Biopsychology Research Methods

Biopsychology research methods study the human brain. Thanks to them, it's now easier to understand how the most mysterious organ in our body works. But what exactly are these methods?

Biopsychology research methods have evolved in the last decades. Although there are several biopsychology research methods, in this article, we'll focus on those that study what happens in the brain under certain conditions.

Authors such as Dewsbury (1991) define biopsychology as "the scientific study of the biology of behavior", a field also called psychobiology. However, other authors prefer the term biopsychology because it "indicates a biological approach to the study of psychology, more than a psychological approach to the study of biology."

Human brain stimulation and visualization methods

Observing and recording brain activity is a very important milestone that was achieved thanks to the different techniques that scientists developed during the 20th century. These biopsychology research methods are, without a doubt, a breakthrough in the study of our most curious organ.

Contrast radiography

This technique consists of injecting a substance in the body to absorb X-rays. This way, scientists see the contrast between the compartment and the tissue around it.

Cerebral angiography is a kind of contrast radiography. To do it, a contrast medium is inserted into a brain vessel. The aim is to observe the circulatory system while performing an X-ray. This technique is very useful to locate vessel injuries and brain tumors.

Computerized axial tomography scan (CT scan)

Through a CT scan, experts can see the whole brain structure. During the test, the patient lies down in the middle of a big cylinder. While the patient holds still, an X-ray tube and a receptor take many separate photographs. This happens while the emitter and the receptor spin around the patient's head.

All this information is transmitted to a computer, which allows doctors to explore the brain on a horizontal plane. Usually, they do it on eight to nine horizontal brain sections. Once all explorations are combined, it's possible to make a three-dimensional representation of the brain.

Nuclear magnetic resonance (NMR)

NMR facilitates high-resolution imaging thanks to the different waves hydrogen atoms emit when activated by radio frequency on a magnetic field. It provides a high spatial resolution and produces three-dimensional images.

Positron emission tomography (PET)

PET provides brain activity images instead of brain structure images. To get the images, scientists inject radioactive fludeoxyglucose (FDG) in the carotid artery. Active neurons rapidly absorb FDG, which accumulates once neurons don't metabolize it anymore, then it slowly degrades. This is how one can observe which neurons are active at a given time during different activities.

Functional magnetic resonance imaging (fMRI)

On the other hand, MRIs offer an image of the increase in the amount of oxygen present in the brain's blood. Thus, it successfully measures brain activity. If we compare it to the PET, it actually has four advantages:

- Doctors don't have to inject the patient with anything.
- It provides both functional and structural information.
- It offers a better spatial resolution.
- Provides three-dimensional images of the entire brain.

Magnetoencephalography (MEG)

It measures the changes in the magnetic fields located on the scalp's surface. These changes occur due to the variations in the neuronal activity guidelines.

Transcranial magnetic stimulation (TMS)

Walsh and Rothwell (2000) state that TMS "alters an area of the cortex, creating a magnetic field under the coil that goes over the cranium." TMS basically "turns off" a part of the brain temporarily, to study behavior and cognition under those circumstances.

Lesion methods

Lesion methods focus on the destruction of a small brain area to see how it affects behavior.

- Aspiration lesion. This method creates a lesion in an exposed or easily accessible cortical tissue area. The doctors remove the tissue with a fine-point crystal pipette.
- Radio-frequency lesion. It's carried out by creating small subcortical lesions. For that, an electrode channels the high-frequency current through the tissue of interest. The size and shape of the lesion depend on three factors:

- Duration of the procedure.
- Intensity of the current.
- Configuration of the electrode's point.

- **Scalpel cuts.** It consists of sectioning the brain area of interest.
- **Cooling lesion**. This biopsychology research method, although included under lesion methods, is actually temporary and reversible. Instead of destroying tissue, **one area is cooled a bit over the freezing point.** Neurons stop emitting signals, so the cold brain area remains blocked. With this, researchers are able to see what behavior alterations are caused by those areas. Once the temperature goes back to normal, brain function is restored.

Electrical stimulation

Another biopsychology research method is electrical stimulation. **The procedure consists of electrically stimulating a nervous system structure to get data about its functions.** Usually, a bipolar electrode is used.

This stimulation "shoots" neurons and alters their behavior. In general, it tends to get the opposite effect of lesion methods. For example, if it's possible to drastically reduce sleep hours with a lesion, then sleep behavior can become inconvenient and harder to control with electrical stimulation.

Lesion methods with electrical recording

- **Intracellular recording.** This technique is carried out by introducing a microelectrode in the interior of a neuron. It records fluctuations of membrane potential.
- **Extracellular unit recording**. A microelectrode is placed in the extracellular fluid that surrounds the neuron. It doesn't provide information on membrane potential.
- **Multi-unit recording.** In this case, the electrode point is bigger than that of a microelectrode, so it captures the signals of many neurons at the same time. The detected potentials then go on a circuit that integrates them.
- **Invasive EEG monitoring**. The stainless steel electrodes go inside the cranium. For subcortical signals, the usual electrodes are made of cable and implanted through stereotactic surgery.

- . **Neuropsychological Testing**
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- **Methods** used to assess psychological deficits of human patients suspected of having **brain damage.**
- a. **General Intelligence**:
- Most **neuropsychological** assessments begin with the Wechsler Adult Intelligence Scale (WAIS)
- It has **11 subtests**;
- 6 comprise the **verbal scale** (e.g., Digit Span, Information, Similarities);
- 5 comprise the **performance scale** (e.g., block design, object assembly)
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- b. Lateralization:
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- Evaluating the effects of damage to the right and left hemispheres
- - the following two tests are well known tests of language lateralization
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- - sodium amytal test: sodium amytal is injected first into one carotid artery and then, many minutes later, into the other;
- the patient is mute following an injection ipsilateral to the dominant hemisphere for language; but the patient makes only a few minor speech errors after an injection contralateral to the dominant hemisphere for language
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- - dichotic listening test: it is a noninvasive test;
- three pairs of digits are presented to the subject through headphones;
- the two digits of each pair are presented simultaneously, one to each ear;
- the subjects are asked to report the six digits that they heard;
- they do slightly better through the ear contralateral to the hemisphere dominant for language
- c. Memory
- - the WAIS digit-span subtest is the most common test of verbal short-term memory
- - the WAIS information test (who is the president of the U.S.A.?) is a quick way of identiiying gross deficits in long-term verbal memory; these can be adapted to an individual's culture
- - a thorough assessment of the various types of memory requires several tests
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- d. Language
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- - the token test is a good initial screening test for language-related deficits;
- (if the token test identifies deficits, it is followed up by a battery of tests of language ability)
- there are 20 tokens of 2 different shapes, 2 different sizes, and 2 different colors;
- the subject is asked to carry out various acts such as
- "touch the small blue circle and then the large green square”
- e. Frontal Lobe Function
- - the Wisconsin Card Sorting Test is often used
- Behavioral Methods of Cognitive Neuroscience
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- a. The constituent cognitive process assumption refers to the premise that complex cognitive processes are the combined activity of simple cognitive processes;
- and that each constituent cognitive process is mediated by neural activity in a particular area of the brain
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- - Cognitive psychologists, computer scientists, and neuroscientists combine efforts to model complex cognitive processes, for clinical as well as artificial intelligence applications
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- b. Paired-image subtraction techniques

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- - are key to coginitive neuroscience research by examining PET or functional MRI images on tasks that differ in only one constituent cognitive process;
- The difference between the two PET or fMRI images is thus viewed as specific to the one constituent cognitive process that was different between the two images
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- - processes such as seeing, reading, thinking of, and speaking the same words are frequently used in this type of research
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- 3. Animal Behavior Paradigms
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- a. Analysis of Species-Common Behaviors
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- - these behaviors are displayed in the same form by virtually all members of a species, of the same sex (e.g., grooming, swimming, nest building, copulating)
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- - the open-field test provides three measures of emotionality:
- (1) degree of inactivity,
- (2) thigmotaxis. and
- (3) defecation
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- - Aggression and defense can be studied by recording encounters between a small male intruder and a colony's dominant (alpha) male;
- aggression involves a sideways approach, sideways pushing, piloerection, and biting directed at the back;
- defense involves boxing, rolling over onto the back (protecting it), biting the face, freezing, and fleeing
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- - rat sexual behavior is another species-common behavior that is widely studied
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- - two common measures of female rat sexual receptivity are:
- (1) lordosis quotient (proportion of mounts producing lordosis), and
- (2) degree of concavity of the back during lordosis
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- - male rat behaviors measured include:
- (1) number of mounts to intromission.
- (2) number of intromissions to ejaculation,
- (3) and time to reinitiate mounting after ejaculation (called the postelaculatory interval)
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- b. Traditional Conditioning Paradigms
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- - Traditional conditioning paradigms play an important role in biopsychology for two reasons:
- (1) conditioning is a phenomenon of primary interest to psychologists; and
- (2) conditioning procedures are often used to train laboratory animals to perform as required in behavioral experiments

There are two kinds of traditional conditioning paradigms:

1) Pavlovian conditioning: in which a

neutral stimulus called a conditioned stimulus (CS; e.g., tone) is paired with an unconditioned stimulus (US; e.g. meat powder) that elicits an unconditioned response (UR; e.g. salivation).

As the CS becomes associated with the US, it begins to elicit a response on its own which is referred to as a conditional response (CR).

The CR is usually similar to the UR, but this is not always the case.

2) Operant Conditioning (AKA Instrumental Conditioning) in which

the rate of a particular response (pressing a bar) is
increased by reinforcement or
decreased by punishment.

c. Seminatural Animal Learning Paradigms

- ethoexperimental animal learning paradigms are controlled laboratory paradigms for studying forms of learning that are assumed to occur in the rat's natural environment;

the following are four examples:

1) Conditioned Taste Aversion:

- the most influential ethoexperimental learning paradigm;

Rats and many other animals learn the relation between a new taste (or smell) and subsequent gastrointestinal distress in one trial and subsequently avoid the novel taste

- taste aversion conditioning experiments in the 1960s challenged three widely held views of learning that had grown out of the study of the traditional conditioning paradigms:

(1) the view that learning is a gradual step-by-step process by showing that it could occur reliably in one trial,

(2) the view that temporal contiguity is necessary for learning by showing that conditioning occurred even when the taste and distress were separated by several hours, and

- (3) the view that associations between any two stimuli are equally easy to learn (the principle of epuipotentiality) by showing that rats could learn the relation between gastrointestinal distress and a taste, but not a light for example.
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- 2) Radial-Arm Maze
- This device is used to study foraging behavior in the laboratory
- - foraging in the wild is complex; the rat must learn where food is likely to be,
- and not to immediately revisit a stripped site where all the food has been consumed
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- in the radial-arm maze rats learn to go directly to the arms that are baited with food each day, but they rarely visit the same arm twice on a given trial
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- 3) Morris Water Maze:
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- - is laboratory paradigm used to study rat spatial ability;
- the Morris water maze is a large tub of milky water; to get out of the water,
- rats must learn to swim to a slightly submerged (invisible) goal platform
- - rats learn to do this very quickly, even when they are placed in the water at a different position on each trial; they use external room cues to guide them
- - it is interesting to look at their search strategies when the platform has been moved to a new location
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- 4) Conditioned Defensive Burying:
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- - based on observation that rats exposed to an inanimate object that has been the source of a single aversive stimulus (e.g., a shock, a bad odor, an airblast, or a flash) will often bury it
- - they bury it by facing it and spraying bedding or sand at it with their head and forelegs
- - it has been used to study antianxiety drug effects which reduce conditioned defensive burying at low doses
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- 4. Conclusion: Converging Operations
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- - you have now learned about many research methods used by biopsychologists; they all have strengths, but they all have weaknesses
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- - the key to scientific progress lies in bringing several methods to bear on the same problem so that each compensates for the shortcomings of the others.