

# LEARNING MODULE

## Non-associative learning: habituation, familiarization, sensitization

What is learning?

- Learning is an adaptive change in behavior resulting from experience: this change has to do with some circuit that was already there
- Learning uses modification of innate behavior and/or **innate reflexes**  
Learning allows the organism to adapt and survive

According to behaviorism any behavior is caused by external or environmental stimuli, i.e. the outcome of “**stimulus-response phenomena**” (Reflexes type), or the consequence of behaviour itself. No need to consider the existence of internal mental states or consciousness.

What is a reflex?

According to Sherrington reflexes were the elementary units of behavior: the reflex is the simplest possible connection between an environmental stimulus and an organismic response.

Reflexes are an important topic because:

1. Learning procedures take advantage of existing automatic (unconditioned) responses to stimuli, usually a reflex, as a part of the natural behavioral repertoire of the subject under study (for example: salivary reflex, eye blink in response to a puff of air, rotation in a pigeon, increased heart rate when aroused, etc.)
2. The most elementary reflexes such as the knee jerk reflex are expressed by hard wired circuits, whose response to a stimulus is innate, involuntary, automatic, in that they occur inevitably in response to an adequate stimulus and occur the first time that stimulus is presented. Their stimulus-response pattern in most cases is usually not or only partially modifiable.
3. Some of these automatic reflex responses can be modified by learning but not all (for example the “knee jerk” reflex is very resilient to changes), with a change in their amplitude, occurrence, or by their occurrence in the absence of any physiological stimuli.

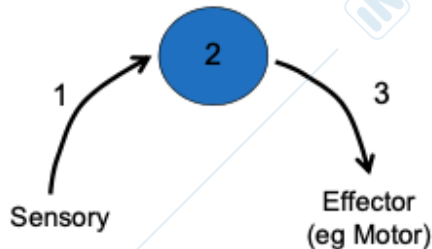
Sherrington talks about the reflex arc:

It is composed of:

1-An afferent path (sensory)

2-A reflex centre

3-An efferent path (motor or autonomic)



It could be monosynaptic (two neurons involved) or polysynaptic (more than two neurons involved)

Usually these reflex responses do not occur in isolation of one another. Rather, a sequential organization of actions is in place, i.e. a **sequence**. In animals, all motivated behavior, i.e. looking for food, searching for a potential partner, defending a territory, feeding children, etc. .... always involves a precise organization of a sequence of actions.

The behaviorists use a terminology that is still used today: they called the early phase of a behavioral sequence “the **appetitive behavior**”, which brings the organism into contact with the stimulus, and the last phase “the **consummatory behavior**” (i.e. hitting, biting, ...).

It is important to understand the effect of learning, because this depends on which component of the natural sequence is altered by experience. As a general rule, consummatory responses are much more stereotyped, less plastic than appetitive behaviors, which vary a lot depending on the situation.

## Classification of Learning & Memory processes

In general, we can distinguish between:

### Long-term vs Long term learning and memory

Different duration, different characteristics, different induction mechanisms, and Involvement of different neural systems

The long-term memory can be divided into:

### Implicit vs explicit forms of learning & memory

Different level of subjective awareness and involvement of different neural systems

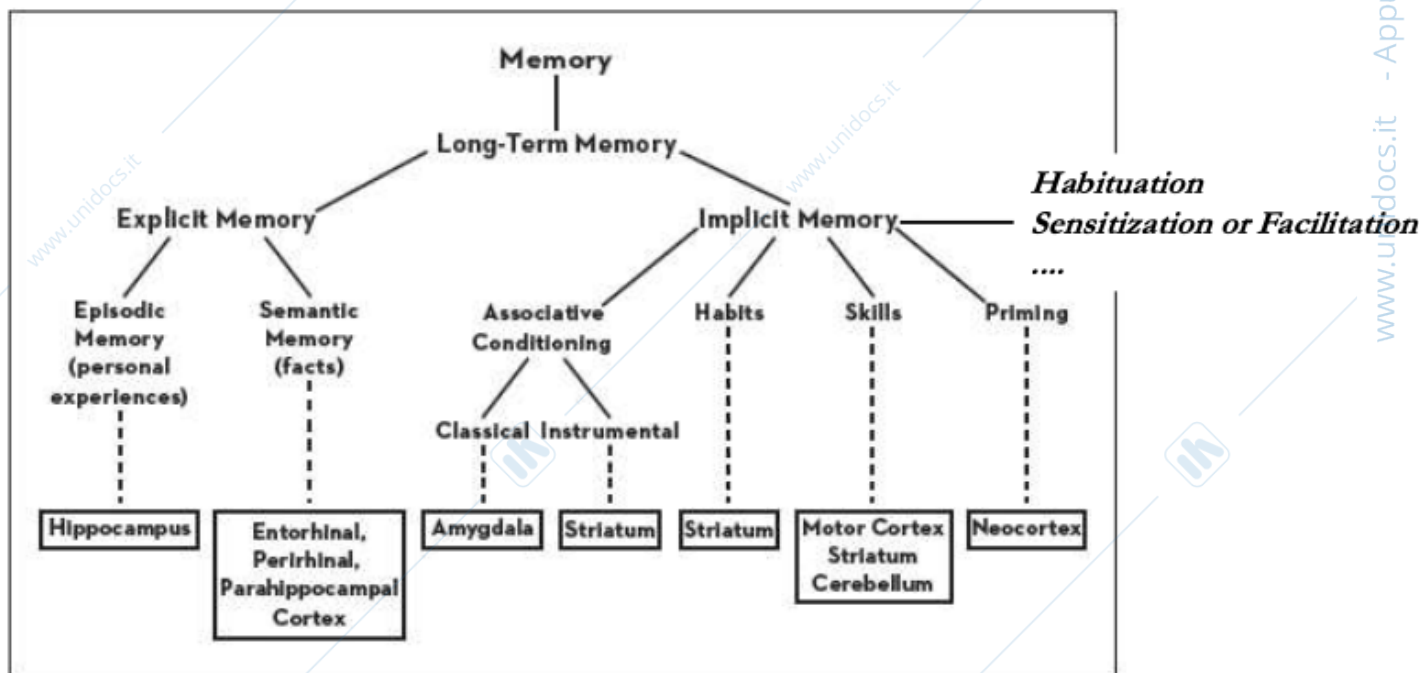
The implicit memory can be divided into:

### Associative vs non-associative (habituation & sensitization) form of learning & memory

Distinction mainly relevant for implicit learning and memory.

With non-associative learning an animal learns about the properties of a single stimulus. Non-associative learning results when a subject is exposed once or repeatedly to a single type of stimulus.

With associative learning the animal learns about the relationship between two stimuli or between a stimulus and a behavior: this might involve two stimuli but also two pieces of information or between organism's behavior and the consequences of that behavior.



Non-associative, implicit, latent learning: here, to different extent depending on the process, a physical or mental effort or initiative isn't required

• **Habituation (habit):** learned suppression of response to a repeated stimulus. Habituation is the simplest form of implicit learning: learned suppression of the response to a repeated (or continuous) stimulus. It occurs for virtually all behavioral responses in virtually all organisms.

Example - suppressed acoustic startle reflex to repeated presentation of a loud sound.

• **Sensitization:** (or Pseudoconditioning or Facilitation) Enhancement of response to a variety of stimuli following stimulus exposure.

Example - stronger response to mild tactile stimulation after a painful one.

Example - Multiple air puffs delivered alone. Each puff produces an eyeblink. If a tone is then sounded alone, an eyeblink will be produced. Note that the UCS (air) and CS (tone) have never been paired before (hence this is pseudoconditioning).

• **Exploratory behavior and novel object recognition.**

In exploratory behavior, an unknown stimulus is treated differently. The object becomes Familiar.

Example – Neophilia, Neophobia

• **Priming:** Even if the object that was encountered doesn't become familiar, it affects somehow the response to a repeated stimulus or to a related stimulus. Prior exposure to a stimulus can improve the ability to recognize that stimulus at a later time point.

Example: word-stem completion task

• **Perceptual Learning and mere exposure learning:** Repeated exposures to a set of stimuli makes you capable of distinguishing them.

• **Spatial Learning** The acquisition of information about your surroundings

## HABITUATION

Through repetition, you may learn not to respond to a particular event, even if—like the man from Jamaica encountering snow—you originally responded with great excitement. This kind of learning, **habituation**, is formally defined as a decrease in the strength or occurrence of a behavior after repeated exposure to the stimulus that produces the behavior. Habituation is sometimes described as the simplest or most basic kind of learning. Nevertheless, experimental studies conducted over the past century have yet to reveal exactly how habituation works (Rankin et al., 2009; Thompson, 2009).

**Habituation:** *a decrease in the strength or occurrence of a behavior after repeated exposure to the stimulus that produces that behavior.*

It occurs for virtually all behavioral responses but has been studied mostly in simple forms of behavior – i.e. reflexes.

For example:

### Flexion withdrawal

- This is a protective reflex to painful stimuli.
- Size, strength, and duration of contraction is a function of stimulus intensity [hot iron vs warm iron]
- *Sherrington* noted that this and other reflexes habituated with repeated stimulation and suggested a decrease in the effectiveness of synaptic transmission in the motor circuits involved. *Spencer and Thompson* examined habituation in cat spinal flexion reflex (limb withdrawal). Intracellular recordings in the spinal cord determined that habituation produces a decrease in synaptic activity between motor neurons and interneurons.

### EEG arousal

- *Sharpless and Jasper* demonstrated habituation of EEG arousal. Using repeated presentations of a brief tone cortical EEG arousal of a sleeping cat became shorter and then finally disappeared. By waiting a few minutes-hours the arousal recovered. This habituation was very specific for the characteristics of the tone used, a different stimulus, if strong could produce dishabituation of the EEG arousal to the original stimulus.
- *Sokolov* found **similar results for the human alpha blocking response induced by opening of the eyelids**, with an EEG that resemble the one seen with arousal.
- Many experiments were then run on the **Acoustic Startle reflex**, the **Moro's reflex** and the **Baby's orienting response**, the **eye blink**, .....

The decrease is usually a negative exponential function of the number of stimulus presentations.

Habituation does not persist for extended periods of time. If the stimulus is withheld, the response tends to recover over time (spontaneous recovery).

### Two forms are recognized:

The effects of habituation may last for a few minutes or several hours and, under some circumstances, may last a day or more. But they generally do not last forever and are especially likely to dissipate if the stimulus is absent for a while.

- **Short-term Habituation:** recovers in minutes and usually the recovery is 100%.  
To induce this form of habituation, stimuli need to be presented at High frequency.
- **Long-term Habituation:** recovers in days-weeks minutes and usually the recovery is incomplete. To induce this form of habituation, stimuli need to be presented at Low Frequency.

If repeated series of habituation training and spontaneous recovery are given, habituation becomes successively more rapid i.e. Potentiation of habituation.

### Acoustic startle reflex and orienting response

In the laboratory, researchers examine simpler examples of habituation that they can describe in terms of a single, easily controlled stimulus and a single, easily measurable response. One such response is the **acoustic startle reflex**, which is a defensive response to a loud, unexpected noise. When a rat in an experimental chamber is startled by a loud noise, it jumps —much as you might jump if someone sneaked up behind you and yelled in your ear. If the same noise is presented to the rat over and over again, every minute or so, the rat's startle reflex declines (**Figure 3.1A**), just as your responsiveness to noises would decrease after moving into a new home; if the process goes on long enough, the rat may cease to startle altogether. At this point, the rat's startle reflex has habituated to the loud noise.

***acoustic startle reflex:*** a defensive response (such as jumping or freezing) to a startling stimulus (such as a loud noise).

Another common way to study habituation involves the **orienting response**, an organism's natural reaction to sensing a novel stimulus or an important event. For example, if a checkerboard pattern (or any other unfamiliar visual stimulus) is presented to an infant, the infant's orienting response is to turn her head and look at it for a few seconds before shifting her gaze elsewhere. If the checkerboard is removed for 10 seconds and then redisplayed, the infant will respond again—but for a shorter time than on the first presentation (Figure 3.1B). The duration of staring, called the *fixation time*, decreases with repeated presentations of the stimulus, in a

manner very much like the habituation of a rat's startle reflex (Malcuit, Bastien, & Pomerleau, 1996).

**orienting response:** *an organism's innate reaction to a novel stimulus.*

Normally, habituation is advantageous for an organism. Through habituation to familiar stimuli, the individual avoids wasting time and energy on unnecessary responses to each repeated event. But habituation carries risks. A deer that has gotten used to the sound of gunshots is a deer whose head may end up as a hunter's trophy.

Think about situations in which you have heard a fire or car alarm go off repeatedly for no apparent reason. Each time such an alarm goes off, you become more skeptical, and at the same time, your orienting response and startle reflex likely decrease. Any time your response decreases with repeated experiences, there is a good chance that habituation is occurring.

Of course, it is also possible that you are simply falling asleep, especially if the alarm is going off at your bedtime.



Some ways that researchers are able to distinguish habituation from fatigue and other causes of decreased behavioral responding to repetition are:

- disrupting the repetition of experienced events
- taking advantage of its **specificity** (habituation is *stimulus specific*)
  - Stimulus Generalization is seen when habituation occurs in response to other stimuli that are similar to the original stimulus.
  - Stimulus Discrimination is when habituation does not occur to other stimuli that are dissimilar to the original stimulus.
- presenting a novel stimulus can lead to recovery of responses after an individual has habituated to familiar stimuli. This renewal of responding after a new stimulus has been presented is called **dishabituation**. Dishabituation often occurs when an arousing stimulus (like a kitten) is introduced into a sequence of otherwise monotonous repetitions, but it can also accompany less eventful changes. Simply adding motion to a familiar stimulus can lead to dishabituation, as demonstrated when adults start waving toys around in front of an infant who seems uninterested. Dishabituation provides another useful way of demonstrating that the absence of responding to a repeated stimulus is indeed the result of habituation and not some other factor, such as fatigue.

**Dishabituation:** *a renewal of a response, previously habituated, that occurs when the organism is presented with a novel stimulus.*

## Factors influencing the rate and duration of habituation

### Can you change the degree of Habituation?

Yes, by changing:

*Strength of the stimulus, i.e. how startling the stimulus is*

*How scary the stimulus is*

*How familiar it is*

*The number of time it is repeated*

*The interval between its repetitions (frequency)*

How rapidly a response habituates and how long the decrease in responding lasts depend on several factors, including how startling the stimulus is, the number of times it is experienced, and the length of time between repeated exposures.

1. how startling the stimulus is: *in general, the less arousing an event is, the more rapidly a response to that event will habituate.*
2. the number of times it is experienced: whenever habituation does occur, larger decreases in responding are seen after earlier repetitions than after later exposures. In other words, the biggest changes in responding are seen when one is first becoming familiar with a stimulus. This pattern, or *learning curve*, is seen for many kinds of learning and is discussed in greater detail in Chapters 4, 5, and 8.
3. length of time between repeated exposures: animals given sessions of multiple exposures to stimuli in which the exposures are separated by short intervals will typically show habituation after fewer exposures than will animals given sessions in which the same number of exposures are more spread out over time (Rankin & Broster, 1992; Thompson & Spencer, 1966): *more rapid repetition of a stimulus generally leads to more rapid habituation.* Exposures that are repeated close together in time are called *massed*, whereas exposures that are spread out over time are called *spaced*.

If the objective is to quickly habituate someone then....

- High frequency exposures to the stimulus: the more rapid the frequency of stimulation, the more rapid and/ or more pronounced is habituation
- Make your stimulus somehow less arousing: the weaker the stimulus, the more rapid and/or more pronounced is habituation. Strong stimuli may yield no significant habituation
- Repeat many series of habituation trainings: keep repeating the exposure trials induces potentiation of habituation.

But if use more time.... the therapy will take longer but once habituated it will last for a longer time.

### Spontaneous recovery

If a rat has gotten used to a loud noise and then goes through a period of an hour or so in which the noise does not occur, the rat is likely to startle anew when the noise is played again, a process called **spontaneous recovery** (referred to in the box on page 80). In spontaneous recovery, a stimulus-evoked response that has been weakened by habituation increases in strength or reappears after a period of no stimulus presentation.

***spontaneous recovery: reappearance (or increase in strength) of a previously habituated response after a short period of no stimulus presentation.***

The factors that determine how quickly an individual's response habituates also affect how long the effects of habituation last. Animals that experience massed exposures to a stimulus learn to ignore that stimulus faster than do animals given spaced exposures, but if they are retested after a relatively long break, the animals given massed exposures are also more likely to show spontaneous recovery. *When exposures are spaced in time, it takes longer for responding to habituate, but once habituation occurs, it lasts for a longer time* (Gatchel, 1975; Pedreira, Romano, Tomsic, Lozada, & Maldonado, 1998).

This finding makes intuitive sense because animals that have gotten used to the intermittent occurrence of a stimulus should find the recurrence of the stimulus after a long interval to be familiar. As a student reading this chapter, you are easily able to detect that repetition is occurring, even when that repetition occurs after moderately long intervals. If your repeated experiences are spread out over time, the likelihood is greater that you will continue to recognize repeating events farther into the future. So, if you want habituation to last for as long as possible, your best bet is to repeatedly expose yourself to the relevant stimulus after longer and longer stretches of time.

Although spontaneous recovery might seem to suggest that habituation is a temporary effect, habituation effects accumulate over time, as in the following example of an infant's experiences with a donut shape. If an infant is shown a donut shape 20 times during a single session, her orienting response to that image will likely habituate. If a day or two later, the infant is shown the donut shape again, spontaneous recovery will probably have occurred, and the infant's fixation time will be as long as if the image were completely novel. However, it may now take only 8 trials before the infant's orienting response becomes habituated: the effects of the repeated experiences have been effectively amplified by the prior repetitions. This shows that the effects of earlier repeated experiences have not simply faded away.

Furthermore, the mechanisms underlying habituation continue to change with repeated exposures, even when behavioral responses are no longer changing. For

instance, a rat exposed many times to a loud sound might stop showing any indication that it even hears the sound; in this case, its response decreases to the point at which there no longer is a response. Nevertheless, if the sound continues to be repeated many times after this point is reached, the amount of time required before spontaneous recovery occurs will increase. In this case, the learning associated with repeated exposures is latent because there are no observable changes in the rat's behavior associated with the increased number of repetitions. The additional effects of repeated exposures after behavioral responding to a stimulus has ceased are evident only when subsequent tests show delayed spontaneous recovery (Thompson & Spencer, 1966).

## Biological mechanisms which may underlie these phenomena

- activity dependent synaptic modification
  - presynaptic enhancement of release
  - presynaptic suppression of release
  - postsynaptic enhancement of response
- alteration in membrane properties
- changes in neural excitability
- enhancement of action potential transmission reliability
- structural changes
- .....

## SENSITIZATION

Sensitization is another form of implicit learning: learned enhancement of the response to a single or repeated stimulation. It is seen with many different forms of stimulations.

Sensitization is a phenomenon in which experiences with an arousing stimulus lead to stronger responses to a later stimulus. In some cases, a single, very intense stimulus can produce sensitization, whereas in others, repeated exposures are required. In some ways, sensitization seems to be the opposite of habituation. Whereas in habituation repeated experiences can attenuate a rat's acoustic startle reflex, in sensitization repeated experiences can heighten it.

***Sensitization: a phenomenon in which a salient stimulus (such as an electric shock) temporarily increases the strength of responses to other stimuli.***

Like habituation, sensitization can rapidly dissipate in some situations but can lead to longer-lasting learning in others—and as with habituation, the long-term effects can be difficult to predict (Borszcz, Cranney, & Leaton, 1989; Davis, 1972, 1980; Poon & Young, 2006). However, fewer exposures are typically necessary to produce sensitization than to produce habituation, and whereas habituation is stimulus specific, sensitization is not. For example, an animal's startle reflex may habituate to one loud tone that is repeated over and over; but if a different loud noise is presented, the startle reflex reappears in full force—habituation doesn't transfer to the new sound. By contrast, exposure to a sensitizing stimulus (such as an electric shock) can amplify the startle reflex to any stimulus that comes later: tone, loud noise, butterfly, or anything else.

- The sensitization can be induced by using **high intensity stimuli** or by **adding an additional arousing stimulus** (An horror scene in a movie, a painful stimulation, etc.)

- Both short and long term components can be elicited

*Example. In rats, the startle response can be potentiated by an electric shock followed by the loud noise, the startle response will be much greater than that of the rats who did not receive a shock.*

- Sensitization is usually short-lived. It may last for 10 or 15 minutes after the end of the stimulation and drops back to control levels.
- Single trials produce short-term sensitization (minutes in duration). Repeated sessions might enhance further sensitization producing longer lasting effects (weeks)
- In *Aplysia*, facilitation of connections of sensory neurons onto interneurons and motor neurons through interneurons which enhance transmitter release. Note that this is heterosynaptic but involves the same connections as in habituation. Compare with the depression seen in habituation.

- **Habituation** simply follows the repetition of the stimulus, it occurs in what is called the **S-R system** (S for sensory stimulus, R for the response), which is a reflex arc.
- This is not the case for **Sensitization**, where the emotional and motivational states control the behavioral output
- Sensitization is activated when **novel** or **arousing events** are presented. The systems that control arousal are therefore central in Sensitization (the **State System**)
- Therefore Sensitization involves circuits which control the general responsiveness and readiness of an organism (State System) together with the S-R system

It explains why pumping up the volume is a very good way to increase excitement. Making something loud is a common strategy to increase the enjoyment of movies, sport events, car races, and this works because of sensitization.

Sensitization plays a major role also in sexual behavior where a major component relates to our reaction to a tactile cue. A caress or a kiss doesn't feel the same if is not given by a romantic partner or by someone that is arousing.

Relevant to many psychopathological conditions: anxiety, excessive fear, PTSD, drug and other forms of addiction....

## *Sensitization and PTSD*

- PTSD symptoms include hyperarousal and the enhancement of startle responses
- Eyeblink responses are exaggerated in PTSD patients when these are exposed to traumatic imagery
- After a single discrete trauma, a clear potentiation of startle response to fear memories is seen
- If a history of repeated trauma or abuse is present, much less startle potentiation to fear memories is seen, but the clinical outcome is worse with chronic PTSD, anxiety, depression, ...

Can you change the degree of sensitization? Yes, by changing

*The nature of the repeated events*

*The strength of the events*

*The level of arousal they induce*

*The novelty*

*Their distribution in time*

*The state of the subject*

Generally, individuals spend much more time looking at novel objects as they do with familiar ones. In the animal is well adapted to the context, from this difference you can recognize if the object was seen before hence familiar.

N.B. *No Specificity*, they amplification applies to a large number of stimuli  
(Generalization)

## Biological mechanisms which may underlie these phenomena

- activity dependent synaptic modification
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### A few theories for habituation & sensitization

#### The Stimulus-Model Comparator Theory of Sokolov & the Wagner-Konorski Gnostic Unit Theory

Both argue that because of the stimulus, a signal is sent via the afferent fibers to a memory system (where you form a memory model of the stimulus) and to the arousal system.

When the stimulus is repeated multiple times, the memory circuit is reinforced with the production of a very accurate description of the nature of this stimulus. This memory circuits becomes increasingly strong and in the end it can activate or suppress an inhibitory system that inhibits the arousal system. Depending on the outcome, this will result in habituation or sensitization.

(Read: *Habituation: A History*. R. F. Thompson, 2009)

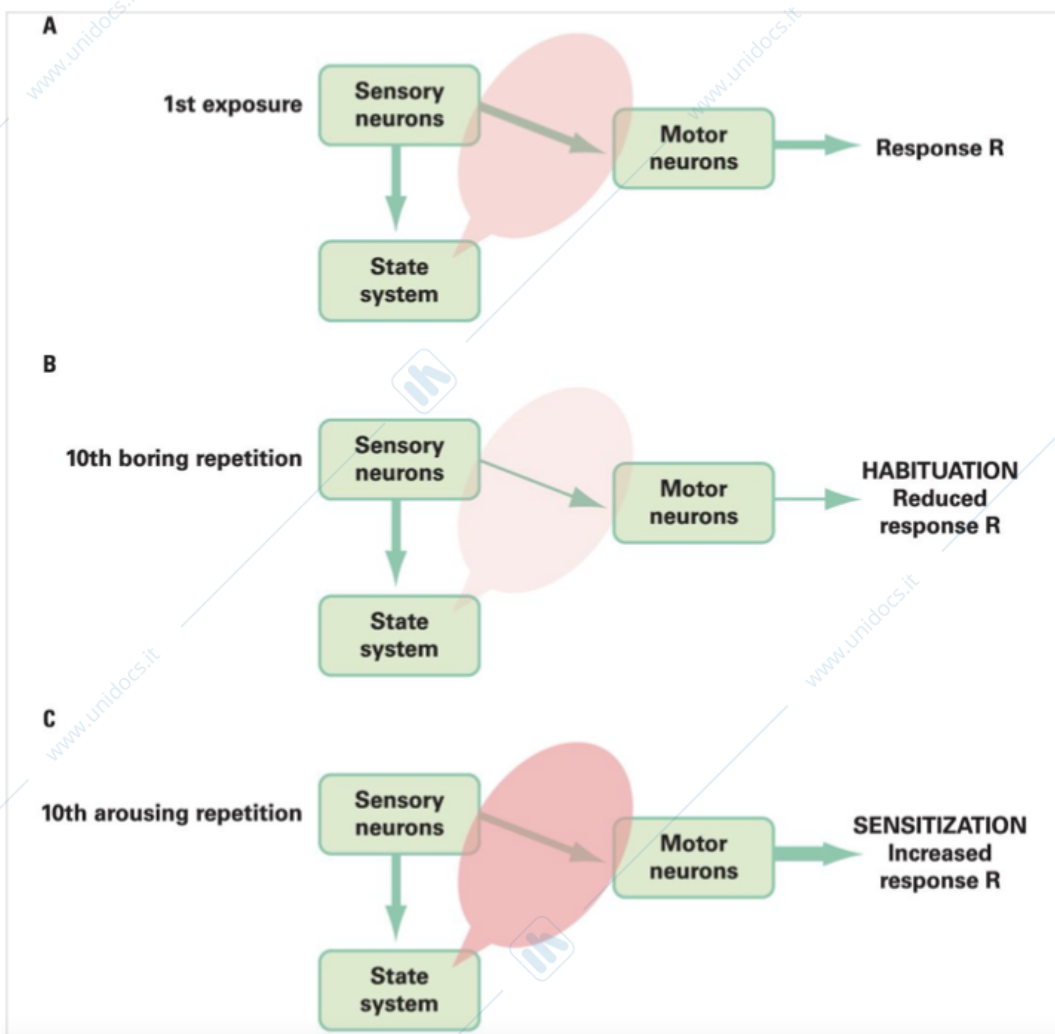
#### The dual process theory

The two distinct processes are a habituation process and a sensitization process. This theory argues that noticeable stimuli will elicit both of these processes which will then compete for control of behavior, the output will reflect the net sum of them.

Habituation will depend on a S-R system (S for sense and R for response), which may be viewed as a reflex arc. At each stimulation the activation of the the S-R system causes some buildup of habituation.

Sensitization on the other hand, occurs in the state system, which is a system that determines the organism's general level of responsiveness or readiness to respond. This is not always activated at each stimuli as the S-R system, but just by arousing events. The state system is relatively quiescent during sleep, it gets activated by emotional events and stimulants.

**dual process theory:** *the theory that habituation and sensitization are independent of each other but operate in parallel.*



Dual process theory suggests that both habituation and sensitization processes occur in parallel during every presentation of a stimulus and that the final response after repeated presentations results from the combination of both processes. (A) Initially, a stimulus such as S activates sensory neurons that lead to a motor response R and also activates a separate state system signaling detection of the stimulus. (B) In habituation, repeated "boring" presentations of S can weaken the connections between neurons (thinner arrows), thus reducing the strength of R or the likelihood that S leads to R. (C) In sensitization, repeated exposure to an arousing stimulus increases the likelihood that subsequent presentations of S lead to R by changing the global state of the circuit (pink balloons) such that all effects of stimuli are amplified.

### The opponent process theory

The opponent process theory is based on the idea that the arousal level (which is essential for sensitization) is controlled by neurophysiological homeostatic mechanisms which are used to maintain emotional stability, i.e. to minimize our highs and the lows. For example if you feel Sad an opponent process will be activated to make you become more Happy.

This theory, proposed by Richard Solomon and John Corbit, says that an emotion-arousing stimulus pushes our emotional state away from neutrality and this triggers an opponent process that counteracts the shift. The primary events is fast and dominates the initial response but when the stimulus is repeated, what came first habituates and the secondary process begins to dominate. The habituation vs sensitization response to the stimulus depends on this dynamic behavior, a moment-to-moment integration of two opposite forces.

**From the manual:** Opponent process theory is similar to dual process theory in assuming that an experienced event leads to two independent processes—in this case, two emotional processes: one that is pleasurable and one that is less pleasant. The overall emotion a person experiences in response to an event is the combined result of these two independent processes. Repeated experiences have different effects on the initial reaction versus the rebound reaction, causing the initial response to habituate faster than the rebound. Thus, your first time skydiving may not be nearly as much fun as your fifth time because your initial response, a fear response, will be much stronger than the rebound “thrill.” Two features of the opponent process theory that distinguish it from the dual process theory are (1) the rebound, or opposing process, which is directly triggered by the initial emotional response, and (2) that both underlying processes in the opponent process theory are associated with emotional arousal (a change in the state of the individual).

Both dual process theory and opponent process theory suggest that the learning that results from repeated experiences is not as simple as may first appear. A “simple” decrease or increase in responding to an increasingly familiar event may reflect multiple learning processes occurring in parallel. In addition, repeated experiences can change not only how an individual reflexively responds to familiar events but also how the person perceives and interprets those events, as described in the following section.

## Biological mechanisms which may underlie these phenomena

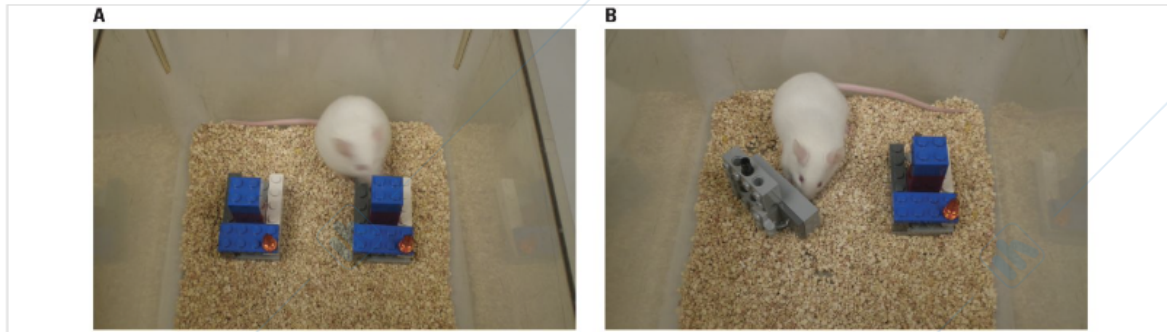
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### EXPLORATORY BEHAVIOR AND NOVEL OBJECT RECOGNITION

In exploratory behavior, an unknown stimulus is treated differently. The object becomes familiar.

Earlier, we noted that when a novel stimulus appears after repeated presentations of a familiar stimulus, babies show a strong orienting response to the new stimulus (because habituation is stimulus specific). A similar phenomenon can be seen in exploratory behavior.

In experiments, people, monkeys, or rodents are first allowed to freely explore the room or box where the testing will be done, so that they become acclimated to the *context* of the experiment. Next, two identical objects or images are briefly presented within the experimental setting (**Figure 3.4A**). After a variable delay, one of these stimuli is presented again, this time paired with a new object or image (Figure 3.4B). Generally, individuals will spend about twice as much time examining the novel object as they do inspecting the familiar one. From this difference, researchers can infer that the individuals recognize the previously experienced object as one they have investigated before—that is, the repeated stimulus is perceived as familiar.



B: Ellen Ann Walker, PhD

**FIGURE 3.4 Novel object recognition** (A) Subjects are first exposed to objects and allowed to explore and become familiar with them. (B) Later, subjects are given another opportunity to explore, but with a novel object in place of one of the familiar objects. Typically, subjects show more interest in the novel object, which indicates that they recognize the familiar object.

Not all animals are so eager to investigate novel objects, however. Some actively avoid them, a phenomenon known as *neophobia*.

### Familiarity

The perception of *familiarity* is a fundamental component of memory. It can be described as the perception of similarity that occurs when an event is repeated. Prior encounter with a stimulus can lead to a sense of familiarity the next time that stimulus is observed.

The novel object recognition test can be adapted to evaluate what kinds of information a subject remembers about the object, about a place, position of objects, their color, texture... hence the resilience of memories which are formed through observations or exploration.

Prior encounter with a stimulus can lead to a **sense of familiarity** the next time that stimulus is observed.

**Perception of familiarity** is an essential characteristic of memory.

**The novel object recognition test** can be adapted to evaluate what kinds of information a subject remembers about the object, about a place, position of objects, their color, texture... hence the resilience of memories which are formed through observations or exploration.

## PRIMING

Prior exposure to a stimulus can lead to a sense of familiarity the next time that stimulus is observed. Even when it does not lead to a conscious sense of familiarity, the prior exposure can still affect the individual's response to the repeated stimulus (or to related stimuli); this unconscious effect is called **priming**.

**Priming:** a phenomenon in which prior exposure to a stimulus can improve the ability to recognize that stimulus later.

**Positive and negative priming** (depending on the type of change in the speed of processing)

**Perceptual priming** (based on the form and modality of the stimulus) Sensory cortices, Fusiform gyri

**Conceptual priming** (based on the meaning of a stimulus) PFC

**Repetition or direct priming** (improvements in a behavioral response when stimuli are repeatedly presented)

**Semantic priming** (the prime and the target are from the same semantic category)

**Associative or context priming** (the target is "associated" with the prime even if not semantically related)

**Response priming** (a visuo-motor effect, speed and coordination of motor responses)

**Masked priming** (When the prime is masked)

**Kindness priming** (effect of an act of kindness on a subsequent threshold of activation)

Even if the object that was encountered doesn't seem familiar, because of a prior exposure it affects somehow the response to a repeated stimulus or to a related stimulus. Prior exposure to a stimulus can improve the ability to recognize that stimulus at a later time point.

An example: **word-stem completion task:** a task in which participants are asked to fill in the blanks in a list of word stems (e.g., MOT ) to produce the first word that comes to mind; in a priming experiment, participants are more likely to produce a particular word (e.g., MOTEL) if they have been exposed to that word previously even if they do not consciously remember having previously seen the words on the list (Graf, Squire, & Mandler, 1984). When they complete the word stem with a previously experienced word, they do not recognize the word as one they recently saw, and yet the prior experience clearly affects their word choice.

**word-stem completion task:** a task in which participants are asked to fill in the blanks in a list of word stems (e.g., MOT ) to produce the first word that comes to mind; in a priming experiment, participants are more likely to produce a particular word (e.g., MOTEL) if they have been exposed to that word previously.

## Implicit Memory Tasks

Participants are exposed to a word list

Tiger  
Lion  
Zebra  
Panda  
Leopard  
Elephant

After a delay...

Participants then complete word puzzles; they are not aware this is a type of memory test

Word fragment completion:

C \_ E \_ T A \_

E \_ E \_ \_ A \_ N \_

\_ E \_ R A

Word stem completion:

Mon \_\_\_\_\_

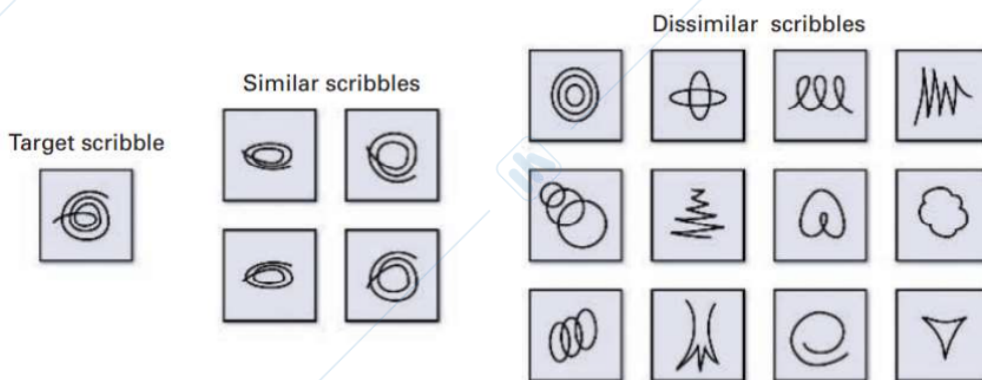
Pan \_\_\_\_\_

## PERCEPTUAL LEARNING AND MERE EXPOSURE LEARNING

Learning in which repeated experiences with a set of stimuli make those stimuli easier to distinguish is called **perceptual learning**. Consider the making of medical diagnoses. All rashes may look alike to an inexperienced medical student, but an experienced dermatologist can glance at a rash and tell immediately, and with high accuracy, whether a patient has contact dermatitis, ringworm, or some other condition. You too may have perceptual expertise in making certain kinds of precise sensory distinctions. Whatever your specialty, you likely developed your capacities to detect subtle differences through repeated exposures to those stimuli. This is the essence of perceptual learning.

### perceptual learning

Learning in which experience with a set of stimuli makes it easier to distinguish those stimuli.



**Figure 3.7 Mere exposure learning in humans** A person repeatedly views a particular scribble (target), then tries to identify cards with the same scribble when they are mixed into a deck of cards with other scribbles varying in similarity to the target scribble. The ability to identify the target scribble gradually improves, even without feedback about performance.

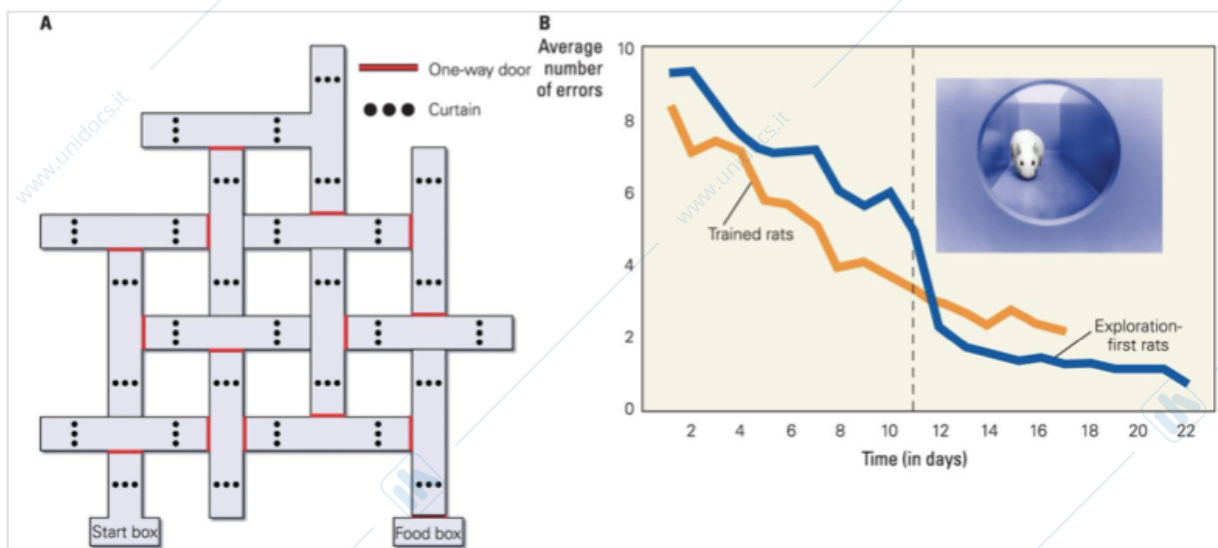
Images from J. J. Gibson and Gibson, "Perceptual Learning and Differentiation or Enrichment?" Vol. 62, No. 1, 32-41, 1955, APA. Adapted with permission.

Perceptual learning is similar to priming in that it leads to more effective processing on subsequent encounters with the stimuli. In addition, perceptual learning can

happen even if the learner is not aware that her sensitivities to perceptual differences are increasing. One way in which perceptual learning differs from priming is that the resulting increase in the ability to tell similar stimuli apart is long lasting (discussed further in Chapter 6). Priming is more often associated with short-term changes in the detection and recognition of recently experienced stimuli.

## SPATIAL LEARNING

**Spatial learning** is the acquisition of information about one's surroundings.



Gluck et al., *Learning and Memory*, 4e, © 2020 Worth Publishers  
B: Will & Deni McIntyre/The Image Bank/Getty Images

**FIGURE 3.7 Learning by exploration in rats** (A) Tolman placed rats in the start box of a complex maze. (B) Rats rewarded with food every time they reached the food box (“trained rats”) learned gradually to run to the food box. Other rats (“exploration-first rats”) were simply placed in the maze and allowed to explore, with no food reward. On the 11th day, these rats began receiving rewards and immediately learned to run to the box for food.

(A) Information from [Elliot, 1928](#); (B) Data from [Tolman & Honzik, 1930](#).

Rats independently from the presence of a reward (if the reward is present we have to talk about associative learning) learn about the maze and the location of the food box: **latent learning**.

Explanation for latent learning:

- Number of turns while exploring structure of the maze
- Visual cues in the room
- Some unknown orienting system

## SUMMARY

Process	Example
Habituation	After repeated trips on airplanes, you no longer notice when babies start crying.
Sensitization	After repeated trips on airplanes, you start pulling out your hair when babies start crying.
Familiarization	Passing the same person on your walk every day leads to a feeling of familiarity when you see her.
Priming	You see a commercial for junk food and later crave junk food as a result, without recalling the commercial.
Perceptual learning	You work for a year at a coffee shop and learn to identify brands of coffee from their odors.
Spatial learning	You work at a coffee shop and become able to tell customers where to find specific brands of coffee.

- Habituation is a process in which repeated exposure to a stimulus leads to a decrease in the strength or frequency of the responses evoked by that stimulus.
- In sensitization, exposure to an arousing stimulus causes a heightened response to stimuli that follow.
- Dual process theory proposes that behavioral changes caused by repeated exposures to a stimulus reflect the combined effects of habituation and sensitization.
- In novel object recognition tasks, an organism typically responds more to a novel stimulus than to a stimulus it was previously exposed to, providing evidence of familiarity.
- Priming is a phenomenon in which exposure to a stimulus, even without a conscious memory of that exposure, affects the organism's response to the stimulus later.
- Perceptual learning occurs when repeated experiences with a set of stimuli improve the organism's ability to distinguish those stimuli.
- Spatial learning often involves latent learning about features of the environment (including encountered objects) through exploration.

## WHAT YOU SHOULD RETAIN

The fact that learning processes use modification of innate behavior and/or innate reflexes

### What is habituation?

A decrease in the strength or occurrence of a behavior after repeated exposure to the stimulus that produces that behavior.

### How can habituation be induced?

With a repetition of a stimuli

### How can its amount be incremented?

If the objective is to quickly habituate someone then....

- High frequency exposures to the stimulus: the more rapid the frequency of stimulation, the more rapid and/ or more pronounced is habituation
- Make your stimulus somehow less arousing: the weaker the stimulus, the more rapid and/or more pronounced habituation is. Strong stimuli may yield no significant habituation
- Repeat many series of habituation trainings: keep repeating the exposure trials induces potentiation of habituation.

### How habituation can be distinguished from fatigue?

Some ways that researchers are able to distinguish habituation from fatigue and other causes of decreased behavioral responding to repetition are:

- disrupting the repetition of experienced events
- taking advantage of its **specificity** (habituation is *stimulus specific*)
  - Stimulus Generalization is seen when habituation occurs in response to other stimuli that are similar to the original stimulus.
  - Stimulus Discrimination is when habituation does not occur to other stimuli that are dissimilar to the original stimulus.
- presenting a novel stimulus can lead to recovery of responses after an individual has habituated to familiar stimuli. This renewal of responding after a new stimulus has been presented is called **dishabituation**

What we know about the underlying neurobiological mechanisms of habituation?

## Biological mechanisms which may underlie these phenomena

- activity dependent synaptic modification
  - presynaptic enhancement of release
  - presynaptic suppression of release
  - postsynaptic enhancement of response
- alteration in membrane properties
- changes in neural excitability
- enhancement of action potential transmission reliability
- structural changes
- .....

What is Sensitization?

It is a phenomenon in which a salient stimulus (such as an electric shock) temporarily increases the strength of responses to other stimuli.

Which are the most effective protocols to induce sensitization?

The sensitization can be induced by using high intensity stimuli or by adding an additional arousing stimulus (An horror scene in a movie, a painful stimulation, etc.)

How can you induce sensitization and not habituation?

Habituation simply follows the repetition of the stimulus, it occur in what is called the S-R system (S for sensory stimulus, R for the response), which is a reflex arc. This is not the case for Sensitization, where the emotional and motivational states control the behavioral output. Sensitization is activated when novel or arousing events are presented. The system that controls arousal are therefore central in Sensitization (the State System)

How can you increment its amount?

By changing: the nature of the repeated events, the strength of the events, the level of arousal they induce, the novelty, their distribution in time The state of the subject (N.B. No Specificity, they amplification applies to a large number of stimuli (Generalization))

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## Theories that have been developed to understand why in some conditions an event will generate increasing arousal while the same in different conditions can generate the opposite

The Stimulus-Model Comparator Theory of Sokolov

The Wagner-Konorski Gnostic Unit Theory

The dual process theory

The opponent process theory

## How to use Habituation and sensitization to develop effective psycho-therapeutical protocols

## Some general knowledge about the other forms of Non-associative, Implicit, Latent learning

- Exploratory behavior and novel object recognition: in exploratory behavior, an unknown stimulus is treated differently than non-novel one. The non-novel object becomes Familiar.  
Example – Neophilia, Neophobia
- Priming: Even if the object that was encountered doesn't become familiar, it affect somehow the response to a repeated stimulus or to a related stimulus. Prior exposure to a stimulus can improve the ability to recognize that stimulus at a later time point.  
Example: word-stem completion task
- Perceptual Learning and mere exposure learning: Repeated exposures to a set of stimuli makes you capable of distinguishing them.
- Spatial Learning: The acquisition of information about your surroundings