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Behavioral Science. Theoretical Models of Learning and Methodological Practices for Teaching

La scienza del comportamento. Modelli teorici dell'apprendimento e pratiche metodologiche per l'insegnamento

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Abstract:
In the first part of this work we focused on the main protagonists of the behaviorist movement (until the 1950s) in order to highlight its most significant aspects. In the second part of this work, however, we will focus on the early methodological models prompted by the main scholars of behavioral science: this development should not be seen as a linear one, since the pedagogical-didactic research has contributed in perfecting its structure despite its weaknesses, especially in Italy, on the empirical-experimental side.

Keywords: behavior, conditioned reflex, stimulus-response; teaching-machines, programming of teaching.

Abstract:
Nella prima parte di questo lavoro ci siamo soffermati sui principali protagonisti del movimento comportamentista (sino agli anni Cinquanta) al fine di evidenziare gli aspetti maggiormente significativi che l'hanno caratterizzato. Nella seconda parte di questo lavoro, invece, abbiamo preso in analisi i primi modelli metodologici che hanno preso piede a partire dai principali protagonisti sopra ricordati: tale sviluppo, vogliamo sottolinearlo, non dovrà essere visto meramente in forma lineare, dal momento in cui la ricerca pedagogico-didattica ha contribuito a perfezionarne la struttura nonostante le debolezze che nel nostro Paese l'hanno caratterizzata sul versante empirico-sperimentale.

Parole chiave: comportamento, riflesso condizionato, stimolo-risposta, macchine per insegnare, programmare l'insegnamento.

1. Observing behavior

Behavioral science aims to know the human being through the study of their external manifestations, drawing conclusions from everything referred to observable behavior; the latter becomes the object of study regardless of the dynamics acting within the individual (some authors have described it as an *anti-mentalist* attitude).
Behaviorism dominated in the United States until the 1950s. However, this movement should not be understood as unitary in its objectives (Zuriff, 1985): on the contrary, it did include multiple theoretical orientations.
We mentioned that the focus is on *observable behavior*, on responses – such as verbal, motor, etc. – that can be registered from the outside, instead of on the acts of conscience, to which there is no access (without recurring to philosophical speculation). From a methodological point of view, it makes use of *objective observation* (or *experiment*), guided by precise rules. Therefore, psychology seeks a status similar to the one of natural sciences, freeing it from everything that cannot be subject to verification (Castiglioni, 2001; Legrenzi, 1994).

2. Russian physiology

Russian physiology had undoubtedly a relevant influence on behaviorism: the one who will be remembered as the "father" of Russian physiology, Ivan Michajlovič Sečenov (1829-1905) sets aside the old, unproved conceptions, elaborating through experimental investigation a theory of psychic faculties. In 1866 he published the pamphlet *Refleksy golovnogo mozga*[1], where he

[1] *I riflessi del cervello* has been published in Italian in 1971 in Rome, by Editori Riuniti: we recall that one of the first titles of the work, according to the author, should have been something as *An attempt to physiologically explain psychic phenomena*, a title that was going to be rejected by the tsarist censorship, mainly for ideological reasons.

demonstrates that human behavior has its origin in reflexes, including complex activities such as, for example, thinking. The concept of *reflex* becomes its unit of analysis: according to the reflex arc scheme, in the animal an environmental stimulus produces a motor reaction whose mediation, automatic and involuntary, is caused by the nerve centers located in the spinal cord. Sečenov, in addition to this type of reflexes, believes that there are other ones, whose importance is paramount, controlled by the brain centers and constituting the engine of voluntary activity. We would therefore consider two types of behavior, whose dynamics of action are the same: the first, the lower one, whose control must be attributed to the spinal centers; the second, the higher one, whose control, on the other hand, will lie within the brain centers (Mecacci, 1999). His approach, at least in his initial writings (Mecacci, 1977), proves to be strongly *reductionist*, having entirely traced back psychic processes to physiological ones: psychic activity is understood as a complicated series of reflex acts (linked together and integrated), whose etiology is due to the mediation of brain structures.

The work of Ivan Petrovič Pavlov (1849-1936), we could say, develops and realizes the Secenovian intentions of including psychological phenomena within the physiology of the nervous system, thus making psychology a sort of "brain science". Pavlov spent about twenty-five years studying the functions of the cardiovascular and digestive systems, and his research results earned him the Nobel Prize in 1904; after the prize, he pioneeringly focused his attention on physiological processes (once the object of introspection in psychology) called *conditioned reflexes*[2]. According to Pavlov, conditioned reflexes, which are regulated by the cerebral cortex and which are acquired during ontogenesis, allow the animal organism to act in the environment – going beyond the innate sequences of stimulus and response – with greater plasticity, thus favoring a better adaptation to it. Conditioning is the general law that guides all functions of behavior: this means that recourse to the mind becomes superfluous; instead, it will be necessary to focus on the characteristics of the environment and how it interacts with the organism.

Here we will not report all the phases of his famous experiment on conditioning, but we will look at some of such phases in order to understand the scientifically surprising results of his work as a scientist. We know that when food is put into its mouth – that is, in front of an *unconditional stimulus* – a dog emits saliva, namely, it produces an *unconditional response*: this means that reflexes such as swallowing deriving from a particular stimulation occur naturally. However, during the experiments, Pavlov noted that the dog emits saliva even when food is not put into its mouth, for example when the dog hears a ringing of a bell – the stimulus – which previously was been operated several times shortly before feeding. The dog responds by emitting saliva in the same way, thus providing a conditioned response to a stimulus – the sound of a bell – which, from a *neutral stimulus*, becomes a *conditioned stimulus* (the adjective *conditioned* is used to emphasize that both the stimulus and the answer are as such *only* in the case in which specific conditions are met). The stimulus is exactly the same, its physical nature remains unchanged: what has been changed,

[2] Pavlov, in 1924, wrote an essay on conditioned reflexes including a series of conference speeches: *Dvadcatiletnij opyt ob" ektivnogo izučenija vyššej nervnoj dejatel' nosti (povedenija) životnyh* [A twenty-year experience of objective studies on the higher nervous activity (demeanor) in animals], translated in English in 1927.

however, is its psychological role, since it is capable of provoking a response that it previously did not arouse (Santoianni, Striano, 2003). Pavlov, therefore, realizes that any stimulus could have triggered the same reaction (salivation), as long as it aroused the dog's attention. Through rigorous experiments, Pavlov, in addition to conditioned responses, studied other phenomena: reinforcement, extinction, spontaneous recovery and so on.
In regard with some interpretations that are sometimes encountered regarding the coincidence of Pavlovian theory with behaviorism, we would like to emphasize that the Russian physiologist strongly disagreed with North American scholars in the field (Mecacci, 1970)[3].

3. Prominent figures in the behaviorist movement

In 1913, John Broadus Watson (1878-1958) published in "Psychological Review" the article *Psychology as the Behaviorist Views it*, considered the programmatic manifesto of behaviorism; the first systematic work on behaviorism came out the following year with the title *Behavior: an Introduction to Comparative Psychology* (1914) TOG. Watson aims to allow psychology to acquire the dignity of an objective science, like natural sciences. With the gaze of the experimentalist, he sees several disagreements between scholars of mental states, due to the subjective character of such studies. According to Watson, introspection is not a scientific methodology, since it does not allow to obtain verifiable results. He aims to exclude from scientific research the study of consciousness (considered an impenetrable *boîte noire*), although, we want to point out, he still does not deny its existence (Thomson, 1972).
Innate reflexes and basic emotions aside, behaviors exhibited by humans are acquired in the environment through a long period of concatenation of conditioned stimuli and responses. Therefore, even the most complex human behaviors are the result of a combination of simpler behaviors (Meazzini, 1980): language, for example, is acquired through conditioning (Oléron, 1975).
Functionalism clearly played a decisive role in Watson's culture; some ideas of Darwinian evolutionism, such as the adaptation of the organism to the environment and the substantial continuity between the TOG. animal and human behavior, are fully embraced by the American scholar and by behavioral psychologists in general. Therefore, the animal can be studied – also for the advantages that this approach entails – in order to know the psychology of man, i.e., the behavior (between animal and human there is a functional analogy – or at least a similarity – rather than a biunivocal correspondence). Hence, Watson challenges – in accordance with Lloyd Morgan's thesis, later developed by Edward Lee Thorndike – functionalist research, because it aims to explain the behavior of animals from a *consciousness-inspired*, and therefore *anthropomorphic* perspective

[3] Pavlov, answering to the objections that Guthrie raised towards him, writes that one thinks that the psychologist, recently separated from the philosopher, has not yet completely freed himself from the passion for the philosophical method of deduction, from the procedure of pure logic, which does not verify at every step the correspondence between thought and reality (Pavlov, 1950).

(Miller, 1964)[4]. Two among Watson's principles are essential in explaining the consolidation of behavioral habits: the principle of *frequency*, and the one of *recency*. These principles state, respectively, that the more often and the more recently a stimulus-response association has occurred, the more likely it will occur again. The principles of classical conditioning are also adopted by Watson to explain some emotional reactions such as fear: the newborn has three forms of innate emotional reactions, namely fear, anger and love, therefore emotional learning is explained as the conditioning of these three emotional reactions in presence of specific stimuli. In the well-known experiment conducted with Rosalie Rayner, the two scholars note that a nine-month-old baby, Albert, shows no signs of fear in front of animals or inanimate objects, while showing fear hearing a metallic sound produced by a hammer beaten on a rod. During the experiment, a white mouse is presented to Albert and at the same time the unpleasant sound is produced: by repeating the *mouse-unpleasant sound* association several times, Albert begins to cry at the mere sight of the mouse or similar animals. The noise, in this case, is considered the *unconditioned* stimulus of fear, while the mouse is transformed into a *conditioned* stimulus of fear (Smith, 2004). One of the key concepts of behavioral psychology is indeed the notion of *plasmability* of human conduct, from which derives the belief that the differences between individuals are not hereditary – and therefore immutable – but strictly linked to the subject's own experiential circumstances (a possibly democratic point of view).

Many scholars consider Edwin Ray Guthrie (1886-1959) very faithful to Watson's original theses. Guthrie believed that learning occurs through a change in behavior, the cause of which lies, quite simply, in the temporal contiguity between a stimulus and a response (he and Watson, in fact, are remembered as the *theorists of contiguity*). If a stimulus is associated with a response, it is subsequently verified that the same response is associated with the same stimulus. Guthrie identifies behavior with *movement*[5]. In the framework of a simple but *rigorous* theory (unlike Watson's one, which proved to be deficient from an epistemological point of view) he highlights that movements are the only observable facts, and that stimuli and responses are contained in the movements themselves (hence attracting fierce criticism because of his *reductionism*). It should be noted that he introduced a distinction between *simple movements* and *acts*: the former, on which he focuses his attention, must be understood as motor responses, while the latter as complex combinations of movements that can be explained but not experimentally verified.

Edward Chace Tolman (1886-1959), drawing on the neo-empiric philosopher Edwin Bissel Holt's theses, proposes a *molar* approach to the study of behavior, compared to Watson's *molecular* approach related to the movements of muscles and glandular or neural secretions: while, according to Watson, behavior could be reduced to simple units – stimuli and responses –, Tolman sees behavior as dependent on associations between sets of stimuli and sets of responses. Within a molar

[4] We owe in particular to Morgan the methodological criterion, known as the Morgan canon, according to which an action must never be interpreted as the result of a 'higher faculty', if it can be explained as the expression of a faculty located more at the bottom of the psychological scale. This is a criterion that every human observer should keep in mind to avoid falling into the recurring temptation to anthropomorphize animals (Cardaci, 2012).

[5] In his work *The Psychology of Learning* (1935, p. 23) Guthrie writes: "A combination of stimuli which has accompanied a movement will on its recurrence tend to be followed by that movement" (quoted in: Hill, 1970, p. 47).

approach, when we consider the behaviorist movement in evolutionary perspective, it is unavoidable to discuss the denial of stimulus as exclusive cause. Tolman believes that other variables must be added to it, variables defined as *interfering* or *intermediate*, which are not directly observable but inferentially deduced, and whose origin is of a hereditary or remote nature; they mediate the links between the stimulus and the response (such as age, fatigue, gratification, temperamental traits, beliefs, cognitions). The S-O-R formula (Stimulus → Organism → Response) substitutes the S-R formula (Stimulus → Response). A turning point has clearly been reached: the assumption that learning was be the result of stimulus-response concatenations is overcome; although the scholar has avoided *mentalistic degenerations* (Tolman, 1925), the intermediate or intervening variables become a necessary condition for learning (Morabito, 2007). Especially on molar behavior, the American psychologist – certainly inspired by the thought of his mentor Hugo Münsterberg – is able to identify intentionality (the *purpose*) and cognition (the *sign structures*): he believes that both animals and humans want to achieve goals (*intentional behaviorism*), and this induces them to act in one way instead of another.

Moreover, cognitions are present both in human and animal: problems are not necessarily solved through *trial and error* but through mental representations (*cognitive maps*), provided by the environment and conceived during the process (a form of *latent* learning); they produce expectations necessary to address the new problem (Tolman, 1948). Hence Tolman has been considered a precursor of cognitivism (Belluardo, 2008).

A similar perspective is proposed by Clark Leonard Hull (1884-1952). He aims to find the biological processes (even if not directly observable) underlying the behavior under analysis: this is the case of the *intervening variables* mentioned above, of which he introduces new typologies. A typical intervening variable introduced by Hull concerns the concept of *force of habit*, meaning that the subject's responses react to stimulations diversely, with different intensity depending on the variables involved, including, for example, the pulsional state of the organism (Hull, 1943). We specify that the link between stimulus and response, produced by habit and *suitably reinforced*, grows progressively: there is a clear reference to Thorndike's "law of effect" (as we will see); however, differently from Thorndike, reinforcement is considered the satisfaction of a primary impulse (need), therefore linked to survival, and of a secondary (or learned) impulse that is not essential, but connected to the adaptation of the organism to the environment.

Tolman and Hull, defined as "mediators", aimed to highlight the insufficiency of the S-R links through the concept of intermediate variables, since these links are limited to the peripherals of the organism, such as glandular, sensorimotor, etc. Although the two scholars do not deny that the matrix of their thought is behaviorist, they do not rely uniquely on the data coming from observation, to make room for mental processes able to restore a more complex image of man.

Burrhus Frederic Skinner (1904-1990) focuses, among other things, on *operating conditioning* (Skinner, 1938), which assumes that the response precedes the stimulus rather than following it as in Pavlov. In the Pavlovian experiment, as we have seen, the stimulus (food) causes the response (salivation), while in the logic of operating conditioning it is evident that the body emits the response more frequently when it is followed by a reinforcement. It is defined as *operating* conditioning because the behaviour *acts*, operates on the environment in order to produce a certain effect (Trisciuzzi, 1999). The bestknown experiment concerns a hungry mouse who, inside an

experimental set, while exploring the environment presses a small lever and realizes that, thanks to this pressure, it obtains food; the rat will press the trigger again, this time voluntarily, and will get food again. The experiment allows the psychologist to understand that an operating behavior is consolidated (as well as by practice) whenever it is followed by a reinforcing stimulus. Skinner draws on Thorndike's "law of effect", and both emphasize the role of *reinforcement* as a fundamental element of the learning process. Compared to classical conditioning, in this case we can see that the body acts autonomously *regardless of external stimulations*; although stimuli play an important role, Skinner believes that the organism itself produces behaviors.

We will return later to Skinner: here we close this short overview with Edward Lee Thorndike (1874-1949), who, despite being an exponent of *functionalism*, has been defined in the literature as a behaviorist *ante litteram*. A pupil of William James and Lloyd Morgan, he was the first theorist of reinforcement, although he does not use this term; "reinforcement" is the term used by Skinner to express what Thorndike calls the *law of effect*. Unlike his masters, who argued that what strengthens the link between the stimulus and the response depends on the responses themselves, Thorndike, although accepting this idea, emphasizes the role of *satisfaction* linked to the response, while the bond weakens in the event that a *nuisance* intervenes.

His interest is projected on stimulus-response *associative connections*. Thorndike, who defines his theoretical system as *connectionism* (a particular form of associationism)[6], promotes multiple experiments on what he calls "animal intelligence". We recall the experiment with the cat reported in one of his main works *Animal Intelligence: An Experimental Study of the Associative Processes in Animals* (1898); in the prototypical situation a hungry cat is locked inside a cage and tries in every way to get out of it to reach the food placed outside; in the cage there is a latch able to open the door; after several attempts (by biting, scratching, etc.) the cat is able to operate the latch and, therefore, to go out to reach the food. In subsequent attempts, the cat tends to gradually eliminate errors and repeat the actions allowing it to get out of the cage. Thorndike believes that the cat, in order to get out of the box, uses a form of learning "by trial and error" (regulated by the two laws of exercise and effect), where success is built slowly: with *exercise*, the animal selects the most effective answers (we speak, in this regard, of *mechanical learning*, as the animal remembers the effective answers and discards the wrong ones). He tries the experiment several times, and the psychologist notes that the cat was able to get out faster through more coordinated movements, and for this reason he defined the *law of exercise*.

It should be added that the relationship between the finding of the way out and the food has allowed the scholar to enunciate the aforementioned *law of effect*, which explains that a success tends to repeat itself more easily when it is reinforced (in this case from food), while useless actions are generally removed (Ballanti, 1988).

4. Rationalizing teaching: towards a scientific pedagogy

[6] Thorndike defines his conception as 'connectionist', meaning that psychic processes are made up of innate or acquired connections between the situation and the response. While traditional theories tried to grasp associations between the contents of the mind, connectionism, the result of its comparative investigations, analyzed the associations between environmental events that affect the sensory apparatus and the motor responses that are produced (Caramelli, 2001).

In the second part of this work we will focus on the early methodological models prompted by the main scholars of behavioral science: this development should not be seen as a linear one, since the pedagogical-didactic research has contributed in perfecting its structure despite its weaknesses, especially in Italy, on the empirical-experimental side.

4.1 Teaching machines

Skinner publishes in 1954 a speech given at a conference, considered as the *manifesto of programmed education* (Skinner, 1958)[7]. After this publication, the discussion on planned education began in many countries (e.g. in U.S.S.R., Germany, etc., while in Italy the theme began to be discussed *only* around the seventies).

With "programmed education" we refer to teaching methodologies aimed at rationalizing the teaching process. Although many prejudices have arisen about it (possible mechanization, excessive confidence in self-education, etc.), we can observe that it allowed to shift teaching from an intuitive and non-scientific situation to one based on research and experimentation.

Skinner replaces Sydney Leavitt Pressey's *testing machines* (namely, self-correcting machines for objective tests) with proper *teaching machines*, which transmit information and *reinforce* (making the students aware of their mastery of the subject) the correct answers (Pressey, 1926; Pressey 1927). Skinner thinks that teaching *lacks in reinforcing* the pupils' performance: the pupil learns almost exclusively to avoid unpleasant events such as a low grade, the teacher's call, humiliation from classmates, etc. Some clarifications are needed on programmed instruction: it does not intend to support a purely mnemonic teaching based on notions; on the contrary, the use of teaching machines aims to provide students, in the best possible way, with basic knowledge, on which it is possible to graft, through various methodologies, more complex knowledge. From a didactic point of view, it would be ineffective to work for the achievement of high levels of formal learning, if the pupils are weak in elementary learning. Another issue concerns the automation of teaching which seems to replace the teacher with a machine: since the role of the teacher is essential, this critique can be easily dismissed.

In order to dispel this prejudice, let us see how the *linear or extrinsic program* (Skinner, 1958; 1968) proposed by Skinner is structured. The program includes learning units, *frames* (structures or photo-frames), to be presented one by one to the student; each frame contains different information, prepared with great care, with the intention of being as clear as possible. Each unit of information is followed by a very specific evaluative question to which the student must answer: once the answer is provided, the student moves on to the next unit and he knows whether the answer provided is correct or not. In this case, students *must build the answer* (they do not find it ready as in the case of structured tests) by writing it in an *ad hoc* space. Skinner prefers a self-constructed answer, because in his opinion it favors the *transfert* better than the already structured one. In the case of Pressey's machines or, as we will see, in Crowder's, the evaluation item is a multiple choice prepared by the teacher: Skinner, on the other hand, believes that it must be elaborated by the student himself, who risks to learning the wrong answer he had himself chosen.

[7] We want to clarify that Skinner, although not the only one who has studied this teaching method, was able to generate large interest in this type of teaching.

The programming of the material to be taught also involves the repeated presentation of the same concept, albeit with different words: this means that the information units must be *redundant*. Redundancy is a characteristic of Skinner's programming: if the student must be systematically reinforced, the conditions must be created *so that he does not make mistakes* (students, in the opinion of the American psychologist, do not learn from mistakes, because they lead them to failure and therefore to punishment); this means that to ensure effective learning it will be necessary to facilitate the didactic path by minimizing the possibility of making the mistake, also through *prompting*, a set of suggestions aimed at guiding the student to answer correctly.
Obviously, the Skinnerian program cannot be shortened: on the contrary, it requires diversified commitment and skills (the contribution of the psychologist, of the subject matter expert, and of the technician). Last but not least, there is the principle of adaptation: it is advisable to respect the student's *learning rhythms* (an aspect that was widely formalized, later, by John Bissell Carroll in the context of *learning for mastery*) in order to allow him to achieve the goal.
As we have seen, the teaching machine, in addition to providing information, *requires information* and therefore an active participation of the student; this means that the information flow is bidirectional: the student is guided in order to understand how to learn actively and in an increasingly autonomous way.
Norman Allison Crowder (1921-1998) was another theorist of programmed education. In a controversy with Skinner, he criticized the *linear* structure of his program by proposing a more complex *branched* definition. How is Crowder's *intrinsic* or *branched* program structured?
The student is presented with a frame containing a greater amount of information than the Skinnerian one, followed by a structured multiple choice test: Crowder, unlike Skinner who required the student to construct the answer, believes that it is important to learn to distinguish - discriminate - what is correct *versus* what is not (Crowder, 1962). The students will have to choose one of the alternatives and if they answer correctly, they can move on to the next frame. If they choose an incorrect alternative, they could recur to a secondary unit (i.e. alternative material) to clarify why the chosen answer is incorrect; there is also the opportunity to benefit from additional learning material, structured differently than the previous one. If the one just described is the simple branched program, there is also the complex one which has more branches. It implies asking questions following the recovery, and, in the event that the students make new mistakes, they will have to be sent back to alternative units and so on; in other words, the ramifications will have to be increased as long as it is deemed appropriate. We are here getting closer to the princeps model of individualized teaching: *mastery learning* (Bonazza 2021). In Crowder's device, attention is paid to both the *learning rhythms* of individuals and the *training path*, similarly to mastery learning, in the moment of recovery/consolidation. Moreover, we find particularly interesting the different role played by the feedback in the two authors: according to Skinner, feedback is a simple *informational reinforcement* and serves to communicate to students the accuracy of their cognitive behavior; while according to Crowder, in addition to approving the student's response, it illustrates the motivations behind the response itself or, in case of error, explains the underlying reasons (Varisco & Mason, 1989). It may be noted that Crowder does not find the error dangerous as Skinner did: on the contrary, he believes that the incorrect answer may be useful for diagnostic purposes, necessary to adapt the training path to the needs of individuals. We will not discuss this matter further: or the

purposes of our discourse it was important to highlight the close link (not an overlap) between the laws of learning (law of exercise, effect and reinforcement), which constitute its theoretic foundations, and the construction of courses and teaching materials; and to remember, among other things, that not all the many proposals for programmed education have their roots in the behaviorist movement.

4.2 Programming of teaching

Beyond teaching machines, it is important to keep our attention – in order to better understand the educational "implications" of behaviorism – on the broader concept of *programmed teaching* (we are referring to the first forms of didactic programming, of which here we will trace the main coordinates). It is the type of teaching which provides for a more accurate *rationalization* of educational practice; planning schooling means preparing an itinerary characterized by progressive learning sequences aimed at achieving specific objectives. If the students make mistakes, most likely this means that something is wrong with the planning of the work and will therefore have to be revised. In this framework, the concept of *effectiveness* will have to be traced back to what was *taught* and not only – as often happened – to what had been achieved by the students.

To understand the dynamics underlying the programming of teaching we must resort to the concept of *reinforcement* (the specific one of *operant conditioning*)[8]. The reinforcement, essential during teaching, will have to be placed in time following the production of a response; this means that the teacher intervenes directly to confirm (or disconfirm) the answers of students: good, continue, right, (or, on the contrary, *pay attention*, *try again*, *reflect*) are direct reinforcing behaviors that produce learning. The comparison between the didactic practice of operating conditioning with that relating to responding conditioning is necessary: in the context of the *respondent conditioning* model, the teacher has the burden of eliciting the student's responses (controls them through the stimulus) on the basis of the laws of exercise; that is, the teacher shows how to solve a problem (illustrates the different steps) and the students too, through the exercise, learn to solve it.

In the context of the operant conditioning model, as we have said, it is the student's response that determines the reinforcement (since there is no *ad hoc* stimulus that causes it); the teaching does not directly elicit the answer, but directs the students to discern the best one.

A further concept of essential importance on didactic programming is *intentionality*, which we can explain as an anticipation of the goal to be achieved. Between intentionality and programming there is a relationship of circularity: intentionality or the "tension towards" requires programming, which in turn, being the rational planning of a path, needs intentionality; both require that the goal to be reached is prepared *a priori*; the objectives to be achieved (both intermediate and final), if clearly arranged, multiply the possibilities of being able to develop an habit. Above, we have seen how Tolman inserts the teleological dimension in his research, implying that both animals and man do not learn mechanically, but pursuing goals that they reach through previous learning.

[8] For a study on respondent conditioning and operant conditioning, see: Hilgard & Bower, 1970, a book which, among other things, as the writer of the preface Dario Romano stated, constitutes a real "summa" of behavioral knowledge.

If, in order to learn, every *signal* is useful for the subject to reach the goal[9], also in teaching it is important to direct the entire learning behavior in order to allow students to achieve the goal. In the context of didactic planning, objectives have a leading role: if they have been *well built*, much of the work has been done (we should remember that one of the main characteristics of an objective is *observability*). From the accurate build-up of objectives, methods and learning sequences will proceed; more in general, we will derive the entire itinerary to be followed. It should be emphasized that the necessary condition for achieving the final objectives are the *entry prerequisites*: without the possession of basic knowledge, the desired learning will not occur.

The third essential concept in the context of didactic programming is *rationality* (Ballanti & Fontana, 1981): programming requires rationalizing the order of succession. The methodological itinerary, divided into phases, will follow a rigorous temporal order: 1) the definition of the objectives (as we have seen before); 2) the initial assessment (to ascertain the entry conditions of individual students and the teaching materials available); 3) the presentation of the task (strategies, methods and everything that can contribute to the achievement of objectives); 4) the final evaluation (to check the results achieved, if the means have been adequate, and provide feedback if the objectives have not been achieved). It is evident that the order of the four phases must be respected, in order to preserve the fair programming.

Additionally, programming requires to *rationalize the order of achievements*: what needs to be learned requires an order, and a good warranty of order are taxonomies (also called *performance lists*). We recall – albeit passingly – that Robert Mills Gagné and Benjamin Samuel Bloom have developed *hierarchical* taxonomies that proceed from the simplest learning to the most complex (Bonazza, 2012). Gagné's taxonomy is based, unlike that of Bloom, on precise learning laws, and prescribes the steps of the teacher following an order of increasing complexity. The importance of feedback should also be mentioned: teachers provide feedback to students, for example, when they correct their homework, making them know if they have achieved satisfactory results or not; it is clear that these feedbacks, in turn, affect learning by allowing it to be adjusted. The students themselves produce feedback, for example, showing satisfaction, boredom, or even difficulty in learning while listening to a lesson; it is evident that these feedbacks influence teaching, favoring a change of route. It may have been noted that the concept of feedback is superimposable to the one of *evaluation*: therefore the latter, more than in traditional teaching, becomes part of the teaching process itself. The behaviorist lesson taught us that evaluation allows the teacher to guide the path and keep it constantly monitored in order to direct the students towards the objectives established *a priori*: an evaluation understood simply as a final judgment gives way to an evaluation that accompanies the entire teaching itinerary until it becomes, in Bloom's words, the pivot of the *quality of education* (Bloom, 1976; Vertecchi, 1978).

[9] Tolman emphasizes that subjects learn the meaning of environmental stimuli (namely, signs) and that each single signal refers to the entire context, that is, to a *Gestalt*.

5. Terminological carelessness

The reader may have noticed that in this contribution we have never used the term *paradigm* (we refer to the concept of paradigm in the Kuhnian sense) as opposed to what has happened in other works dealing with similar topics. We believe, in fact, that Thomas Samuel Kuhn wanted to mean by this concept something that does not fit well with our contents: it is therefore necessary to understand, at least in its essence, the Kuhnian arguments in order to draw the necessary conclusions. In his (now famous and much discussed) work *The Structure of Scientific Revolutions* (1962)[10], the American historian of science highlights that scientific development (not to be intended as linear and cumulative) is marked by *revolutions*. In each revolution two antithetical positions oppose themselves, and as soon as one of them wins – generally the more recent theory overthrows the past one – the winning theory (the new paradigm) dominates the scene while the losing one is confined to the realm of historical research. A commonly reported example concerns the Copernican system which supplanted the Ptolemaic one. We therefore want to clarify that the scientific revolutions that allow the succession of one paradigm to another should not be considered, with respect to what Karl Popper (Giorello, 1976) said, as refutations of previously accredited hypotheses, but as overall changes in the reference framework (paradigm) of the scientific community. The new theory establishes a phase of normal science: scientists, within a shared theoretical framework, promote and implement various kinds of research and if divergences arise, they are not related to the main theory but to methodological failures. Researchers do not communicate with those of the old paradigm since the theoretical products of the new one are "immeasurable" (literally, there are no common measures): they belong to a different world and there is no common language (although some form of comparison is always possible). In the event that there are clashes, differences, antinomies, etc. inherent to the theory – which end up questioning the uniqueness of the reference paradigm – we are in the phase of an immature science, therefore preparadigmatic. It follows that psychology, according to Kuhn, is still in an immature phase and, consequently, is not yet in a position to define itself as normal science; the reason for this statement lies precisely in the fact that in the psychological field we are not in a position to speak of a unitary paradigm, but *we are witnessing the simultaneous presence of several schools and therefore the coexistence of alternative approaches*. Mainly for this reason we have witnessed, by many, the adoption of a *simplistic Kuhnianism* (Mecacci, 2003) which has improperly defined the various theoretical orientations (behavioral paradigm, psychoanalytic paradigm, etc.) as "paradigms".

Subsequent epistemological orientations have proved more consonant – mitigating the rigidity of the Kuhnian paradigm – with what has happened within the history of psychology, such as those of Imre Lakatos and Larry Laudan; the latter, as Dario Antiseri (2004, p. 163) reported, is convinced that both Kuhn's *paradigms* and Lakatos' *research programs* are - not to mention other defects – *too rigid*. And Laudan tries to overcome the difficulties in which Kuhn and Lakatos incurred, proposing his own theory of *research traditions*. Behaviorism, for example, in this perspective, can be seen as a research tradition with multiple theories (think, as we have seen, of

[10] We point out that the concept of *paradigm*, in the 1969 edition, is further specified in the postscript, as in the original edition multiple semantic oscillations were found.

Guthrie or Hull) that can even be conflicting. The praised "cognitivist revolution", which saw the victory of cognitivism over behaviorism, did not actually occur since both belong to different research traditions; on the contrary, it has happened that in some cases behaviorism proceeded parallel to cognitivism, in others that there were prevailing attitudes; it has not happened that the cognitive paradigm has definitively won over the behavioral one, in the Kuhnian sense of reestablishing a new normal phase of psychology in which this science assumes the cognitive assumptions and throws those of the old behaviorist paradigm overboard. If, according to the most accredited epistemological and historical analyses, such clear changes did not occur in the history of physics or other sciences, it is likely that such a 'revolution' has similarly not occurred for psychology (Mecacci, 2003, pp. 48-49; Mecacci 2019).

6. A non-conclusion

In this initial analysis, our aim was to draw the reader's attention to a scientific movement which was subject, also in scientific literature, to ideological criticism and to scarcely useful textbook simplifications. On the contrary, we believe that the richness of scientific innovation due to experimental research, the breadth of the debate promoted, among others, both in the psychological and pedagogical context, the proliferation of didactic models, would have deserved a more open-minded attitude, fostering more interest, studies and research. We are far from proposing a nostalgic apology of behaviorism: we were interested in highlighting – paying attention to avoid the classic cognitive bias known as "hindsight" (Moderato & Presti, 2013, p. 16) – the precious advancements produced *in its time* by behaviorism, whose didactic implications are still extremely relevant.

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