
FROM CONDITIONING TO STATE-DEPENDENT LEARNING

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ABSTRACT

In re-examining whether mankind can rely on a free will, conditioning is first taken into consideration in its two types as a learning process typical of mobile beings and as a form of hypnotic trance. Rossi and Cheek's research work on the unconscious perception of meaningful sounds during surgical anaesthesia led to the belief that Pavlov's and Skinner's conditioning is a form of state-dependent memory learning and behaviour (SDMLB), a hypothesis shared by other researchers. SDMLB is analysed with its consequences on free will and contrasted with a personal belief in a new law, 'the law of imperfection', which undermines all rules and certainties.

Key words: learning, behaviour, state-dependent learning and behaviour, 'law of imperfection'

INTRODUCTION

Conditioning is just one form of the many processes with an adaptive value. It apparently unfolded with many others in the course of natural selection to favour the development of the ambitious project of some wanton boy with a lot of clay, or primordial matter, at his disposal and no need to be logical, economical, or productive, as the high percentage of discarding and extinction proves (perhaps over 80%). So far, the main determinants of our behaviour are biological, environmental, cognitive, and unconscious. Yet, here we are, once more, to re-examine whether mankind can rely on a free will.

A FAMOUS CONDITIONING

Very few people have read Marcel Proust's seven-volume masterpiece, *À la recherche du temps perdu* (1913–1927/1954), but almost everybody knows what a *madeleine* is and the profound influence of an ever-present conditioning on the Western cultural and literary history of the twentieth century. In exploring the power of memory and the unconscious, Proust states that it is the artist's task to recover, together with lost times, the vital non-material elements to which habits have made us blind (in opposition to Sainte-Beuve's popular view that in order to understand an artist and his work we must understand his biography).

Thirty years after his childhood holiday at Combray, Proust tastes a *madeleine*, a biscuit, dipped in a cup of tea:

... et tout d'un coup le souvenir m'est apparu. Ce goût, c'était celui du petit morceau de madeleine que ... ma tante Léonie m'offrait après l'avoir trempé dans une infusion de thé ou de

tilleul. La vue de la petite madeleine ne m'avait rien rappelé avant que je n'y eusse goûté ... mais quand d'un passé ancien rien ne subsiste, après la mort des êtres, après la destruction des choses, seules, plus frêles mais plus vivaces, l'odeur et la saveur restent encore longtemps comme des âmes, à se rappeler, à attendre, à espérer, sur la ruine de tout le reste, à porter sans fléchir, sur leur gouttelettes presque impalpable, l'édifice immense du souvenir.

Memory beats ruins and time. For many of us, Proust's experience was a splendid example of classical conditioning (in a cenaesthetic subject) yesterday, and of a state-dependent memory today.

WHAT IS CONDITIONING?

Two contemporary geniuses laid the foundations for a scientific study of the mechanisms and laws of mind–body communications: Freud and Pavlov. Freud picked out the roots of anxiety: 'Goaded by the id, hemmed in by the superego, and rebuffed by reality, the ego struggles to cope, but when it is forced to acknowledge its weakness, it breaks out into anxiety' (Freud, 1968). Pavlov, a Russian physiologist, identified the force of the conditioned (classical) reflex (typical of the dreamers) and opened the way to the awareness of the strength of a second conditioning force: the operant (to be found in the doers). He introduced the word 'conditioning' while studying the process of salivation in dogs strapped into a harness, by making holes in their cheeks (Babkin, 1949).

If someone looks up the word 'conditioning' in an English or an Italian dictionary, very seldom can he find it. Alternatively he is invited to look for another word, 'learning', of which it is an extremely simplified form, and which is defined as 'any relatively permanent change in activity that results from experience with the physical and social environment' (Morgan & King, 1956), which memory can then make available for problem-solving.

According to the *Encyclopædia Britannica*, 'conditioning' is a form of learning in which either (1) a given stimulus becomes increasingly effective in evoking a response, or (2) a response occurs with increasing regularity in a well-specified and stable environment. In physiology, it is a behavioural process whereby a response becomes more frequent or more predictable in a given environment as a result of reinforcement. Conditioning can also be defined as 'two types of an elementary associative learning process, seen in many invertebrates and all vertebrates' or frail mobile beings to better adapt them and survive in a contradictory, inconsistent world where the primitive forces of their emotions are dangerous and devastating. Being relatively free of innate and automatic behaviours, man is the most adaptable and flexible of all species (still wondering on his own self-determinant capacities).

CLASSICAL CONDITIONING

The first class of learning is classical (or Pavlovian, associative, or respondent) conditioning or the conditioned reflex. The theory is based on the classical experiments of Pavlov and the Eastern European scientists who have adapted and developed reflex psychology. The essential operation is attaching an already known response to a new stimulus by pairing the two. One, initially neutral, is called the conditioned stimulus (CS); the other, which consistently elicits a response, is the unconditioned stimulus (US). Its response is the unconditioned response (UR).

As a result of the pairing of CS with US, the previously neutral CS comes to elicit the conditioned response (CR).

The essential requirement for conditioning is that the two stimuli will occur together or with the new stimulus slightly prior to the old one. No learning, or very little learning, occurs if the old stimulus is presented before the new one (like giving a child a reward before he performs a task).

All these phenomena were called 'excitation' by Pavlov (whose theory was based on strictly physiological determinism; he considered himself a physiologist and did not seem to have a good opinion of psychology). He soon discovered that the conditioned reflex could be easily disrupted by the complementary fact of 'inhibition', either external or internal, which led to the 'extinction' of the phenomenon, but could be counteracted after a reasonable pause by a spontaneous 'recovery'.

So inhibition is an active process, produced by experimental extinction which counteracts the effects of excitation in a process where inhibition dissipates more quickly than excitation. Does this mean more freedom?

Pavlov's discoveries were exciting. But the dogs subjected to seemingly innocuous procedures of difficult or prolonged conditioning developed serious signs of emotional disturbance which tended to chronicize. When a dog was confused about whether a signal meant food or no food, it became extremely worried or anxious and this sometimes led to the equivalent of what we would call a nervous breakdown. It was a further exciting discovery. In Pavlov's lab it became a standardized manoeuvre to cause 'experimental neuroses' in dogs at will.

THE EXPERIMENTAL INDUCTION OF NEUROSES

Pavlov's theory on the origin of neuroses, and the possibility of studying conditioning in the lab, started an unusual series of experiments and observations on normal behaviour (its function in the formulation of simple 'habits') and neurotic behaviour in animals and humans. It was based on the assumption that maladaptive behaviour results from deficient conditioned reactions (a failure to acquire adaptive responses as a consequence of defective conditioning powers), lack of opportunity to learn, and a surplus of conditioned reactions – maladaptive anxiety reactions learned under certain conditions and generalized to other situations (Thomson, 1968; Coleman, 1950).

To the same end, Dollard and Miller (1950) used the analogy of a very hungry man confronting food, which he knows is poisoned, to emphasize the conflict between incompatible drives.

Just to mention a few of these experiments: Masserman (1978) conditioned animals to respond to a food signal; then he associated a noxious stimulus with the feeding situation, creating anxiety, phobic reactions, somatic and motor dysfunctions, and repetitive activity, such as pacing back and forth in the experimental cage. Homosexual and autoerotic activity increased even in the presence of receptive females. The dominant animals lost their position and were frequently attacked by other members of the colony. Combs and Snygg (1959) listed the consequences of impossible choices: constant tension, inability to sleep, vague aches and pains, emotional lability, and inability to concentrate. Shapiro (1962) theorized an intrapsychic conflict between various subselves (trying to be the self his mother, father, or other people expect) in a poorly differentiated individual.

TWO FAMOUS CASES OF CLASSICAL CONDITIONING

The first case was created by Watson (the founder of behaviourism) and presented by Eysenck (1965). Watson maintained it was possible to create experimental phobias simply by using Pavlov's conditioning paradigm—and proved it by using an 11-month-old orphan, Little Albert. He was fond of white rats, used to play with them a lot, and showed no signs of fear. Watson stood behind the boy with a metal bar in one hand and a hammer in the other. Whenever Little Albert reached out for the rats (CS) to play with them, Watson would bang the metal bar with a hammer, thus making a loud noise (US), ensuring that the sight and touch of CS just preceded the onset of US, the noise. After a number of repetitions, Little Albert became afraid of rats: he would whimper and try to crawl away from them in a severe rat phobia which continued unabated during the following days. As in any CR, it showed a generalization gradient: now the boy was afraid not only of rats but also of other furry animals.

Eysenck's purpose was to contrast Little Albert's notorious case of experimental induction of neuroses, followed by experimental extinction, with that of another boy's famous phobia: Little Hans (Freud, 1909, 1955). A famous psychoanalyst of the time had hailed Freud's work as a remarkable achievement wherein the psychoanalytic concepts of phobia formation, the Oedipus complex, ambivalence, castration anxiety, erotic fixation, and repression had been greatly reinforced (Eysenck, 1965).

Two behaviourist psychologists, Wolpe and Rachman (1960), carefully analysed the case and concluded that the incident to which Freud refers as merely the exciting cause of Hans's phobia was in fact the cause of the entire disorder. Hans had actually said 'No, I only got it [the phobia] then. When the horse and the bus fell down it gave me such a fright, really!' and his father: 'All of this was confirmed by my wife ... the anxiety broke out immediately after.' They concluded: 'The case does not provide anything resembling direct proof of psychoanalytic theorems ... infantile complexes were not revealed behind Hans's phobia: they were merely hypothesized.' But Freud believed that he had obtained in Little Hans a direct confirmation of his theories, for he speaks of 'the infantile complexes that were revealed behind Hans's phobia for horses', while both his neurosis and his recovery could be explained on classical conditioning principles. Unfortunately the actual mechanism that operated could not be identified since the child's father was not concerned with the kind of information that would be of interest. Just as Little Albert had reacted with anxiety not only to the original CS but to other similar stimuli, Little Hans had reacted anxiously to 'horses, horse-drawn buses, vans, horses' blinkers and muzzles ... more afraid of large carts, vans or buses than small carts ... the less close to phobic stimulus, the less disturbing'.

OPERANT CONDITIONING (OR INSTRUMENTAL LEARNING)

According to Pavlov's theory of conditioning, the essential requirement for learning is mere contiguity or association of CS with US. Salivation is not instrumental in providing a reward; the subject has the response (R) elicited from him.

Vice versa, in operant (or Skinnerian) conditioning the subject is active—the learned conditioned response is instrumental in getting the reward (CR)—according to the main principles of behaviourism and of its founder Watson (one of his famous statements is that he could take almost any infant and through proper training make him into a beggar, a lawyer, or any kind of person he desired), and in line with the recently discovered experimental method which

makes happen what is needed to be observed, rejects the introspection of mental processes as illegitimate and restricts the observation to the study of man's or animals' behaviour.

It is called *operant* since it is primarily interested in behaviour which has some effect on the environment, producing a feedback of information which influences future behaviour. The response which produces the reinforcement becomes stronger (i.e. more likely to occur), while that which is not reinforced becomes weaker. The reinforcement is also contingent upon certain responses—those which the subject needs (positive reinforcements) or which allow them to escape from a painful situation (negative reinforcements).

The apparatus for this demonstration is a box with a lever which may operate a reward mechanism (food or water) or turn off a shock given through the grid floor. It is called a Skinner box, as it was first used by Skinner, and it allows techniques for the precise control of reinforcing effects to shape the subject's behaviour. Without reinforcements, an instrumental response gradually extinguishes. Partial or differential reinforcements, which can be arranged according to number, rate, pattern, or time, give higher or lower resistance to extinction and steady rates of responding; for instance, the variable-interval schedules in gambling, or in superstition, are the schedules which make these behaviours so difficult to stop.

Skinner discovered by mere chance that pigeons conditioned in the Skinner box to associate any subject to any positive contemporary response, tend to *freeze* the behaviour they were engaged in at the moment the reinforcement came out, no matter how unusual or tiring that is (e.g. getting rid of fleas under one wing).

CLASSICAL AND OPERANT CONDITIONING IN EVERYDAY LIFE

According to Dollard and Miller (1950), much of what is called unconscious consists not of conscious classical conditioning; instead it seems probable that many of our subjective emotional feelings are classical conditioned responses connected to a forgotten face, voice, or scene. Many of them have been learned before we could talk. Probably most neurotic disorders (anxiety, fears, phobias, obsessive-compulsive habits) are conditioned emotional reactions (introverts condition more easily) (Eysenck, 1965). It is a modestly sophisticated strategy that tries to take nature's ways into consideration and helps us to choose fast choices in emergencies, by first dividing the world into at least two parts: the good and the bad.

Since Pavlov's time, the Russians have carried on a great deal of experimental work on the conditioning of physiological adjustment (breathing and psychosomatic disorders) since they believe many of them are caused by classical conditioned responses. Classical conditioning also plays a part in how we learn our first metaphors, the words; even if, as far as learning is concerned, operant conditioning plays a greater part.

But classical conditioning has often been considered an inferior form of learning since it makes use of glandular secretions and visceral activities associated with the autonomic system, while operant conditioning deals with conditioned responses involving muscles and bones; that is, voluntary activities versus the largely involuntary activities of classical conditioning. As a matter of fact, in everyday life they complement each other and contribute to the acquisition of different kinds of skills.

Operant conditioning, or instrumental learning, goes on around us all the time. It informs our beliefs, customs, and goals and is especially evident in all socializing processes.

CONDITIONING AND HYPNOSIS

Up to the decade of the brain (1990s), hundreds of volumes were written on certain phenomena which temporarily change our usual ways of looking at or experiencing internal or external reality. Hotly debated meetings were held to prove somebody's theory was correct despite lacking real scientific proof. Let's list the most popular, beginning from the *siècle des lumières*, the eighteenth century:

- Mesmer's (1734–1815) mesmerism was interpreted in terms of animal magnetism as Elliotson (1791–1868) would do over half a century later, at University College, London. Astonishingly, the Commissioner of the Société Royale de Médecine (which included as members Franklin, American ambassador at the time; Lavoisier, the chemist; Bailly, the astronomer; Guillotin, the inventor of the homonymous instrument of execution; and other famous scholars) in charge of examining it for Louis XVI (who will be guillotined during the French Revolution) reported in Paris in 1784: 'imagination without magnetism produces convulsions, magnetism without imagination produces nothing, and the fluid is useless, but the violent results observed in the public are caused by: contact (touching), imagination in action and mere imitation'.
- For the Marquis de Puységur (1751–1825), hypnosis was artificial somnambulism controlled by the will power of the hypnotist.
- For José Custódio de Faria (1746–1819), the first to refuse all previous theories, somnambulism was produced by the subject's expectancy and receptivity, possibly increased by passes, magnets, and so on. (Dumas made him one of the main characters in his famous *Le Comte de Monte-Christo*).
- For Braid (1795–1860), braidism or hypnotism (*nervous sleep*, in his opinion), closely related to sleep, was brought about by fatigue of the eye muscles caused by fixation; later he called it *monoideism* since it was the result of concentration on a single idea. He was the first to realize that there was no direct physiological link between the hypnotist and the subject.
- For Charcot (1825–1893), director of the Salpêtrière, one of his students, Babinski (1857–1932), and later Pallier (1892) and his followers, hypnosis was an experimental neurosis (different degrees *de la meme pâte*, i.e. a make-believe), which Babinski called *pithiatisme*.
- For Bernheim (1837–1919) and Liébeault (1823–1904) the *persona* was the only active part in the process with suggestion (i.e. imagination is the main factor).
- For Coué (1857–1926) hypnosis was self-suggestion caused by imagination.
- For Janet (1859–1947), one of Charcot's students and his successor as director of the psychological lab at the Salpêtrière, hypnosis was a secondary dissociated consciousness.
- For Sarbin and Coe (1972), hypnosis was simply a role-taking behaviour ('a person in hypnosis acts as he believes a hypnotized person should act'), a theory no longer sustainable after the Canadian experiments of the 1990s.
- Some atavistic biologists such as Granone (1983) and Perussia (2011) hypothesized that hypnotic phenomena, such as immobility (death faking), regression, self-hypnosis, non-verbal communications, post-hypnotic suggestions, hallucinations, and so on are archaic atavistic defence behaviours typical of weaker phylogenetic species.

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- For the East European scientists who adopted and developed Pavlov's reflex psychology, hypnosis was considered to be 'a physiological state produced by a life-time of conditioning, in the course of which certain words tend to act like Pavlov's bell in causing effects due to long association'.

Today, hypnosis is commonly accepted as a learning technique and, as such, an example of classical conditioning, called into play as a form of hypnotic trance, of negligence to some stimuli which give strength to imaging and to its consequent ideoplastic force.

THE STATE-DEPENDENT THEORY OF MIND AND BODY

Pavlov, Skinner, and all the pioneers in the first half of the twentieth century who started—at first by mere chance, then more deeply—their research work in animal/human conditioning/learning processes, were not aware of the role that stress hormones of parasynaptic cellular modulation play in the learned association between stimulus and response. Pavlov's distrust of psychology oversimplified his basic conditioning experiment as a model for learning and memory. But humans do not always react in a rigid stimulus-response manner to behavioural conditioning. It is a common belief that patients may lose all motor reflexes, all ability to communicate with the outside world, and all sense of pain, and be able to hear and remember significant events and conversational remarks by significant medical personnel during surgical operations at a deep level of unconscious thought, which puts them at greater risk with negative consequences on recovery rates. Meaningful sounds, meaningful silence, meaningful conversation are all registered and may have a profound and lasting influence on the patient. The last resource of the human organism in maintaining contact with their external environment seems to rest with the sense of hearing.

A severely depressed brain can quickly acquire Pavlovian defensive conditioning. Thus far, there is very little recognition of this evidence. Rossi and Cheek (1988), during their research on the unconscious perception of meaningful sounds during surgical anaesthesia, reached the belief that post-traumatic stress disorder is essentially a form of state-dependent memory, learning, and behaviour (SDMLB) and the classical paradigms of Pavlovian and Skinnerian conditioning are actually varieties of SDMLB—which reminds us that biological systems, being highly dynamic, are non-linear.

In the last few decades, SDMLB has been investigated as the broader and more generic form of learning that takes place in all complex organisms with a cerebral cortex, a limbic-hypothalamic system, and closely related systems. Epinephrine, an information substance utilized in parasynaptic cellular modulation and which is released during stress—with a highly significant role in the state-dependent, state-bound phenomena of human behaviour—has been demonstrated to be a facilitator of memory and learning under general anaesthesia. Beta-endorphin, adrenocorticotrophic hormone, and a variety of endocrinal hormones and their peptide analogues, released together, also have been found to encode and modulate state-dependent memory learning and behaviour processes encoded in the limbic-hypothalamic and closely related systems. They are the major information transducers between mind and body. An important example is the post-traumatic stress disorders that, by stimulating excessive arousal, can lead to varying clinical symptomatology.

Van der Kolk (1989) sees state-dependent memory as the basic process of:

1. Freud's traumatic neurosis as the organic basis of psychopathology; the history of psychoanalysis as a prolonged clinical investigation of how dissociated and state-dependent memories remain active at unconscious levels, giving rise to complexes;
2. Jung's source of psychological and psychosomatic problems.

CONTEXT AND STATE-PLACE-TIME DEPENDENT MEMORY

Memory has two largely separated working models: the short term and the long term; of two types: semantic and episodic; and with different levels of strength. Semantic memory contains information about our organized knowledge of the world (Hayes, 1998). Episodic memory, which records life as it happens, can be context dependent (related to external autobiographical memory) and state dependent (internal). Each process of storing the memory of an event implies the storing of its context (i.e. a cue to the associated memories, never lost even if inaccessible.) It can be determined by stimuli such as places, smells, music, and a variety of sensorial cues. Context dependency was proved by Baddeley's scuba divers who memorized lists of words underwater or on land and recalled them better when tested in the environment (context) in which they had learnt them (Godden & Baddeley, 1975).

STATE-DEPENDENT MEMORY

State-dependent memory is the increment in memory that occurs when a person's physiological conditions or emotional state is the same during the test as it was during encoding. Baddeley's heavy drinkers could remember where they had hidden money only when returned to the drunken state in which they had hidden it (Baddeley, 2000). Facco (2012) produced a more dramatic example of state/place-dependent recall on reporting on a case (see Holden and MacHovec, 1993) regarding a man who had previously had a very pleasant near-death experience during an anaphylactic shock yielded by iodine contrast medium administration for a radiological investigation. The patient had been submitted to hypnosis with the direct suggestion of going back to the moment of near-death experience: when he recalled it, he underwent a sudden fall of arterial blood pressure with an increase in his heart rate of up to 190 beats/min, which reversed after dehypnotization.

This paper began with a quotation from Proust's *À la recherche du temps perdu* in the original French, as a key example of the power of context-dependent memory that no intellectual effort would have reached, based on taste and smell alone:

as soon as he had recognized the taste of the piece of madeleine soaked in her decoction of lime blossom which his aunt used to give him, immediately ... *a vast memory gap could be re-created by using the senses as a bridge of union between body and mind, of recollection between the present and the past.* (Proust, 1992; author's emphasis)

STATE-DEPENDENT MEMORY IS NO NOVELTY

Mankind used state-dependent memory long before it was theorized. If it is at the base of all rituals—the religious and the civil ones, in war, in peace, in games, to remind and recreate state-dependent memories, learning and behaviour—it is because it has always proved its efficacy. It is a way of physiologically going back to a space/time/mind/behaviour, clue directed for a full immersion into a profound emotional environment and recreated for the present; it might even be the mental 'safe comfortable place' a patient may be invited to imagine during a therapeutic session.

Endogenous generated behavioural states causally influence regulatory physiology. All living organisms exhibit cyclic patterns of activity/inactivity (just as mammals do with the ultradian sleep cycle) (Rossi & Cheek, 1988).

The following are everyday instances of spontaneous (Skinnerian) conditioning or instrumental learning and state-dependent memory (Morgan & King, 1956). Any situation regularly associated with a goal becomes a secondary goal and, when achieved, gives pleasure. Thus we like to be around people with whom we have shared satisfying experiences. We like to make money because it satisfies other needs. We like to go back to places where we formerly had a good time. We derive pleasures from those situations which were associated with the satisfaction of goals.

In everyday life we understand that there is a 'state-dependent remembering'. If, for example, we arrive in the lounge only to discover that we have forgotten whatever it was that we have come in from the kitchen to find, we instinctively know we'll recall whatever it was far better if we return to the kitchen and stand in the spot where we had our original thought.

Today the idea of state-dependency is becoming something of a cult: it can be found in state-dependent memory (see *Lancet*, 1991), memory deficit (Gianlorenço et al., 2011), ethanol abuse (Rezayof et al., 2008, 2009), state-dependent mood retrieval (Kenealy, 1997), state-dependent spike timing (Wierzynski et al., 2009), state-dependent cognitive processes (Berridge & Waterhouse, 2003), state-dependent valuation learning in fish (Aw et al., 2009), state-dependent memory produced by aerobic exercise (Miles & Hardman, 1998), state-dependent retrieval hypothesis of drug conditioning and sensitization (Braga et al., 2009), state-dependent firing neurons (Jo et al., 2005), and cue- and dopamine-dependent fear conditioning (Fadok et al., 2009).

FREE WILL

Free will is an everlasting ambiguous dream. Can conditioning and SDMLB influence it? Apparently, by tying behavior to further links it can only contribute to hindering it. For personal use, I invented 'the law of imperfection', because I have too often seen it at work. Nothing is perfect in our world: the unexpected, which breaks traditional rules and solutions, compels us to use those tiny, freelance rebel specks in us and make of them the freedom flag in the revolt against a too-conditioned world.

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