of a part of the inhabitants and, on the other hand, in the sense of a statistical totality without one's immediately being able to determine the sense in which it is being used from the context - above all, because "specification" of the "population" is not expressly undertaken in most cases.

That a specifif knowledge of means of a person who acts rationally, when the goals are given, allows certain behavior patterns but not others is an analytically true statement for whose justification no empirical laws are necessary. The analytical predictions which can be made on the basis of a person's knowledge of means and which regard the person's actions, are valid in the deterministic sense - just as predictions of behavior in Scandura's theory. That is, they are true when the interpretation of a person's knowledge of means and objectives, as well as his judgement of a situation are correct.

VI.

If a person's knowledge of means is to be interpreted from his observable behavior, the question arises, which are the observation correlates which allow one to infer a certain knowledge of means - or better still, because a person's so called "knowledge of means" can be all manner of nonsense - certain technical opinions[23]. For answering this question we have, on the one hand, at our disposal the possibility of making analytical predictions concerning a person's actions from preconjectures - which, however, cannot be made arbitrarily - about the person's technical opinions. On the other hand, however, we face the difficulty that it is not meaningful to doubt a person's technical opionions and the objectives which he pursues at the same time. Otherwise, every counterargument against an assertion regarding his objectives can be countered with the assertion that the subject has another opinion and every counterargument against an assertion regarding his technical opinions can be countered by the argument that the subject is pursuing another goal than the one which was assumed[24].

For the extrapolation of a person's knowledge of means, we, therefore, have no other possibility than that of producing such situations in which the assumed objectives need not to be doubted. In educational diagnostics, one usually calls such a situation, a test situation. When construing such situations, one must proceed with some thoroughness so that one must not, for instance, doubt if the person - to use the usual mode of expression - has grasped the task, i.e. that possibly agreement exists with respect to the objectives to be pursued in certain situations. The uselessness of data which has been gathered by the usual means in pupil group

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23) I.e. might have arisen on the basis of these opinions at least do not falsify the assertion that the person acted on the basis of these opinions.

24) Cf. Schwemmer, 1976.

tests, and which was noticed by Spada[25] during his efforts to present arguments for a probabilistic approach need not disturb us any further. We are not forced to adhere to this customary ritual of gathering data.

A second difficulty which we face is the question of the beginning: i.e. the question of the preconjectures about a person's technical opinions with which we should begin. Let us here, too, proceed from the maxim that only that should be questioned which can meaningfully be questioned. Thus, we can apply the knowledge which is publicly spread and formulated wherever it is a question of the interpretation of a person's previous knowledge, and, whenever it is a question of determining whether or not the person has acquired the knowledge which we wanted to teach him, we can apply the knowledge to be taught. Then we need reasons for deviation in individual cases. Such reasons are present when an observation correlate of knowledge is absent, i.e. when a person is not able to solve a problem which he should be able to solve on the basis of the assumed knowledge of means.

A third difficulty is the question of how we can arrive at a justified revision of the assumption concerning a person's technical opinions. It is easiest to overcome this difficulty in a certain case - to whose treatment structural learning theory has limited itself: namely, the case in which the knowledge of means in question - similar to the construction rules for the ciphers - can be represented algorithmically, i.e. when all problem solutions conveyed through this knowledge can be broken down into a finite number of steps whereby the knowledge clearly dictates not only the first step but also the transition from one step to the next. In this case, we can choose the test items in such a way that, from one item to the next, at most one further step is added and at most one further rule must be followed. If a person has then solved n items but fails to solve the (n + 1)st item, we can back the contention that it is the rule which has been newly added to the (n + 1)st item which is not being followed. How one can come to a founded interpretation as to which rule a person is then following, can, however, no longer be answered by a critical reconstruction of Scandura's structural learning theory. Instead, it is a research program which must be tackled.

This much can, however, be said today: to do this, the empirical basis of the structural learning theory will have to be expanded by means of, firstly, going beyond the mere operational characterization of the subjects' problem solutions as "correct" or "incorrect"; firstly by making use of information about what

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[25] 1976, p. 45.

is wrong in the student's response and, secondly, by supplementing the empirical reduction of a person's knowledge by means of a genetic reconstruction on the basis of the examples and counter-examples on which the knowledge was to be practiced.

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