Introduction to Psychology

September-09-10
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What is Psychology?

- Psychology is the study of the study of mental events and behaviour.
- However we must be able to quantify and study these two categories, as psychology is a science
- Mental processes are what is going on within the mind, they cannot be observed
    - As such we must infer, is this sceintific?

Major Divisions of Psychology

Experimental (mid-to-late 1800s)

- Roots of psychology, under a branch of physics
- Basic principles of experimentation are used to explain psychological phenomena
- Wundt began by wondering how we experienced the world
- Titchener
    - Structuralism - attempted to discover the basic structures of the mind
    - Introspection - the participant had to reflect on the contents of their consciousness
- William James
    - Functionalism - pragmatism OR what is the function of our thoughts and emotions
    - Did not experiment, but rather theorized
    - Wrote the first psychology textbook

- Clinical
    - Counselling, psychotherapy
    - S. Freud is considered to be the founder of psychotherapy but Frued was not a psychologist
    - Clinical psychology and therapy were founded just after the Second World War in response to the needs of veterans
- Applied
    - Apply knowledge gathered from experimental psychology and use it in the field
    - Social, development, educational and industrial psychology

Schools of Psychology

- Biological
    - Attempt to measure actualy events
        - Manipulate psychological state and see the effect on the brain itself (structure, activity)
        - Manipulate brain(physically) and determine effect on psychology/mental events

- Cognitive
    - major branch from 1800s-1900s
    - Study of higher mental functions
        - Consciousness, memory, attention, decision-making, language
    - Attempts to infer hypothetical mental states of “information” processing based on current response patterns/performance.
    - Fell into disrepute because inferring was thought to be unscientific
    - Revival in 1950s, now a boom field
    - Provides an elegant way to test cognitive functions
    - **Cognitive Neuroscience**
        - Uses biological methods to study cognitive activity
    - **Neural/Cognitive Modeling**
        - Use computers to mimic cognitive/information processing, how many decisions must the

computer need to arrive at a solution

- **Behavioural**
  - 1920s with J. Watson and his criticism of cognitive psychology and analysis
  - Skinner laid out much of the tenets of behaviourism
  - An objective science
  - Study of mental events is unscientific because
    - Mental events are private
    - Cannot be observed
    - Why do we act the way we do
  - An environmental; explanation of behaviour
  - All behaviour is learned
    - No need to postulate about genetic influence
  - *Deterministic* - all behaviour is determined by the e consequential events
  - What has been learned can be re-learned

- **Social**
  - Emphasis on behaviour in groups
    - How do your peers, friends, family etc influence your behaviour
  - **Socio-biology**
    - Most human behaviours can be explained through evolutionary principles
    - Survival of our species
    - Deterministic theory - we act the way we do in an effort to ensure the survival of MY genes
- **Psychoanalytical**
  - Is a separate branch of psychology, neither medicine nor psychology - founded by Freud
  - Role of the unconscious in our behaviour
  - Much of our behaviour is repressed, but influenced by our unconscious influences
  - Deterministic - behaviour is determined by unconscious "drives"
- **Phenomenological**
  - *Humanistic theory* - emphasis on unique human quality of behaviour
  - Concerned with individuals personal experience - focus on subjective experience
  - Concern with developing theories of inner life

- **Differences between psychoanalysis, psychiatry, clinical psychology, experimental psychology**
  - Psycholoanalyst - trained in psychoanalysis
    - May or may not be a psychiatrist - emphasis on Freud and post-Freud
  - Psychiatrist - must have an M.D.
    - Theory that psychiatric disorders are a mental illness - employ a medical model
    - Only people who can prescribe medication
  - Clinical psychologist
    - Must have a research degree, a Ph.D. Is trained in both research and clinical psychology
    - Emphasis on abnormal behaviour as opposed to an illness
  - Experimental psychologist - trained as a researcher
    - Legally cannot claim to be a psychologist - cannot provide psychotherapy or counselling

Lecture Outline

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Nature of Psychology

What is "psychology"? There is no easy definition. Its origins come from the words "logos" (the study) and "psyche" (the mind). Logically, therefore, psychology is the study of the mind, but this does not help much if we cannot define what we mean by the mind. Many claim that mental events take place within the mind. By mental events, we mean activities such as attention-consciousness, information processing, thought-language, memory, and decision-making. These labels, however, are still vague and abstract. If Psychology is a science, we need to define and measure our terms. These vague terms are neither easily defined nor measured. Some claim that Psychology is (or should be) the study of overt behaviour. A scientist cannot observe "mental events" but overt behaviour can be observed. For this course, we shall use a compromise definition of psychology – the study of mental events and behaviour.
Modern psychology consists of many different branches. These branches and divisions are somewhat arbitrary and are based on (1) whether the psychologist is a basic, fundamental researcher (an experimental psychologist), an applied psychologist using the applications of experimental psychology (thus an "applied" psychologist) or a clinical psychologist. The general public and many students first studying psychology assume that all psychologists are clinical psychologists (or psychotherapists-counsellors). While many psychologists are clinical psychologists, many are not. Psychology really began as a branch of Physics (and was called Psychophysics). There is real physical energy in the universe; this is studied by physicists. Humans (and other animals), however, experience (or are conscious) of only a small portion of this energy. This is because our sensory receptors are sensitive to only a tiny fraction of the physical energy in the universe. Moreover, our information processing systems assure that we are conscious of only a small portion of all the energy that bombards our receptors, that which is most relevant for our survival. Our attentional systems thus filter stimulus input, only allowing a tiny portion of it "through". Psychophysicists study the what and why of consciousness. We shall first examine the three major divisions of Psychology. Within each of these branches, there are also several divisions or what I call "schools".

Major Divisions of Psychology

Experimental Psychology

- Began in mid- to late-1800s. First experimental psychology lab considered to be that of Wilhelm Wundt in Leipzig, Germany. Wundt studies basic and simple concepts of consciousness.
- Structuralism. One of Wundt's students, Edward Titchener attempted to isolate the basic elements of the mind. This was known *structuralism* (the basic structures of the mind). Our experience of the external world is probably also made up of a mixture of simpler elements. He used the analogy of chemistry. Salt is made up of a "mixture" of sodium and chloride. Is human consciousness (the "mind") similar? What we see and experience as a "yellow" light is not in fact a yellow light. The retina in our eyes has receptors for only 3 types of colour, red, green and blue. When the "red" receptor fires, we experience red light. But how can we experience "yellow". There is no yellow receptor. It represents the firing of two receptor cells, those corresponding to red and green. We are conscious of yellow; we are not conscious of the fact that the red and green signals are being translated by the brain-mind. He asked his research participants to verbally state what they were "experiencing" when, for example, they smelled a flower, heard music, and so forth. This method of looking inward and reflecting on one's own conscious experience was called *introspection*. It however proved to be very subjective and unreliable. What one individual might report following introspection might be very different from what another individual might report.
- Nevertheless, the initial studies indicated that the basic principles of experimentation can be used

to explain psychological phenomena. The principles of experimental psychology had thus initiated.

- William James at Harvard University is considered to be the father of American psychology. James wrote a great deal about what we would now consider to be "cognitive" psychology (see section on Schools of Psychology). James did little actual experimentation. Thus, he did not experimentally test most of his theories. James is also considered by many to be an important (if not the most important) contributor to a branch of (an almost unique American) philosophy called pragmatism (following in the tradition of other American thinkers such as Benjamin Franklin). Philosophers had long debated whether human existence was mainly material or nonmaterial in nature (the materialism versus idealism debate). As an example, is the mind "strictly" material in nature. Is it simply part of the physical brain? We shall see more about this later when we discuss scientific methods. The James pragmatic approach declared, in essence, that the philosophical debate was really of no concern. What counted was the pragmatic end result. Pragmatism also forms the basis of another American economic model, capitalism. For many philosophers, this is an exceedingly empty principle. James is also credited with writing the first major textbook in psychology, a volume that is still often cited.

Clinical Psychology

* Counselling; psychotherapy. Sigmund Freud, in Vienna, Austria is generally considered to be the founder of psychotherapy but Freud was not a psychologist. He was a psychoanalyst. Major roots of clinical psychology and therapy are recent – perhaps as late as the 1940s in the U.S. Now the major field in Psychology.

Applied Psychology

* Social, developmental, educational, industrial psychology

Schools of Psychology

Each of the above divisions (experimental, clinical, applied) can also be sub-divided into a number of other branches, that we shall call "schools". Again, these are somewhat arbitrary. Thus, many experimental, clinical and applied psychologists might take a so-called "cognitive" approach while others might take a more "biological" approach.

Cognitive

- Initially began in late 19th Century (William James). Fell into disrepute. Revival in 1950s. Now a "boom" field.
- Study of higher "mental functions" -- memory, attention, decision-making, language.
- Attempts to infer hypothetical mental states of "information" processing based on current response patterns/performance.
- An example of an experiment in cognitive psychology: A group of participants is presented with 200 single words and 200 single pictures. They are asked to remember only the words. They are told that the pictures are there only to distract the participant from the task, remembering the words. The experimenter now presents a second series of words and pictures, some of which were presented before, some of which were not presented before. The participant recognizes perhaps 80% of the previously presented words, but surprisingly also recognizes about 80% of the pictures. The experimenter infers that images (or pictures) are stored automatically even if the experimenter does not ask the participant to do so. But perhaps words are also stored automatically. The clever experimenter now changes the task. A second group of participants is tested again being presented with the same long list of words and pictures. This time however they are told to remember all of the pictures and that the words are irrelevant. Again, they are shown another list of words and pictures and asked if they were previously presented. This time

only 30% of the words are correctly recognized but 80% of the pictures are correctly recognized. The cognitive psychologist thus infers that pictures are processed automatically even if the subject is told to ignore them. Words are not however processed automatically.

(Sub-Divisions of Cognitive Psychology)

Cognitive psychology has proven to be immensely powerful and popular (although there are major criticisms of the cognitive approach… see the scathing comments of behaviourists below).

- Cognitive Psychology
    - As outlined above, use measures such as performance and decision-time to *infer* about *hypothetical* brain functions
- Cognitive Neuroscience
- A problem with the usual methods employed in Cognitive Psychology is that the experimenter cannot directly *observe* the cognitive functions (for example, the automatic processing of pictures) that are of interest. Rather they are inferred on the basis of variance in performance. In scirence, we must be able to observe these measures of interest. How do we actually know that words and pictures are indeed processed differently in the brain? Recent innovations in neuroscience provide a method of overcoming this criticism. Modern brain imaging techniques permit the experimenter to actually observe the changes in brain activity as the participant is engaged in some cognitive task. Thus, in the word-picture task above, certain brain regions will be activated when you are presented with a word and asked to remember it. Now, when you are asked to ignore the words (or at least not remember them), not all of the same brain regions will be activated. This may not be the case with pictures. When you are asked to remember the pictures, certain brain areas will be activated (and these will be different from words, because pictures are not words). Now you are asked to ignore the pictures. If you cannot, the same brain regions are again activated.
- Neural/Cognitive Modelling
    - Use of computers to mimic cognitive/information processing. How many "decisions" must the computer make to arrive at a solution to a problem?

Biological

- Manipulate psychological state (attention, memory, decision-making) and see effect of this manipulation on brain activity, brain structure
- Manipulate brain (stimulate, lesion, drugs) and determine effect on psychology.

Behavioural

- Began in 1920s with J. Watson and his criticism of cognitive psychology and psychoanalysis (see below). B.F. Skinner (1935-1990!!!) laid out much of the tenets of "behaviourism"
- Psychology as an objective science. All psychological events must be directly observable. Cognitive events cannot be observed (only inferred). The study of cognition is therefore unscientific according to behaviourists. Similarly, psychoanalytic principles cannot be observed. The existence of the unconscious, so critical to psychoanalytic principles, also cannot be observed.
- Only behaviour can be observed. Thus, this school is called "behaviourism".
- The study of unobservable, undefinable, unmeasureable mental events(thwe field of study of cognitive psychology) is unscientific. The study of the mind is unscientific and thus a waste of time.
- All behaviours can be explained by their consequences! Behaviour is caused by what happened once the individual acted (behaved) in the past (i.e., the consequences of the behaviour). Behaviours that are rewarded (technically "reinforced") will be repeated. . A strict, environmental explanation of behaviour. We do not need to hypothesize about some inner, hidden, unobservable cause of behaviour.
- Deterministic -- all behaviour is determined by consequential events (reinforcement, punishment). Behaviour that is reinforced will be repeated. That which is not reinforced will not

be repeated.
- All behaviour is learned. To stop inappropriate behaviour, remove what is causing it to be repeated, the reinforcer.
- Most of clinical psychology and psychotherapy does not follow principles of behaviourism and thus is rejected as being unworthy of study.

Social

- Emphasis on social "behaviour".
- Study of social environment and its effects.
- Social attitudes; social learning.
- There are certain social psychologists who believe that most of human behaviour can be explained through evolutionary/genetic principles. These are called socio-biologists. Emphasis on the study of animal behaviour (ethology). Deterministic theory. This is almost the opposite of behaviourists who believe that it is learning that determines our behaviour. Social biologists claim it is largely our biology and genetic endowment that determines our behaviour.
- A newer branch of social psychology is social neuroscience (not the same as sociobiology). Social neuroscientists use neuroscience methods to study social phenomena (social interaction, emotions, attitudes)

Psychoanalytical

- S. Freud (late 19th, early 20th century)
- Role of the unconscious in determining our behaviour
- Much of behaviour and "emotion" is repressed (especially sexuality) and it is these repressed, unconscious influences that dictate our personality and behaviour.
- Deterministic -- behaviour is determined by unconscious "drives".

(Differences among psychoanalysis, psychiatry, clinical psychology, experimental psychology)

- Psychoanalyst -- trained in psychoanalysis. May or may not be a psychiatrist. Emphasis on Freud and post-Freudian (e.g., Jung) theory.
- Psychiatrist -- Must have an M.D. and then a residency in "psychiatry". Theory that psychiatric disorders are a mental "illness". Psychiatrists employ a medical model. Treatment methods can include psychotherapy but most often use drug therapy. This is because mental illness is often viewed as a chemical imbalance. In Canada. only psychiatrists can prescribe medication.
- Clinical psychologist -- In most provinces in Canada and states in the U.S., must have a research degree, a Ph.D. Is trained in both research and clinical psychology. In some regions in the U.S., a D.Ps will suffice (i.e., not trained in research). Emphasis on "abnormal" behaviour and not necessarily "illness". Emphasis on "change" through counselling/ psychotherapy.
- Experimental psychologist -- Trained as a researcher (in one of several different areas) Degree is Ph.D. Not trained in clinical psychology. Legally, cannot provide psychotherapy or counselling (cannot claim to be a "psychologist" to the public).
- Anyone can call themselves a "counsellor" or a "therapist". A counselor or therapist does not have to be a trained clinical psychologist. This does not mean that the non-psychologist "counselor" is a poor counsellor. It simply means they do not have a Ph.D. in clinical psychology.

Phenomenological / Humanistic (clinical psychology)

- *Humanistic* theories -- Emphasis on unique human quality of behaviour
- Concerned with individual's unique personal experience, their *phenomenology*
- Focus on subjective experience
- Concern with developing theories of inner life rather than explaining behaviour
- Criticized as being unscientific. Science can only study that which is objective and that which we

can observe.

Scientific Method

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- **Three main research issues**
  - *Stability versus change*
  - *Rationality versus irrationality*
  - *Nature versus nurture*
- **Methods of gaining knowledge**
  - Divine insight
  - Pure logic and thought
  - Scientific manipulation
- **Idealism versus Materialism**
  - Is all that exists material in form
    - Laws of physical universe
  - Psychology "concepts"?
    - Love, hate, liberty, free will - THESE MUST BE MEASURABLE
- **Scientific Process**
  i. Observation of universe - identifying a problem that needs to be solved
  ii. Development of a theory - posit a solution to the problem
    - The development of a theory requires considerable amount of literature search and a summary of what is already known
      - Explanations are logically deduced
      - Not an opinion, a statement of hypothesis
  iii. Definition of variables - operational definition.
    - Allows for clarity in terms of replication and terminology (i.e. What qualifies as ___ for the purposes of the experiment)
  iv. Measure/quantification of variables
    - In any science we need to quantify what we are measuring, in any science we can use more than/less than terms
  v. Design the study
    - Requires a knowledge of difference research designs and the advantages/disadvantages to each
  vi. Run the study
  vii. Analyze the results
    - Usually requires the use of statistics
  viii. Interpret the results
    i. Is the hypothesis supported, and should the theory be updated

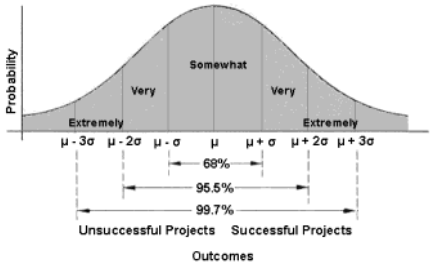
Logical Positivism

- Love or passion as a principle and reason as a base
  - Order and progress
- **Falsifcation of theory**
  - Every scientific theory must be falsifiable
  - Theories are false until proven correct
- Based on theory scientists predict or hypothesize

- Must be stated in a specific enough manner we can prove it wrong
- The onus is on the researcher to prove their theory true
- The theory is always assumed wrong
- Scientists thus state a null hypothesis

Identifying Variables

- If our theory is true the independent variable causes the dependent variable to change
  - The objective is to find a cause and effect relationship
  - If the dependent variable changes we have the research to say why
    - When scientists do not know why, they are ignorant
  - We should be able to explain
    - Variance between the groups
    - Effects of the experimental manipulation
      - This is called explain variance
  - The variance we cannot explain is called error or unexplained variance



- **Statistical Significance**
  - If the effects of the independent variable are different, there is statistical significance
  - Statistical significance is determined by comparing the ratio of explained variance and the un explained variance
    - Divide knowledge by ignorance
    - If this ratio is large enough the difference is said to be statistically significant
    - **Factors that affect…**
      - Reflection of the two variables
    - **How to ensure statistical difference…**
      - F=explained var/unexplained var
      - Ensure explained variance is large
        - Size of experimental effect
      - **Larger differences more likely to be significant**
- **Measures of Central Tendency**
  - There are always those above the curve/average
  - There are usually three measures of central tendency
    - Mode
    - Median
      - When the mean is distorted the median may be a better measure
    - Mean
      - Extremely high or low scores can distort the mean
- **Case studies**
  - One exceptional individual is studied in detail
  - Problems and generalisations

- **Group studies - sampling**
  - Sample a small number of individuals from a population(specify)
    - Randomisation
  - Its better to have a small but representative sample than a large and unrepresentative sample
- **True experiments**
  - Experimental manipulation applied
    - Problems:
      - Sample size, too small
      - Experiment must often be carried out in a controlled setting
      - Can we generalize lab results as applicable to the real word
- **Quasi-Experiments**
  - In the social environment the scientist cannot always manipulate the independent variable
  - Comparing two groups
  - Experimental manipulation is impossible
  - Assume that the difference are caused by the independent variable
- **Experimental Design**
  - One design uses control and experimental conditions
  - Random assignment - participants are randomly assigned groups
  - **Pre-Post**
    - A problem with the use of two groups is that our differneces may be due to chance
    - Solution: use the same groups twice with a reversal in roles
  - **Placebo**
    - Used to examine the effects of treatment
    - A treatment given to a patient who improves over time
      - Was it effective?
    - **Placebo effect**
      - Two groups - first given legit treatment, second given what they think is treatment
      - Control condition = placebo condition
    - Double blind design
    - No drug is approved by the Ministry of Health without a placebo study
    - Good explanation of the supposed benefits of psychotherapy and counselling
    - Anti depressants effective in about 40-50% of cases
      - Placebo effective in 40% of cases

Lecture Outline

September-16-10
11:21 AM

Introduction to Experimental Psychology
Scientific Method

Epistemology (Methods of obtaining knowledge)

Philosophers have identified at least three methods by which we gain knowledge ("truth"). These are:

- Divine (non-physical) insight. We gain knowledge through "communication" with a higher, nonphysical being. Presumably this higher being knows much more than mortal humans. We then must have belief or "faith" in this divine truth.
- Pure logic and thought (Aristotle). If we are logical enough in our reasoning, we should be able to deduce all knowledge.
- Scientific manipulation. This is the only method of gaining knowledge that we shall study in this course. A biologist might want to know if water affects plant growth. The biologist then manipulates the amount of water that is given to a specific plant. The biologist *varies* (thus the word "variable") the amount of water given to the plant. He/she gives the plant more or less water. He/she then observes the *effect* of this variable (the amount of water that is given) on plant growth. The result might well be that plants that are given more water grow higher. We now have *knowledge*. We *know* that water will *cause* plants to grow.

Materialism versus Idealism

For many centuries, philosophers and scientists debated about the nature of human experience (consciousness). A pure materialist assumes that all that exists must exist in some physical form. This material existence is subject to the laws of the physical universe. There is thus no room in this model of the universe for non-material existence. A pure materialist is thus an atheist. He or she does not believe in any higher non-physical existence, in god(s) or in the soul/mind (assuming that souls and minds are not physical). By contrast, a pure idealist does not believe in the physical reality of our existence. This is best exemplified by the Greek philosopher, Plato. How do we know that physical reality exists at all? How do I know that I am not simply experiencing dream-like existence? It was not until several centuries after Plato that a compromise solution was made by the French philosopher and mathematician, Descartes, who found room for a nonphysical existence (the mind or soul) and physical existence (the body). The laws of science operate *only* on a physical, material existence. Nevertheless, philosophers point out that we do have concepts such as love, hate, free will and in psychology we have concepts such as the mind, consciousness-unconsciousness. Are these entirely physical in nature?

Scientific Process

- *Observation of the universe*. There are many things we do not understand, for which we do not have an explanation. So…
- *Define a problem*. What is the problem that needs explanation? What questions are you asking? (What is the controversy?) Let's take an example from psychology. We know that a drug, alcohol, affects performance on many tasks. Why does it affect performance on these tasks? You might *speculate* (or have an "opinion" more about this later) that alcohol mainly affects tasks that are very complex. Simple tasks are thus spared. Even if this was true, it does not explain why alcohol affects complex tasks more than simple ones. Furthermore, you need to define what you mean by a "complex" and an "easy" task. What is complex about a complex task? As you can see, we now have many problems that need to be solved.
- *Search the literature*. Go to the library. Read the scientific periodicals (called "journals"). Search the

internet. Has anyone already asked the same questions? Many scientists have already done many, many studies on the effects of alcohol. While you might speculate that alcohol only affects complex tasks, you would be wrong. The fact is that we *know* (that word again) that alcohol may not affect all complex tasks. Speaking is a very complex cognitive function. Yet we manage to speak and to understand speech quite well under the influence of alcohol. Driving a car is also a relatively complex task. It takes several months (if not years) to master this task. Yet under the influence of alcohol, we seem to manage quite well. We can (unfortunately) get into the car, turn on the ignition, put the car in gear, accelerate, turn, navigate. Identifying red lights should be an easy task. Very young children can, after all, discriminate red from green. But, under the influence of alcohol, we sometimes do not do this task well. We sometimes miss the red light.

- *Development of theory*… a summary (synthesis of what we already know). Based on a complete review of existing studies (the "literature"), you might arrive at the conclusion that alcohol appears to mainly affect tasks that require short-term memory. Tasks that require long-term (or permanent) memory are not affected. Now you have developed a *theory* based on a thorough review of the literature. This is no longer speculation.
- Based on theory, scientists form an *hypothesis* (or prediction). In the example above, you would hypothesize that alcohol affects any task that requires short-term memory. It should not however affect tasks that require long-term memory.
- *Testing of hypothesis* (unbiased, objective). This involves the design of a study to answer the questions & resolve the controversy. Obviously you would need to include in your "design" certain tasks that require the use of short-term memory and others that do not.
- *Data collection*. Run the study.
- *Analyses of the data*. Does alcohol cause a *variation* in performance? Do the results *differ* (or vary) depending on which task was run?
- *Interpretation of the results*. Was the hypothesis supported by the results? Are there alternate explanations (theories) that might also explain the results?

Theories/Hypotheses

- Theory - predicts behaviour or events. Theories are formed after a review and synthesis of the relevant literature. It is based on existing *fact*.
- Theory vs speculation (opinions). A theory is only formed after an objective review and synthesis of already published research. It is not formed on the basis of guesswork or subjective opinion. We can all speculate about why things are the way they are. The problem with this is that your opinion is as good as mine. Which opinion is correct? Again, theory is based on fact. You may have an opinion that humans can get by on 2 hours of sleep. Your theory is wrong. It is a fact that humans require more sleep (a subject we will study in this course) and if they do not get, will suffer grave consequences.
- All hypotheses must be testable. (see next section). We must be able to design a study to test the hypotheses. Hypotheses make predictions. The results of the study will allow us to say whether your theory is true or false.
- A GOOD theory is one that potentially can be proven to be WRONG. There is no point in simply stating that alcohol affects performance. Even if I find that it does not affect certain tasks, you can always claim that I was not using the right tasks (the ones that would be affected by alcohol).
- Replication - Others should be able to exactly replicate what you have done and what you have found. This is why science is said to be "objective" and "universal". If we repeat the experiment anywhere in the universe, the results should be the same. We thus obtain "universal" knowledge.

Hypothesis testing

There are many, many problems that remain unsolved. Different theories can, however, be developed, each of which might potentially explain a fact. Fact: men perform slightly better in math than women (to balance matters, women perform slightly better than men on verbal tasks). One theory to explain why men do better on math is that it is a result of evolution, and more specifically, hormonal differences. Another theory, however, maintains that the differences can

be explained on the basis of social learning. Women learn that math skills are not admired. Men learn that they are admired. Both theories cannot be correct. We thus have a *controversy*.

- Scientists state an hypothesis. This is an expectation based on previous scientific research (fact). "If theory X is correct, we would expect that…" On the other hand, if theory Y is correct, we would expect that…"
- The hypothesis must be stated in a specific enough manner that we can prove it to be wrong
- Define variables of interest. *Operational definition*. If you claim alcohol affects performance, how do you define "performance"? If your hypothesis is that alcohol causes you to "feel good", how will you define "feeling good"?
- Means of measuring (quantifying) variables of interest. This is often an extremely difficult step in Psychology. Recall that science operates on the basis of material existence. There must be more or less of it. This implies that you must be able to *quantify* your variable of interest. You need to attach a number to it (to "measure" it). Logically, a variable must "vary". Even if alcohol does make one feel good, how would you measure "feelings" and in particular, "feeling good"?
- According to many philosophers of science, we should assume that all hypotheses are false unless proven otherwise. This is what is meant by the *null* hypothesis. The onus is thus on the researcher to prove their theory true. In this sense, science is very cynical and pessimistic. We assume god(s) does (do) not exist until proven otherwise. We assume there are no aliens on other planets. We assume there are no tigers roaming the campus of the University of Ottawa. If we come upon a tiger, then we have positive evidence. Our null hypothesis is wrong. If we do not find any tigers, it can always be claimed that we have not looked in the right places. In the example of alcohol, we assume that it does not affect performance. If it does, the null hypothesis is wrong. (Incidentally, this is exactly the same logic that we use in British-based "common law" legal systems. We assume that a suspect is not guilty… The *null* hypothesis is that the suspect is *not* guilty. Note we do not assume that they are innocent… it is philosophically difficult (if not impossible) to prove innocence. The onus is on the government (the courts) to prove the suspect to be guilty. There is enough positive evidence to judge the null hypothesis… the assumption that the suspect is not guilty… to be wrong. If there is not enough evidence to find the suspect guilty, they are not judged to be "innocent"; rather they are judged to be "not guilty".

Problems in Psychology

Often many of the questions we ask are exceedingly difficult to test. Frequently, we cannot easily define psychological concepts. We may not agree on a way of measuring the concept. Let's use the example of aggression. We know that certain children are more aggressive than others. As good scientists we need to ask the question, why? Why are some children more aggressive while other children are less aggressive? What is the cause of aggression? Perhaps it is because the very aggressive children have inherited a gene for aggressiveness. But perhaps certain children have also learned to become very aggressive. We go to the library/internet and do a search. We find that there are wide differences across the world. In particular, countries that do not censor very violent computer games, television and movies (the "action thrillers") appear to be much more violent than those that do. A "learning-modelling" theory claims that aggression is learned and indeed it is rewarded (reinforced). Those children that watch the most violence on television (or play the most violent computer games) tend to become the most aggressive.

- Theory: Watching violence on television *causes* children to become more aggressive. Biology has nothing to do with it.
- Alternate theory: It is biology (too much activity in certain "aggression" areas of the brain)) that cause certain children (and boys in particular) to be aggressive. Learning has nothing to do with it.
- Both theories cannot be correct.
- *Operational definition*: Define *variables* of interest: Children? Violence? Aggression?
- Manipulate extent of violence to which children are exposed in the experiment? How will this be done?
- Measure/quantification: How does one quantify violence? aggression?

- Ideally we would also manipulate the brain. We remove the aggression areas of the brain. Now are the aggressive children less aggressive? Obviously, we could not ethically do this type of study. But perhaps we could identify those who are the most and least aggressive and them scan their brains using an MRI. Are the brains of the most aggressive different from those who are the least aggressive? Note that this is not a true experiment (see next section). Further, even if the experimenter does find a difference in the brains, this does not tell us why the brains are different.

Types of Studies

In the natural sciences, *true* experimentation is often carried out. This is often not possible in the humanities, in medicine and in social sciences. We shall examine the following types of studies: case studies, true experiments, quasi-experiments, naturalistic observation, survey studies and correlational studies. Please note that the list is somewhat arbitrary and not mutually exclusive. A survey might also, for example, be a correlational study. It might also be a true experiment.

Case Studies

- Study one or more individuals in detail to obtain data that would be true for all of us. Often these individuals are exceptional cases. For example, we might study a brilliant mathematician, an individual with outstanding memory, or perhaps an extreme autistic.
- Can suggest hypotheses for further testing
- BUT, can be misleading
- We can all think of a single case that would prove the theory right or wrong.

Sampling

When we study groups of individuals, we obviously cannot study all members of the group. If we wish to compare males and females, we cannot study every single member of the Canadian population. We therefore need to select certain individuals who are representative of the population.

- Population - the whole group you wish to study
- Sample - a smaller *random* (every member of the population has an equal likelihood of participating in the study) selection of individuals in the population
    - The sample must be *representative*. It is better to have a small but representative sample than a large, unrepresentative sample.

True Experimental Studies

- In a true experiment, the factor (or *variable*) of interest is *manipulated*. This variable is called the *independent* variable. Let's return to the study of the influence of alcohol. We might manipulate the dosage of alcohol. The scientist will give more or less alcohol. One group gets a large dosage (say 200 ml of vodka… that's about 7 or so oz!). A second group gets a smaller dosage (say 50 ml). A third group gets no alcohol (0 ml of vodka). We mix the alcohol with a mint drink. None of the participants in the experiment can tell which drink they are getting.
- Our hypothesis is that alcohol will affect performance (we obviously need to define "performance". What task will the participants perform? Larger dosages will affect performance more than small dosages.
- We assume our expectation to be wrong! Again, this is the null hypothesis. We thus assume that alcohol does not affect performance until proven otherwise.
- If our theory is true, the manipulation of the independent variable *causes* another variable to change. This is a cause-and-effect relationship. In the example, alcohol might cause performance to worsen. The variable that is affected by manipulation of the independent variable is called the *dependent* variable. In this example, our dependent variable is performance on a task. We need to

define a task. Let us assume that the participant is asked to push one button if a red light is presented and another button if a green light is presented. We will measure how long it takes to respond to each of the lights. (The delay in responding is called the "reaction time" (RT)).

- The dependent variable is that which we measure. Thus, the dependent measure in this example is RT. The dependent variable, RT, might vary because of the independent variable, the dosage of alcohol. If the theory is correct, RT should be slower when a high dosage is given compared to when a low dosage is given.
- While certain variables are manipulated, others are held *constant*. Everything in the alcohol experiment is held constant, except for the dosage of alcohol. All participants, regardless of the amount they drink, see exactly the same lights. They all do exactly the same thing in the lab.
- Note that there are two things that vary. The dosage of alcohol that our three groups receive is varied (or manipulated). Performance (measured by RT) may also vary. We thus have an independent variable (it varies) and a dependent variable (it will vary if the dependent variable causes it to vary; it will not vary if the dependent vary does not cause it to vary). If alcohol does indeed affect performance (RT becomes slower with higher dosages), we *reject* the null hypothesis as being *false*. Our conclusion is thus that it is not true that alcohol does not affect performance. In other words, alcohol does affect performance. Alcohol *causes* RT to vary. If RT is not influenced by alcohol, it will not vary. RT will be the same whether participants drink alcohol of not. In this case, we fail to reject the null hypothesis. We do not have evidence that alcohol affects performance.
- Note that if RT does vary, we will know why. We have obtained *knowledge* about the *effects* of alcohol. It *causes* RT to slow. Assuming this is the first time the experiment has ever been run, we now know something we did not know before. This is called scientific *progress*. When scientists do not know why certain variables vary, they are said to be *ignorant*. Ignorance is the absence of knowledge. Variance that cannot be explained is called *error*. A "mystery" is something we cannot explain (for which we do not have knowledge of why it varies). It is assumed that scientists can potentially explain everything in the universe. If, at the moment, they cannot, they must be making an error. Please note that contrary to popular belief, scientists can, in fact, only explain a very few things. We remain, therefore, very ignorant about most of the mysteries of the universe.
- There is also another very important source of variance in our experiment. We have a certain number of participants in the experiment. Their reaction times will not be identical. Some will be faster. Some will be slower. In other words, there are individual differences (or variance) within each group. What is the cause of this variance? The only variance we can explain is that which we manipulated. We do not know why individual participants' RTs vary. Variance as a result of individual differences is thus called error variance. We can speculate about why individual RTs vary. Perhaps some individuals were more interested in the study. Perhaps certain individuals are simply faster while others are slower. Perhaps some react to alcohol more than others, but we are only guessing. We do not really know any of this. To gain this knowledge, we need to manipulate these variables. So, if you think "interest in the study" explains RT, you now need to design another experiment. You need to define "interest" (and how would you do this?). You need to manipulate "interest". Then, you examine if "interest" in the task does indeed cause RT to vary.
- Our dependent variable (RT in this example) therefore varies for two reasons – because of the effects of the independent variable (that which we manipulated) and individual differences. We can explain the effects of the independent variable. Alcohol causes RT to vary. We cannot explain variation among individual participants. In any experiment, there are thus two sources of variance: one that we can explain, and one that we cannot explain. As we shall later see, this becomes crucial when we attempt to determine if differences due to the independent variable are *statistically significant*.

Experimental Designs

Researchers employ different designs to test their theories. Studies are designed to assure that the results that are obtained cannot be explained by "confounds"

- One design uses *control and experimental* conditions (or perhaps groups). *Control and Experimental groups*.
    - The control condition provides a baseline to which the experimental condition can

be compared. No experimental manipulation is carried out with the control group. In the alcohol example above, the control group receives no alcohol.
    - The experimental manipulation is carried out with the experimental group. In the example above, the experimental groups receive different dosages of alcohol.
    - *Random assignment* -- participants will be randomly assigned to either the control or experimental conditions.
    - Again, an example will be used. We want to know the effects of sleep deprivation on RT. We will manipulate the amount of sleep that participants will have and then examine the effects on performance (on the speed of responding or RT). The independent variable is thus the amount of sleep. The dependent variable is thus RT. Twenty individuals will participate in the study. Half (10) of them are assigned *at random* to the experimental group. The other half are assigned to the control group. The experimental group is tested following 24 hours of sleep deprivation. The control group is not sleep deprived. The amount of sleep is thus manipulated between the two groups.
- *Pre-post designs.* A problem with the use of 2 different groups (experimental and control) is that whatever differences we find in our independent variable might be due to chance. Let us assume that RT is much slower in the experimental than the control group. Can we then conclude that sleep deprivation causes a slowing of decision-making? Not necessarily. Perhaps the experimental group was simply a very slow group. Had this group not been sleep deprived, the participants would still have had slow RTs. The fact that we randomly assigned participants to one group or the other should control for this finding, but it is possible that just by chance the slow responders were randomly assigned to the experimental group (just as it is possible to sometimes flip a coin and get 5 heads in a row).
    - The solution to this dilemma is to use the same group of participants in both *conditions*. The group is then tested prior to sleep deprivation and again following it. They are thus tested pre- and post-deprivation. The *pre-post design* thus controls for possible random differences in the selection of different groups. But… there are also problems with the pre-post design. Differences between pre- and post- conditions might be due to a "confound" such as practice (with repetition of a task performance might be better), or perhaps participants become bored of having to do the same task a second time, in which case, performance deteriorates.
- A special design is used to examine the effects of "treatment". Let us assume that I have a theory that suggests that a new drug I have discovered will be effective in the treatment of cancer. I give the pill to a group of cancer patients. After 3 weeks, it is found that the pill is quite effective. More than 40% of the patients' symptoms are reduced.
- Does this necessarily mean my drug was effective? No! It is entirely possible that the reductions in the symptoms might have happened even if there were no drug treatment. Or, perhaps the fact that patients knew they were being treated for cancer caused the change in their symptoms. These types of improvements are called the *"placebo" effect*.
- To control for this, one group of patients is given the actual drug (or any other treatment) and the other half is given what they think is a valid treatment. They might be given a sugar pill but are given exactly the same expectations as the other group. This control condition is called the *placebo condition*. To ensure that all patients have the same expectations, neither the experimenters nor the patients know which treatment (the actual drug or the placebo) is being given. This is called a *double blind* design. Placebo effects can be extremely powerful. Placebos have been shown to be very effective in decreasing feelings of extreme pain, almost as powerful as a potent anaesthetic. Many medical disorders improve upon administration of a placebo. No medical treatment that is approved by the Ministry of Health can be used with the general public before a placebo study is carried out. In clinical psychology, the placebo effect is a particularly good explanation of the supposed benefits of psychotherapy and counseling.

Problems with True Experiments

- Often the sample size is small. Can we generalize to the population as a whole from such small samples?

- Experiment must be carried out in a controlled setting (often in a laboratory). Is this typical of the real world? Let us suppose we are studying changes in personality as a result of alcohol. We hypothesize that alcohol will make participants less inhibited. They will socialize more and perhaps be more aggressive. Lab results indicate, however, that the participants are not more aggressive or sociable. Perhaps this can be explained by the fact that they are in a lab environment, and do not act as they would in a more normal, social bar-type situation. Is it possible to generalize from the results of a lab-based study to the real world?

Quasi-Experiments

- Often in the humanities and health sciences, it is not possible to manipulate the independent variable.
- As an example, a scientist has done an extensive search of the literature and observed that there is good evidence that that men do perform slightly better in math than women. The scientist then develops a theory that men are better at math because of their male hormones. A study is designed. We arrange to test a sample of undergraduate students on a math test. The results do indeed indicate that the men do better than the women. Why? (Again, in science we want to know the cause of variation. The scores on our math test vary and we do know that sex or gender will cause the scores to vary, but why?). Recall in a true experiment, we manipulate the independent variable. But in this experiment, nothing was manipulated. We know that men did better than women at math but is this actually due to male hormones? To prove that the difference is due to hormones, we need to manipulate the quantity of male and female hormones in our participants. (Recall how we gain knowledge in science). In a true experiment, women would be given massive dosages of male hormones (and thus become men) and men would be given massive dosages of female hormones (and thus become women). If the differences in math were due to hormones, then the women should now do better in math than the men. How many humans would however volunteer to participate in this study?
- Several other examples could be given – differences between younger and older participants; differences between normal controls and patients.
- In a quasi-experiment, it is not possible to manipulate the independent variable (example, sex, age, race…)
- It is however assumed that the differences that are found are *caused* by the independent variable. This can be a very questionable and controversial assumption.

Natural Observation.

Not all studies in the humanities are carried out in a laboratory. As we noted above, it may be difficult to generalize from a lab to true life situations. Human participants may act differently in a lab situation than they would in their natural environment. A participant may be able to compensate for the effects of sleep deprivation in a lab context. However, put them on a real highway and they fall asleep. In the alcohol studies described above, very few participants ever become violent or aggressive. Go to a real bar and there are only too many examples of violence.

- Studies carried out in the field or "natural" environments attempt to overcome the limitation of generalization that is imposed on lab studies.
- The problem with natural observation is that it is exceedingly difficult to implement the control afforded by the lab context. Thus, while there might be considerably more violence in a real bar, what accounts for the violence? Is it only alcohol? How can this be controlled?
- Again, it is very difficult to carry out true experiments in the natural environment. As such, the researcher cannot easily know why differences occur.

Surveys

In the social sciences and in particular in social psychology, we often gain knowledge of human beliefs and attitudes by directly asking about them with *surveys*.

- Participants are asked to report their behaviour, attitudes or beliefs
- The participant is asked a question with which they can either agree or disagree.
- Wording of questions can be crucial.

  Example of survey questions: *Do you agree or disagree that*:
  a. Canada should not allow pornography.
  b. Canada should forbid pornography.

  a. Canada should not put marijuana users in prison.
  b. Canada should legalize marijuana usage.

- Survey studies are often quasi-experiments. If a researcher determines that 65% of men and only 35% of women are opposed to gun control in Canada, this would be an example of a quasi-experiment. The sex (or gender) of the participant could not be manipulated. Therefore, we do not know why males and females answered the way they did.
- Surveys can also be used in a true experiment. Suppose we do the same survey on gun control and obtain the same results. Now, the participants are shown a film depicting just how many people are murdered by guns. Now, the results change. Most men are now no longer opposed to gun control. This study carried out a true manipulation. As a result, it is possible to say that we now *know* that attitudes toward gun control will vary depending on prior learning.

Measures of Central Tendency

- There are usually (almost always) individual differences in the dependent measure. Some individuals score high; some score low.
- Statisticians typically employ three different measures of central tendency (the "typical" score).
- These are the mode, mean and median
- The *mode* is the score that occurs most often.
- The *mean* is the average of all scores.
- The *median* is the score at which half the individuals score above and half score below.

The Normal Curve

- A *distribution of scores* is a graphic representation of how many individuals have a particular score.
- If I ask the age of students in this class, perhaps 40 are 17, 120 are 18, 50 are 19, 30 are 20, 12 are 21, and perhaps 5 more than 21.
- Many psychological measures are distributed according to a bell-shaped *"normal" curve*.
- In the example above (age of students in this class), the age of students would not be distributed normally, but if we survey your grade point average (GPA) in high school, we should obtain a normal curve. Let us suppose the mean (or average) is 83%. Most students have a GPA that is about 83%. A small percentage might have a GPA that is above 95% and a small percentage below 71%.
- Note that the normal curve is balanced. Half of the individuals score at or above the mean and half score at or below the mean. Most score around the mean. Only a small percentage will score well above or well below the mean.
- In a perfectly normal curve, the mean, the median and the mode are identical.

Problems with the Mean as a Measure of Central Tendency

- At times, our measures are not normally distributed. Extremely high (or low) scores might distort the average (or mean). Most university students are in their late teens or early 20s. However, some are in their 70s. The older students would tend to "pull up" the mean.
- In this case, the median might be a better measure of central tendency. Why?

Statistical Significance

- Statisticians have developed a measure called statistical significance.

- This means that differences of a certain magnitude could not occur by chance.
- A statistician might claim that differences this large could only occur by chance on 5% of occasions. This means that if we would run the experiment 100 times, we would find differences this large just by chance on 5% of occasions (i.e., 5 times).
- Let's use the example of alcohol and reaction time. The experimenter chooses 10 individuals at random to be in the control group and 10 individuals to be in the experimental group. The experimental group is asked to drink the equivalent of 10 beers. Subjects (also called "participants") are asked to push a button whenever a red light is flashed on a monitor. The overall (or "grand") mean of all 20 subjects is 390 but this varies. Some individuals are above the mean; others below. The mean RT of the control group is 320 ms (milliseconds) while that of the experimental group is much slower, 460 ms. In short, the experimental manipulation appears to have caused the RT to increase. However, we might randomly select 10 subjects and place them in a group and select another 10 subjects and place them in a second group. We do not give any of the subjects alcohol. The two groups should thus, on average, have the same reaction times, but just by chance (by the luck of ransom selection), they might not. What is the probability that the difference in means of the two groups will vary by 140 ms (exactly the same as in our experiment)? Statisticians will always provide a measure of chance probability. They might thus indicate that a difference of this magnitude could be found by chance (by random chance selection) only on 5% of occasions. In short, if we chose two groups at random (and did not give them any alcohol) and we did this 100 times, we would obtain differences of this magnitude 5 times. This is what we mean by a *chance* finding. There is no reason to expect that the mean RT of the two groups should vary, other than pure chance. Indeed, we have 95% likelihood that these differences could NOT be due to chance. *Statistical significance* thus provides a measure of how often a difference could be found purely by chance.
- Note that statistical significance and practical significance are not the same thing. A result can be statistically significant but have no practical significance.
- There are two sources of variance in any experiment. One we can explain (because of the experimental manipulation); one we cannot (individual differences).
- How do we determine if our experimental effect is statistically significant?
- The explained variance is divided by the unexplained variance (knowledge is divided by what we do not know).
- But how do we measure variance? We need to compute explained variance and unexplained variance. As the name implies, variance is computed by examining the extent to which scores deviate from the mean. You MUST think about the following concepts. They are the essence of ALL science, whether you study Psychology, Physics, Biology, Sociology, Criminology, Medicine or Business. Note that if the experimental manipulation has a large effect, the explained variance will be very large. On the other hand, if the experimental manipulation has no effect at all, the explained variance would be zero (0). Unexplained variance examines the extent of individual differences. If all individuals scored exactly the same, there would be no individual differences. Thus unexplained variance would be zero. On the other hand, if individuals have very different scores, there would be large unexplained variance.
- Unexplained variance is computed by subtracting the mean from each individual's score, telling us how much an individual varies from the mean. (Note that we do not know why these individuals deviate from the mean… this is "unexplained"). As would be expected from the normal curve, some individuals will be above the mean, and some below the mean, giving negative and positive *deviance*. We square these scores (to eliminate the sign), sum up these squared deviances, and then divide by the number of individuals in the group (thus we have a mean or average deviance). In an experiment, there is an overall (or "grand") mean. In the example above, the grand mean was 390 ms (320+460 ms divided by 2). We then subtract this grand mean from the group means (320-390 and 460-390), square the differences, and sum these squares, then divide this sum by the number of groups to give a mean or average explained variance.
- If the ratio of explained to unexplained variance is large enough, the result is probably statistically significant. It is not likely that this difference could be due to chance.

Factors that affect statistical significance

- Recall that significance is a reflection that differences this size are not likely to be found by random chance.
- Explained variance (knowledge) is divided by unexplained variance (individual differences or ignorance).
- Thus, the likelihood of finding statistical significance increases according to the size of the experimental effect. Larger differences are more likely to be significant. The likelihood of finding significance decreases when the size of the experimental effect is small.
- The likelihood of finding significance increases when unexplained (individual) variance is small, and decreases when individual variation (individual differences) is large. In a pre-test, if all individuals score the same, and then in a post-test, they score only slightly higher, this is not due to chance. If the experimental manipulation has a highly consistent effect across all individuals, the effect is likely to be significant. In the alcohol study, we noted that the drug might slow reaction time. If only 10 participants are sampled, the experimental effect of the drug (alcohol) will probably be significant if all 10 participants show slow reaction times following ingestion of alcohol. It would be quite unlikely to flip a coin 10 times, and get heads on each flip.
- The size of the sample. If a very large sample is used, very small differences might be statistically significant. On college entrance exams in the U.S., men score minutely higher than women on math, but this is statistically significant. This reflects the representation of the sample. Large samples, because they are composed of so many members of the population, are much more likely to be representative of the population. In this case, many women actually score higher than men, but on average men score just slightly higher than women. Again, statistical significance does not imply practical significance.

Correlational Studies

Many studies that are carried out in the social and medical sciences are not experiments at all. Rather, they are best described as "correlational" studies. As an example, it is known that poorer people commit more crime than richer people. Does this mean that poverty causes people to commit more crime? Perhaps; perhaps not. Also, the more one smokes, the more likely it is that they will get cancer. Does this mean smoking causes cancer? In these examples a change in one variable is associated with a change in another. There is thus a co-relationship (or a *correlation*) between smoking and cancer.

- Correlation - A statistical measure of the extent of a relationship between two variables
- Correlation allows one to predict scores on one variable if the scores on another variable are known.
- Correlations vary from -1.0 to +1.0. A negative correlation indicates that as the scores on one variable increase, the scores on another decrease. The more alcohol one drinks, the less able one is to drive a car. A positive correlation indicates that as one score increases, the other score increases as well. The more one studies, the higher the marks; the more calories one eats, the heavier one becomes.
- A correlation permits a prediction. If there is a high correlation between eating calories and weight gain, knowing how much you eat, I can predict how much weight you will gain. Knowing how much alcohol you have consumed allows me to predict how well you can drive a car. Both positive and negative correlations allow the researcher to predict. The sign (+ or -) is thus incidental. It is the size of the correlation that is important. With a correlation of 1.0, there is perfect predictability. The closer the correlation is to 1.0, the closer the association between the two variables.
- On the other hand, if there is no relationship, the correlation is 0.0. Knowing the scores on one variable does not help predict the scores on another. Height is a very poor predictor of marks in Intro Psychology. The correlation between height and marks is thus close to 0.
- *Correlation does not prove causality*. While there might be a high correlation between smoking and the incidence of cancer, this does not mean smoking *causes* cancer. Perhaps smokers are under more stress than nonsmokers, and it is the stress that causes cancer, not smoking. There is a strong negative correlation between age and memory. The older we become, the more we forget. This

does not however mean that ageing *causes* memory loss. Because the elderly have lived so long, they have stored much more than younger adults. They thus have a more difficult time searching through all these memories. Perhaps if a younger adult could be identified that also has stored a tremendous amount, they could have difficulty retrieving these memories. In Criminology in certain countries, it is hypothesized that capital punishment should reduce the incidence of murder. However, countries that have capital punishment also have very high murder rates. Does the fact that the sentence for murder is capital punishment actually cause more murders to be committed?

- Again, in order to prove causality, the researcher must carry out a true experiment. In the correlational studies, no manipulation is carried out.

Neuroscience and Synaptic Transmission

September-28-10
1:08 PM


9.2_-_Electrochemical...


9.3_-_The_Central_Ner...

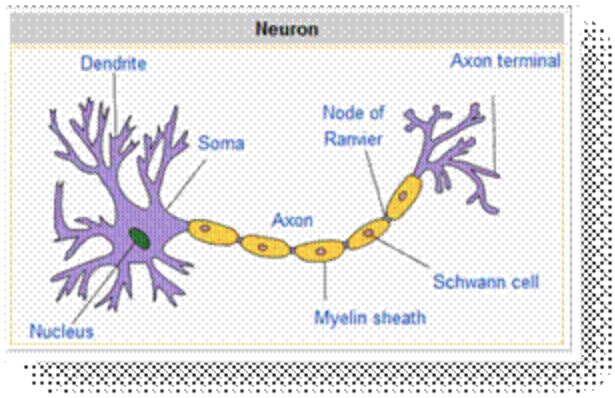
- *DENDRITES*: short branches projecting from cell body. Within the dendrites are embedded highly specialized receptors (see section on terminal endings below)
- *receive* messages from other neurons
- *CELL BODY (soma):* contains the nucleus of the cell and other basic elements necessary for the survival of the cell.
- *AXON*: a long, slender tube which carries information from the cell body to synaptic terminals. It is analogous to a wire or a cable
- Myelin sheath
  - Surround the longer neurons with a lipid material
  - Serve to
    - Protect axon
    - Insulate axon - prevent axonal cross-talk
    - Speed up transmission
- Terminal Ending
  - Pre - send to another neuron
  - Post - send to another muscle or tissue
- Sensory neurons: transmit pulses received by security receptors to CNS (Afferent)
- Motor neurons: carry outgoing signals from CNS to muscles and glands. (Efferent)
- Interneurons
  - Often removed from other neurons
  - Excitatory or inhibitory
  - Flexibility of behavior
- Resting potential
  - All cells carry a changing electrical charge
  - This allows for communication amongst neurons
  - Inactive neurons contains an excess of negative ions
  - Charge of a human neuron is -70
- Depolarization
  - Surplus of negatively charged molecules
  - Buildup of chloride (Cl-)
  - Buildup of positively charged sodium ions outside the membrane
  - When the dendrite is stimulated by another neuron through the release of an excitatory neurotransmitter (or artificially by electrical stimulation), the cell membrane's "channels" (or "gates") open, allowing *positively* charged ions to flow in (point 1 in the figure above).
  - This change in the charge of the neuron (less negativity or more positivity) is called *depolarization.*
- Action potential
  - When the flow of positive ions reaches a threshold of excitation the neuron fires - action potential
  - The gates of the membrane open and positive ions rush into the cell
  - The action potential goes down the length of the axon
  - If there is not enough excitation the charge is not released
- All-or-None Law
  - The action potential will propagate the length of the axon
  - The amplitude of axon will NOT vary - this is the all or none law
  - We either get a charge or we don't the strength doesn't change
- Propagation of Action Potential
  - Action potential will travel down the length of the axon - which may be mylineated
  - The myelin sheath is not continuous
  - Action potential can jump nodes
  - Transmission is much faster in mylineated axons
- Synaptic Transmission
  - Under action potential NT are released into the synaptic gap
  - This gap is intercellular space where the NT are not protected by the cell membrane
  - Special receptors recognise the chemical code of NT
  - The NT attaches to post synaptic receptors --> excitatory/inhibitory effects
  - This will be a long-term effect until actions are terminated by enzymes
  - Reuptake occurs
- Actions of NT
  - Either excitatory or inhibitory
  - An excitatory NT increases the likelihood of post synaptic cell fire --> depolarization -->action potential
  - An inhibitory NT will decrease the likelihood that the post synaptic cell will fire --> hyper polarization --> excessive negative charge on resting potential
- Six ways drugs may affect synaptic transmission
  - Block release of NT
  - Block storage of NT in pre-synaptic membrane
  - Cause release of extra NT
  - Stimulate or block receptor on post-synaptic membrane
  - Attack enzymes that break down NT
  - Block reuptake of NT

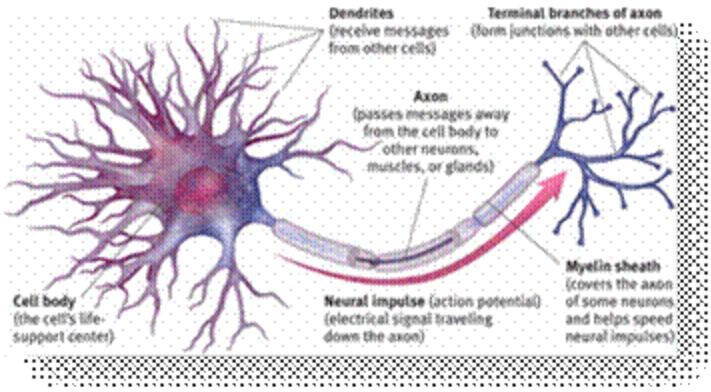
Lecture Outline

September-28-10
1:12 PM

Introduction to Experimental Psychology

Biology of the Mind (Neurosciences): Neuronal-Synaptic Transmission





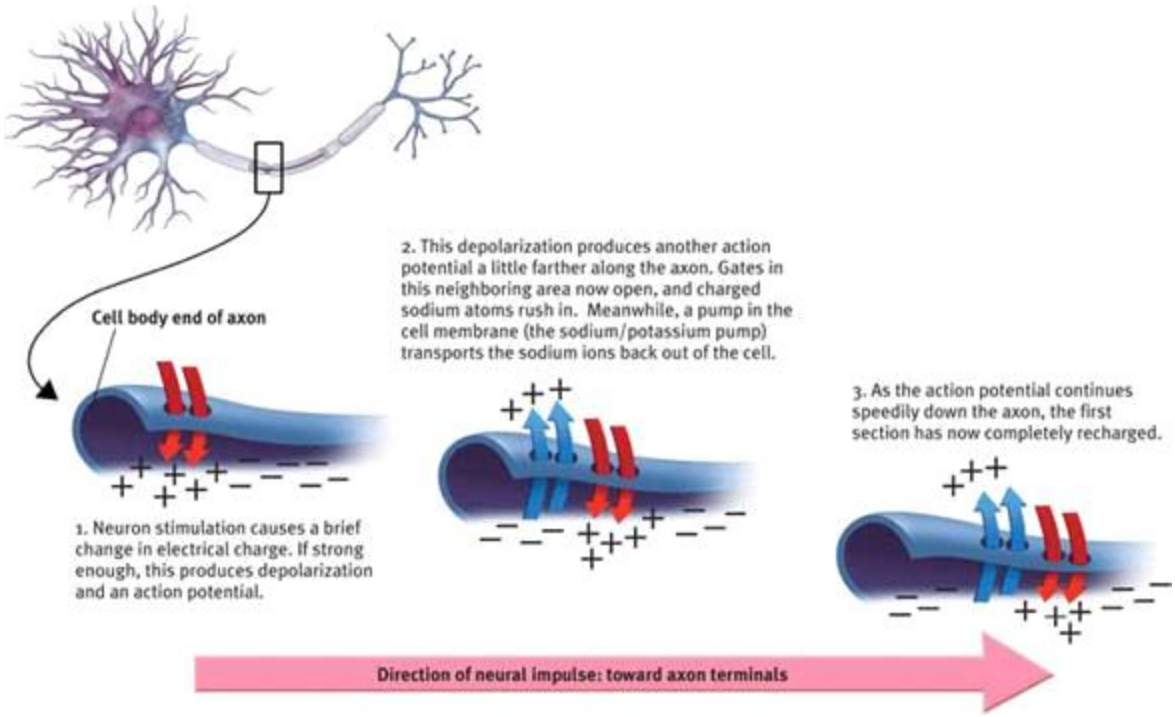
Structure of Neuron

- *DENDRITES*: short branches projecting from cell body. Within the dendrites are embedded highly specialized receptors (see section on terminal endings below)
- *receive* messages from other neurons
- *CELL BODY (soma):* contains the nucleus of the cell and other basic elements necessary for the survival of the cell.
- *AXON*: a long, slender tube which carries information from the cell body to synaptic terminals. It is analogous to a wire or a cable.
    - The axons of longer neurons are surrounded by a *myelin sheath*. This causes them to appear white. Axons of shorter neurons are not surrounded by a myelin sheath. They thus appear to be grey.
    - The myelin sheath is made up of a lipid (fat) material that may surround long axons. They serve to (1) protect the axon (2) insulate the axon … this thus preventing axonal "cross-talk" (3) speed up transmission
- *TERMINAL ENDING (bouton endings):* As the name indicates, this is the terminal ending of the axon. At this ending, there is a swelling (the "bouton"). This is caused by the storage of neurotransmitter substance here. A physical gap (called the "synaptic gap" or simply the "synapse") separates the terminal ending and the dendrites of the next neuron. When (and if) the

neurotransmitters are released, they must travel across this gap. Embedded in the walls of the dendrites of the postsynaptic neuron are highly specialized receptors that can "recognize" the chemical code of the neurotransmitters. The neurotransmitters can then attach themselves (or "bind") to the receptor site. The neurotransmitter may excite or may inhibit the activity of the second neuron (more about this later)

Different Types of Neurons

- *Sensory Neurons*: transmit impulses received by sensory receptors to CNS. These are also called *afferents*.
- *Motor Neurons*: carry outgoing signals from CNS to muscles & glands. These are also called *efferents*.
- *Interneurons*: Sometimes, receive signals from sensory neurons and send impulses to other motor neurons. Much more often, the interneuron is far removed from either sensory or motor neurons. One interneuron communicates with another. This is the route to memory, learning, and complex behaviour.



Neuronal Transmission

Resting Potential

- The neuron, like other cells, carries an electrical charge. Unlike other cells, the charge of the neuron can change.
- This allows one neuron to communicate with another (or perhaps with a muscle).
- An inactive neuron contains an excess of *negatively* charged ions *inside* the cell membrane
- The charge inside the neuron is about -70 mVolt (mV), but this does vary depending on the species studied(see Figure below on Action Potentials.)
- This charged is called the *resting potential* of the neuron. Thus, the resting potential represents the electrical charge of a neuron when it is inactive.

Excitation of the Neuron (*Depolarization*)

- Inside the neuron there is a surplus of negatively charged molecules ("ions"). This is mainly

because of the buildup of chloride. Outside of the neuron, there is a buildup of positively charged ions (largely sodium).

- The sodium-chloride balance is critical for the proper functioning of the neuron. Where does the sodium-chloride come from? The salt balance within the body.
- Sodium cannot easily pass through the cell wall (the membrane) of the neuron. Sodium is a relatively large molecule. Moreover, other molecules easily bind to the sodium molecule making it even larger.
- When the dendrite is stimulated by another neuron through the release of an excitatory neurotransmitter (or artificially by electrical stimulation), the cell membrane's "channels" (or "gates") open, allowing *positively* charged ions to flow in (point 1 in the figure above).
- This change in the charge of the neuron (less negativity or more positivity) is called *depolarization.*

Action Potential

- The flow of the positively charged ions into the nerve cell causes the cell's electrical charge (electrical "potential) to change. The cell in now less negatively charged (depolarization). In the Figure on the right, an electrode stimulates the nerve cell. This causes the cell's electrical potential; to change. The extent of change is dependent on the intensity of stimulation. If it is a small stimulation (low intensity stimulation), the change in the electrical potential of the nerve cell might now be -65 mV (see yellow lines, "failed initiations" in the Figure). If the intensity of the stimulation increases, the electrical potential of the cell may now change to -60 mV (also in yellow).
- When the flow of positively charged ions reaches a certain critical threshold (the "*threshold of excitation"),* the neuron fires. In the Figure on the right, the "threshold" is about -54 mV. Once the change in electrical potential reaches this -54 mV threshold, a dramatic change is observed.
- This is called the *action potential.* The action potential (the rushing in of the sodium and other positively charged molecules) continues inevitably down the entire length of the axon. This is called *propagation* of the action potential. (point 2 and 3 in Figure above)
- If the level of excitation is not enough (the critical threshold is not reached), the electrical charge of the neuron will return to its resting potential ("failed initiations" in the Figure).
- The likelihood of reaching the critical threshold is increased by either having a single (or a few) neurons excite the post-synaptic neuron rapidly (the effects of one excitation summates with the consequent excitation). Alternately, the effects of the excitation of several neurons can summate together.
- Once the action potential is initiated, it will travel down the length of the axon. It may then subsequently influence the firing of another neuron.

All-or-None Law

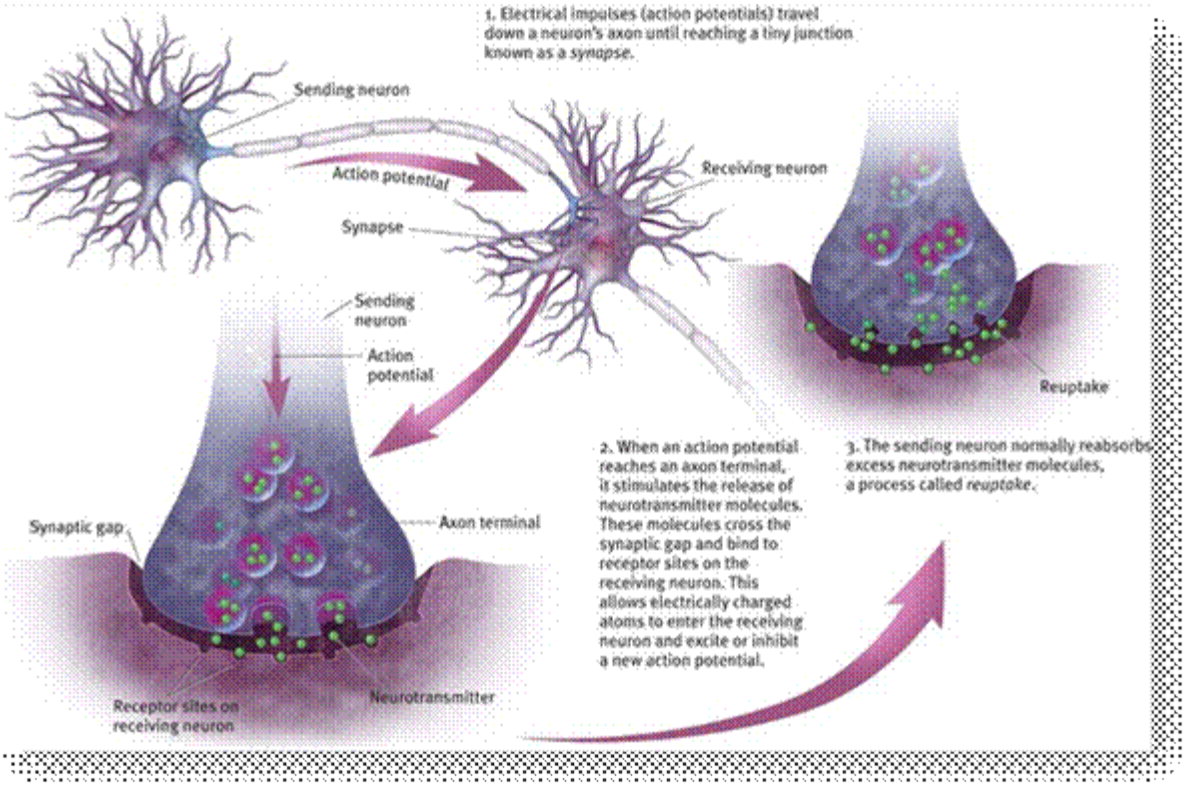
- The action potential will be *propagated* the entire length of the axon.
- The amplitude of the axon potential is also constant (again, no variation here). In the Figure, the change in the electrical potential in now +40 mV. This amplitude will not vary as the charge moves down the length of the axon. This is inevitable (no variation here). This is the *all-or-none law*. We either get the action potential or we do not. Increasing the intensity of stimulation will not cause the action potential to get larger.
- This has important consequences for coding in the nervous system.
- For example, we cannot code the intensity of the stimulus by the size (or amplitude) of the action potential. Its amplitude cannot vary. Intensity could be coded by how often the neuron fires or perhaps by how many neurons carry the message.
- The all-or-none law, however, more or less ensures that once the action potential is initiated, it will travel the length of the axon and its amplitude will not vary. There is little room for "freedom" or "flexibility" in the well-protected world of the axon. The response (the action potential) cannot easily be altered (unless there is a fault with the chemical or nutritional balance). This will not be the case for the synapse. Learning will involve changing how the nervous system responds (we'll see this when we study learning and memory).

Propagation of Action Potential

- Action potentials will travel down the length of the axon.
- This involves a slow, tedious process. The membrane gates initially open upon excitation. This depolarization causes the neighbouring membrane gates to also open, and then this neighbour's gates also open and so forth until the action potential reaches the end of the axon at the terminal ending.
- Long axons are mylineated (they have a myelin sheath).
- The myelin sheath is not continuous. Because the myelin is made of lipid material, the charged molecules cannot penetrate into the axon. At places, the bare axon is exposed. These places are called the nodes (or more correctly, the nodes of Ranvier, named after the French neuroanatomist)
- This allows the action potential to "jump" from node to node.
- Thus, transmission is much faster in mylineated axons. Because long axons tend to be myelinated, while short axons are not, transmission is much faster in long axons.

Release of Neurotransmitter

- Under influence of action potential, neurotransmitters are released into the synaptic gap.
- Neurotransmitters may travel across this gap to the post-synaptic neuron.
- Keep in mind that this gap is the "real" world outside of the well-protected neuron. The neurotransmitters are subject to attack by poisons (toxic agents). They might not be released. They might not reach the post-synaptic site.
- Specialized receptors can "recognize" the chemical code of the neurotransmitter (similar to a lock and key mechanism).
- The neurotransmitter binds to the post-synaptic receptor. It is here that the neurotransmitter has an effect on the post-synaptic neuron. It may have an excitatory or an inhibitory effect (see next section).
-



- Each and every one of these steps can be altered. "Drugs" that are similar in chemical structure to a true neurotransmitter may also bind with the receptor site. They may block the site. When

the true neurotransmitter arrives, it will find the receptor site already occupied. Thus, the neurotransmitter will have no effect. Drugs can also mimic the effect of a neurotransmitter. The reuptake process may be ineffective. Perhaps the enzymes are in short supply. Perhaps drugs "attack" the enzymes. Thus, the effect of the neurotransmitter will be prolonged. And, the reuptake mechanism will be delayed. This will leave a short-supply of neurotransmitters in the pre-synaptic site.

- The cozy protected environment of the axon is not the rule at the synapse. While transmission in the axon was highly inflexible, obeying an all-or-none law, this is not the case at the level of the synapse. If we wish to design a nervous system in which flexibility of behaviour (altering past behaviour), learning, memory and complexity are desired, the synapse is the place to do it. It should come as no surprise that in evolution, complex behaviour comes about as a result of expansion of the grey matter, where tiny, unmyelinated neurons are tightly packed, forming billions and trillions of synapses, and permitting exceedingly complex inter-neuronal communication. Unfortunately, these exceedingly complex interactions are also exceedingly complex to understand. The end result is that we, in fact, poorly understand the functioning of the higher centres (the grey matter of the cortex)of the brain, even in very simple animals (those that are not well-cortically endowed). This should however be good news for students… lots of information yet to be discovered.

Actions of Neurotransmitters

- Recall the all-or-none law of the action potential. No flexibility here. This is not the case with the neurotransmitters.
- Neurotransmitters are either excitatory or inhibitory. Thus, it is possible either to increase or to decrease the likelihood that a post-synaptic neuron will fire.
- An *excitatory* neurotransmitter will increase the likelihood that the post-synaptic cell will fire. An excitatory neurotransmitter *depolarizes* the neuron. The resting potential becomes less negatively charged than normal.
- An *inhibitory* neurotransmitter will decrease the likelihood that the post-synaptic cell will fire. An inhibitory neurotransmitter hyperpolarizes the neuron. The resting potential becomes more negatively charged than normal.
- Why is it necessary to have both excitatory and inhibitory neurotransmitters? Imagine trying to walk. Certain muscles in your leg must be excited (an excited muscle contracts). Others, however, must not contract. If all muscles were contracted, you could not walk (incidentally, this lack of motor "coordination" is often a problem in various dystrophies and in Parkinson's-like diseases). Another example: Your sensory receptors are constantly bombarded with incoming stimuli. Your brain cannot possibly process all this input because of its limited capacity (even though you have a massive amount of grey matter). Only the most relevant of sensory input should reach the very busy cortex. The vast majority of sensory input is irrelevant, thus processing of what in the end is irrelevant, needs to be inhibited. Another example: A good deal of the frontal regions of your brain is involved with the inhibition of inappropriate action. This is the essence of the saying: reason over passion… the need to inhibit the passions.

Drug Interaction

As already mentioned, drugs can wreak havoc on neurotransmitters. There are at least 6 ways that this is possible (again, please note the very large flexibility in synaptic transmission):

- Block release of neurotransmitter
- Block storage of neurotransmitter in pre-synaptic neuron
- Cause release of excessive amount of neurotransmitter
- Stimulate or block receptor on post-synaptic membrane
- May attack enzymes that break down neurotransmitter
- Block reuptake of neurotransmitter

Neurotransmitters

Adding to the complexity and flexibility of synaptic transmission is the fact that there are many different types of neurotransmitters having different chemical structures. Several neurotransmitters have now been identified (although we will mercifully only mention a few) and it is thought that considerably more remain to be discovered (any budding biochemists?) All neurotransmitters need to be synthesized from simpler elements, typically extracted from the circulating blood. We shall return to the neurotransmitters when we discuss how psychoactive drugs can alter the "mind". Here is a short list of neurotransmitters:

Acetylcholine (ACh)

- ACh is generally excitatory on membranes of skeletal-muscle fibers. It causes muscles to contract.
- Muscle paralysis can be caused by, for example:
    - Botulin blocks ACh release. Pure botulin is amongst the most toxic and lethal substances known 100-200 ng (billionths of a gram) can kill a human adult weighing 100 kg. Botox (botulin) causes muscle paralysis preventing "wrinkling" of the skin.
    - Nerve gas may block receptor site, or interfere with reuptake. Many insecticides work in this manner.
- Muscle convulsions can be caused by venom in many animals
    - Example: Black widow spider venom (stimulates release of ACh)
- In CNS, role in memory –
    - ACh is depleted in Alzheimer's disease.

Norepinephrine (NE) in the U.S., but *Noradrenaline (NA)* in many other countries

- Synthesized from epinephrine (or adrenaline), a hormone released by the adrenal gland (and the entire world calls it the adrenal gland).
- Important role in alertness and mood.
- Cocaine and amphetamines prolong action of NE -- stimulant effects.
- Lithium -- speeds up breakdown of NE -- depressed mood.

Gamma-Aminobutyric Acid (GABA)

- Major *inhibitory* neurotransmitter of the brain.
- Sedative, sleep and anti-anxiety medications.
    - Benzodiazepines (For example, valium acts by stimulating GABA receptors)

Dopamine (DA)

- Predominantly inhibitory.
- Implicated in movement in the periphery. In the brain, attention, decision-making and learning. Might be involved in ADHD.
- Insufficient quantity of DA: Parkinson's disease leading to tremors & paralysis
- Too much DA: psychosis.
- A side effect of Parkinson's treatment is psychotic symptoms.

Serotonin (5-HT)

- plays a role in sleep (dreaming?), perhaps control of eating, mood, and pain regulation.
- Drugs that mimic 5-HT may result in bizarre hallucinations. Psychedelic drugs such as LSD, and mescaline have a chemical structure that is remarkably similar to 5-HT. They may thus block the receptor site.
- Certain drugs cause an over-release of 5HT (example NMDA – "Ecstasy"… increase energy). It may cause 5-HT to be completed depleted resulting in withdrawal-like symptoms.

Endorphins

- So-called “natural opiates” of the brain
- Chemical structure similar to opiates (heroin, morphine)
- Inhibit sensation of pain. This explains how pain can be reduced through “natural” means.
- Increase mood and pleasure

The Brain

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Lecture Outline

September-28-10
1:13 PM

Introduction to Experimental Psychology

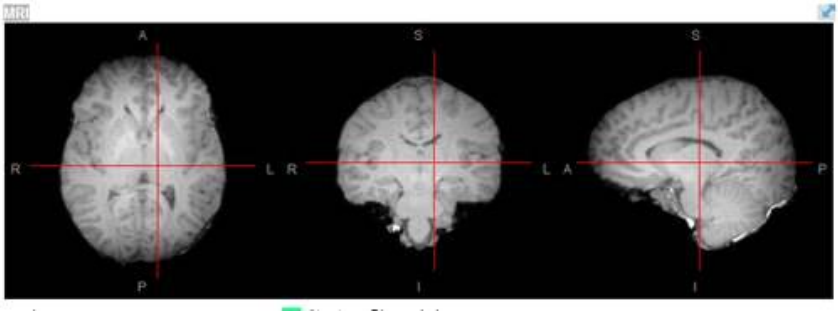
The Brain and Nervous System

Orientation

Medial-Lateral (middle of body/side of body)
Anterior-Posterior aspects of brain (front of head-back of head)
Superior-Inferior aspects of brain (upper portion of head -lower portion of head)

Slices (Viewing the brain in 2-dimensional images)

Horizontal (parallel to the floor) slice. Permits visualisation of anterior-posterior and lateral-medial aspects of brain. One cannot see the superior-inferior aspect. The MRI images on the right show examples of various horizontal "slices" at various levels of the brain (going from an inferior at the bottom to a superior position at the top).
Coronal (from ear-to-ear) slice. Permits visualisation of superior-inferior and lateral-medial aspects of brain. One cannot see the anterior-posterior aspect.
Saggital (from nose to back of head) slice. Permits visualisation of anterior-posterior and superior-inferior aspects of brain. One cannot see the lateral-medial aspect.
Mid-saggital slice: saggital slice that the splits the brain into two equal halves.

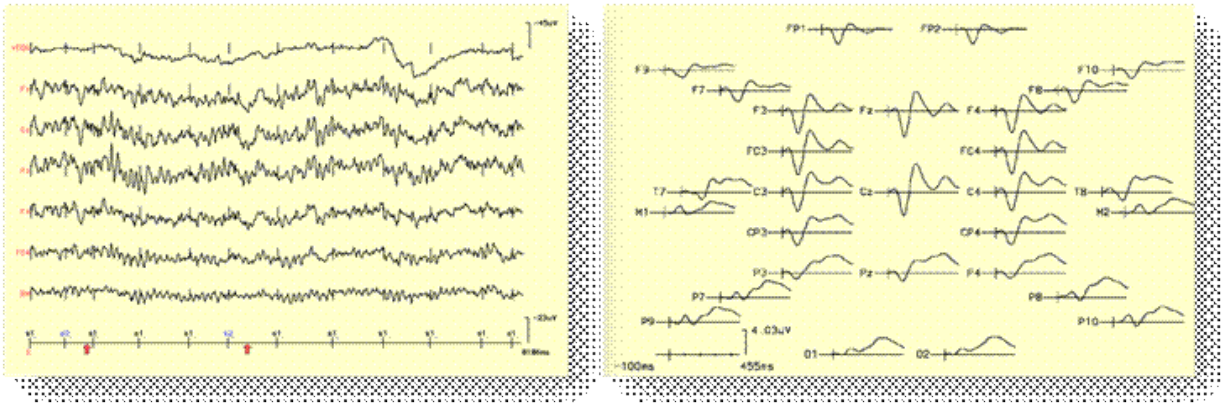


In the image below, a view is shown of a horizontal, coronal and mid-saggital slice (A=anterior, P=posterior; R=Right, L=Left; S=superior, I=Inferior). The crosshairs are located on a part of the brain called the thalamus (see discussion below). Image courtesy www.brainmaps.org

Imaging Techniques

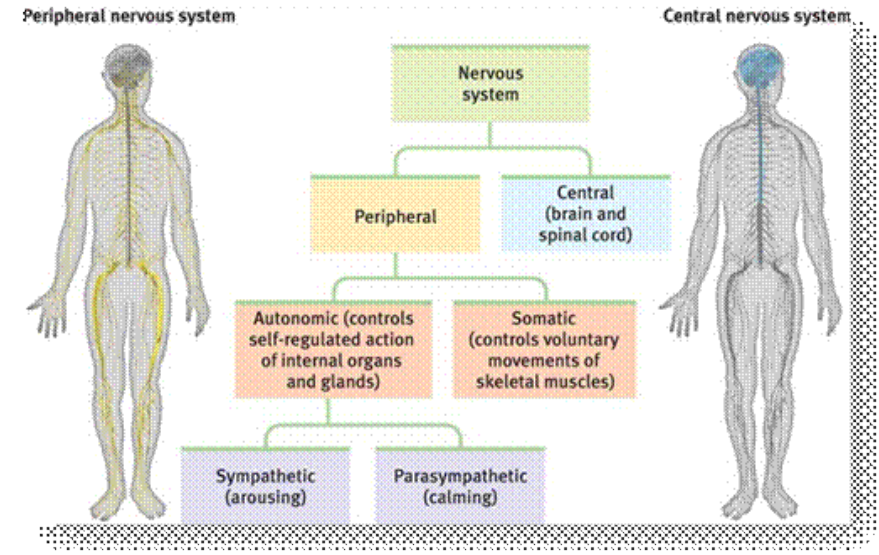
How is the brain actually viewed? Up to quite recently, it was only possible to dissect brains from cadavers (for obvious reasons). With modern scanning techniques, it is possible to obtain high resolution images of the living brain. These give a static image of the brain but cannot show exactly what areas are active during any given task. There are however other techniques that permit the monitoring of the functions of the different brain regions.
Anatomical dissection. Slicing the human brain. Appropriate (obviously) only for cadavers (go to www.brainmaps.org for a wide display of brains from cadavers).
MRI. Magnetic Resonance Imaging. Provides a high resolution image of the human brain. Static: does not indicate which areas of the brain are active during a specific task. Expensive. Figure above is from an MR image.
PET. Positron Emission Tomography. Provides an image of what areas of the brain require glucose for a task to be completed. Somewhat invasive -- deoxyglucose must be injected into the blood stream. Another problem is that it is relatively slow. It can take an image of the active brain only every 60-120 seconds. Brain activity is much faster than this. Expensive.
fMRI. Functional MRI. A recent innovation that is revolutionizing brain research. Looks at the changes in structure (blood flow) as the brain engages in a task. Has largely replaced PET. It is also much faster than the PET. Nevertheless, the blood flows relatively slowly. An image can be taken perhaps every 200-500 ms. This is still too slow for many brain functions. If the brain activity occurs with 200 ms, it will be missed by the fMRI. Expensive. The image on the cover shows a real tennis player and an fMRI image from a supposed vegetative patient (who should not be conscious) told to "think about" playing tennis. The "hot" (in yellow) indicates the area of the cortex that is most active, the motor cortex and more specifically the hand area.
EEG(Electroencephalogram)/Evoked Potentials. Electrodes attached to the surface of the scalp. Provides an indication of the electrical activity of the brain (EEG). When a stimulus is presented, evoked potentials can be used to measure the brain's response to these stimuli. Cheap. Unlike the fMRI, its resolution is very poor (We cannot easily tell where the electrical activity is being generated in the brain. What can one conclude about brain anatomy with electrodes attached to the scalp?). Measures direct changes in the electrical activity of the brain. This is much faster than the fMRI. The advantage of evoked potentials is therefore that they can rapidly (every 1 msec or better) record the changes of the electrical activity of the brain when it must process information contained in a stimulus.

The image below on the left shows the electrical activity of the brain (EEG) recorded from 6 different locations on the scalp. The EEG was recorded for 8.186 sec. At various times, an auditory stimulus was presented. The stimulus is labelled as either S1 or S2 (a low or a high pitched tone). The actual responses (called "evoked potentials") of the brain are very difficult to see in the EEG. This is because the evoked potentials are very small (often measuring only a few μV, or millionths of a Volt).Through computer extraction techniques, the evoked potentials can be made visible. In the figure on the right, evoked potentials are displayed from 32 different scalp locations (the front of the head being on the top, the back of the head at the bottom). A large downward deflection that measures about 4 μV is seen at and it occurs at about 100 msec (thousandths of a sec). The fMRI because it ultimately relies on changes in blood flow (very slow) would not be able to display changes in processing within the brain this rapidly. There are 32 different electrodes on the scalp and it is possible to see that the amplitude of the large downward deflection varies across the scalp (remember the statistical concept of "variance"). But where is this activity actually coming from within the brain?



Divisions of the Nervous System

1. Peripheral nervous system
1. Autonomic
1. Sympathetic
2. Parasympathetic
2. Somatic
2. Central nervous system:
1. The spinal cord
2. The brain



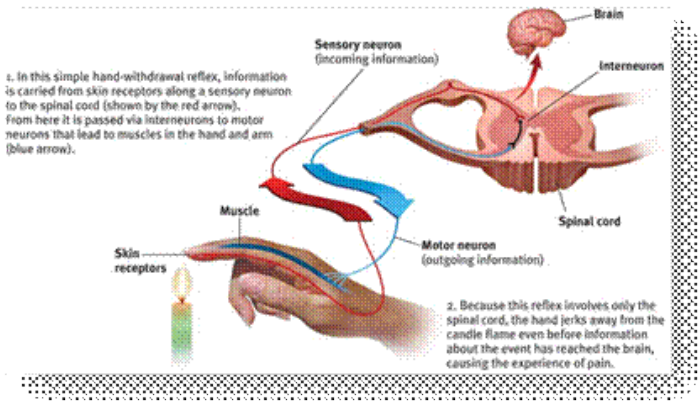
The Peripheral Nervous System

1. Sensory receptors -- in the body and also, specialized receptors in the head
2. Sensory and motor "nerves" -- in the body (soma) and in the head (specialized "senses")
3. Sensory nerves -- *afferent* information from the sensory receptors to the C.N.S.
4. Motor nerves -- *efferent* information from the C.N.S. to the muscles; motor action. Control of "autonomic" or smooth muscles. Control of skeletal (peripheral, surface) muscles. Division is thus known as the autonomic and somatic nervous system. We cannot (easily) control the autonomic nervous (note, it is not called the "automatic"

nervous system). It operates essentially independent of our "volition". By contrast, we do have voluntary control of the somatic nervous system.

The Spinal Cord

1. Central grey region: Central region (looks like an "H") takes on a greyish colour because of densely-packed neurons in this region are not surrounded by a myelin sheath. The neurons are very short. There is very elaborate inter-neuronal communication. Inter-neuronal communication permits flexibility in behaviour. It is this complexity of inter-neuronal communication that will lead in evolution to complex behaviour such as learning, memory and so forth.
2. White surround region: Surrounding the central grey region is the white "surround". This consists of ascending "sensory" pathways that ascend from the spinal cord to the brain and the descending "motor" pathways that descend from the brain to the spinal cord. These ascending sensory pathways are located in the dorsal region of the spinal cord. The descending motor pathways are located in the ventral portion of the spinal cord. The sensory and motor pathways can be very long, up to 5 metres in animals such as the giraffe and whale. Because of their length, the pathways need a means to communicate rapidly. The addition of the myelin sheath to the axons permits very rapid neuronal transmission. Since myelin is lipid (i.e. , fat) material, it takes on a white colour. Thus, the long ascending and descending pathways appear white to the eye.
3. Flexibility of behaviour is also called "plasticity" (it can be moulded). It is also called soft-wiring.
4.



The opposite of flexibility is the hard-wiring. Many connections in the nervous system as "wired" genetically. This forms the basis of a reflex (inevitable sensory input-motor output that cannot be altered through learning).

5. Monosynaptic reflex. Sensory input -> motor output (see image below of withdrawal reflex)
6. Polysynaptic reflex

Divisions of the Brain

1. Hindbrain -- medulla, pons, CEREBELLUM
2. Midbrain. Collectively, the medulla, pons and midbrain form what is called the *brainstem*.
3. Forebrain -- diencephalon; cerebrum

The Brainstem

1. Medulla, pons, midbrain
2. Specialized senses of the head (vision, hearing, taste, smell)
3. Head "muscles" -- eye, ear movement, facial muscles, tongue, lips, etc.
4. Life "support" systems -- temperature; heart, respiration
5. Sleep-wake cycle
6. Reticular activating system (central red area in image). Looks like a spider's web or net (rete in Latin means net). Stimulate any part of the reticular formation and eventually all parts will be stimulated. This does not allow for specific communication. But it is a good means of assuring a generalized reaction. This system allows for general arousal of the brain.

The Diencephalon

1. Thalamus – Located immediately superior to the brainstem (see image immediately above and MRI image immediately to the right) and inferior to the massive cortices. This is the first place where all sensory systems merge. The thalamus can thus act as a type of receptionist, filtering through which sensory afferents are relevant (and in which case, the message will be relayed to the very busy cortex) and those that are not (in which case, further processing will be inhibited). Functions include integration of incoming sensory information, attention, and consciousness.

MASSIVE 'grey' area

2. Hypothalamus – Located inferior to the thalamus at the base of the brain. The MRI sagittal scan on the right shows the brainstem and posterior to it, the cerebellum and superior to the brainstem is the thalamus. The hypothalamus is inferior to the thalamus (shown in orange). The hypothalamus has many subdivisions each of which controls the basic needs and drives of the organism: eating, drinking, mating, temperature regulation. The hypothalamus

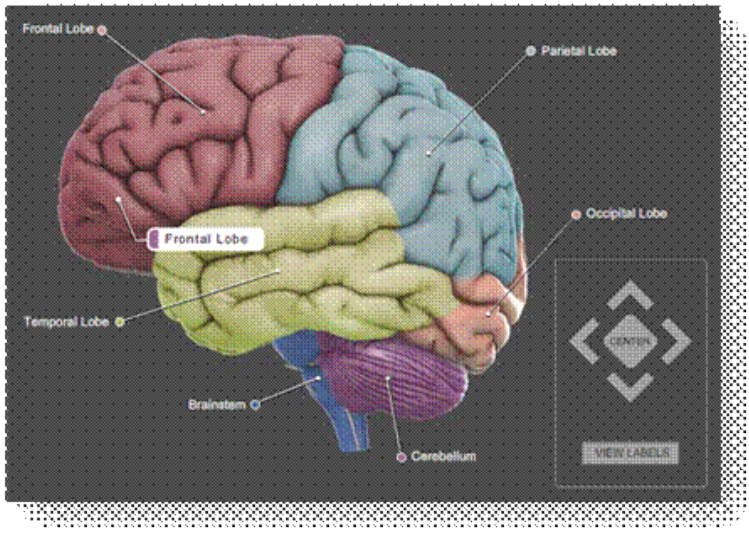
monitors the blood that is circulating at the base of the brain. As an example, if there is not enough glucose, a signal goes out and we feel "hungry". If blood pressure is low, we feel "thirsty". The hypothalamus forms part of the autonomic nervous system. The ANS operates autonomically and is generally not under the control of the cortex. Indeed, it appears to operate independently of our conscious awareness. The hypothalamus is connected at its base to the pituitary gland and ultimately controls it.

3. Pituitary gland – Located at the base of the brain, inferior to the hypothalamus (circled in red in the MRI scan). The pituitary gland, properly speaking is not part of the brain at all. It is the "master" gland of another system of communication, the endocrine system. The endocrine glands release hormones that circulate in the blood. This is believed to be an older system of communication in the body. The neuronal means of communication is very rapid and can be very specific (it is possible to lift only the left index finger) or can be quite general (generalized sleep, wakefulness). Hormonal communication by contrast is very slow (because hormones circulate in the blood), long-lasting, and generalized. As a result, hormones produce a generalized "drive" that appears to haunt and invade consciousness. The hypothalamus closely monitors the endocrine levels that are circulating in the blood. It can then command the pituitary to increase or decrease the output of hormones in other glands. Ultimately, however, the pituitary is under the control of the brain and more specifically, under the control of the hypothalamus. Thus, it is the hypothalamus that controls the endocrine system.

The Neocortex

1. Sulci and gyri
2. Architecture (6-layered)
3. Central white (more or less) and grey surround
4. Complex interconnections
5. Sub-divided into the frontal, parietal, temporal, occipital lobes
6. Longitudinal fissure separates the left and right hemispheres
7. Central fissure separates the frontal and parietal lobes
8. Lateral fissure separates the frontal/parietal lobes from the temporal lobe.
9.

Image courtesy of www.g2conline.org



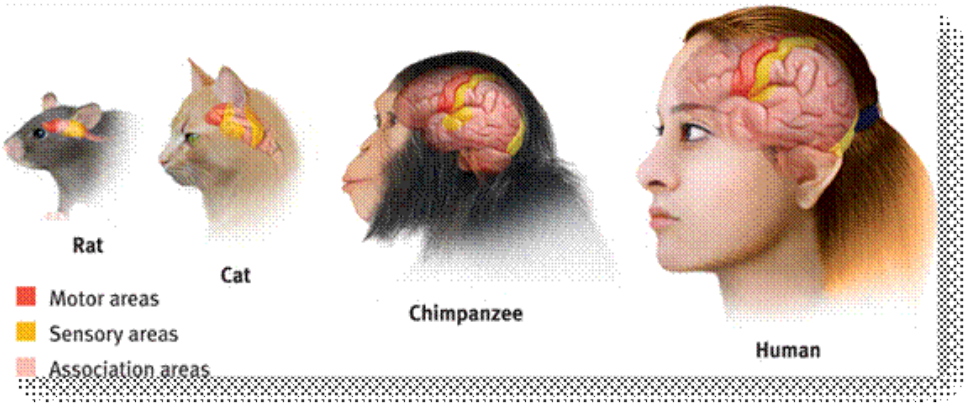
Corpus callosum. A thick band of white matter that connects the left and right hemispheres so that one knows what the other is doing.

Architecture of the Cortex

- Neocortex: 6 layered grey matter. In evolution, as the behavioural complexity of the animal increases, the amount of grey cortical matter must also increase. Behavioural complexity-flexibility (learning, memory) requires the complex interaction that is only possible with massive interneuronal communication. The formation of new memories requires a physical change in the structure of the brain! New synapses must develop, or at the very least, the nature of existing synapses must alter. Note the significance of this statement. It implies that a good deal of the neocortex is not genetically determined. The connections that are made in the cortex are largely not genetically laid out. However, other researchers would say that this statement is too strong. They would claim that while some of the neocortex is not genetically laid out, most of it is. Some (if not large) portions of the neocortex develop with learning (i.e., "experience" with the environment).
    - The image on the right is a coronal slice showing the left and right hemispheres. The dark areas are grey matter and the light areas, white matter. The neocortex consist of sulci (the various crevices) and six layers of grey matter (the gyri). The left and right hemispheres are connected by a thick layer of white matter, the corpus callosum. The rear and frontal lobes are divided by the central fissure

Sensory/Motor/Association Cortices

1.



There are 3 major types of cortices within the brain: the sensory, the motor and the association.

2. The *sensory* cortex receives input about sensory information via relays from the thalamus (although there are direct inputs from the olfactory system that bypass the thalamus).
3. The *motor* cortex in turn sends motor output into the peripheral via the efferent projection system.
4. The *association* cortex has no direct contact with the outside world. The association cortex has very elaborate inter-neuronal communication. One neuron communicates with perhaps several other neurons. It is the association cortex that permits the complex behaviour, learning and memory that is associated with "intelligent" species. It is the association cortex that allows for considerable behavioural flexibility.

Sensory Cortex - basic features of stimuus input

1. Visual (almost 50% of the occipital lobe)
2. Auditory (the gyrus of Heschl, embedded in the superior part of the temporal lobe))
3. Somatosensory (post-central gyrus - immediately posterior to the central fissure; thus in the parietal lobe.). Touch, temperature -

Motor Cortex

1. motor (pre-central gyrus – immediately anterior to the central fissure. Thus in the frontal lobe)
2. Cerebellum (read Myers for details)

Speech Areas

1. Motor (communicate) aspects: Broca's area in the inferior region of the frontal lobe
2. Sensory (receptive) aspects: Wernicke's area at the junction of the parietal and temporal lobes.
3. Hemispheric differences. In 95-99% of right-handed individuals, the "dominant" (dominant means the centre for speech) hemisphere is the left hemisphere. In left-handers, it is not quite this simple. For about 50%, the left hemisphere is still dominant but for perhaps as many as 40%, the right is dominant. For some left-handers (from 10-25%), both hemispheres are dominant. Assuming that the left hemisphere is dominant, damage to Broca's area in the left hemisphere will result in an inability to speak. Damage to the Wernicke's area in the left hemisphere will result in an inability to understand speech. But there are also important language roles in the right hemisphere. Damage to Broca's area in the right hemisphere will result in monotone speech. Speech lacks "tonality". Damage to Wernicke's area in the right hemisphere will result in an inability to understand the emotional aspects of speech.

Association Cortex

1. Includes very large areas of the frontal lobe, parietal lobe, temporal lobe and portions of the occipital lobe
2. Association areas have no direct contact with the outside world. They are neither sensory nor motor cortices. They receive information only after considerable processing by the sensory (or motor) cortices.
3. Their architecture consists of small interneurons with very elaborate and complex interconnections. Their function is exceedingly complex.
4. The size of the association cortices massively expands with evolution. A monkey thus has much more of its cortex devoted to association functions than a horse. A human has much more association cortex than a monkey. One should not be terribly impressed by the size of the human brain. Whales and elephants also have large brains. A good deal of the elephant's brain is, however, devoted to motor activity (there is a good deal of muscle to control). Sharks, who are considered to be simple animals, actually have a fairly large brain, at least with respect to fish. However, most of this is devoted to sensory (smell) and motor functions (the exquisitely fine and rapid motion associated with swimming).

Frontal Lobe

1. Motor functions.

1. Primary motor cortex in the pre-central gyrus
2. Broca's area and speech

2. Psychological function - highly complex "higher mental" functions. Selective attention, concentration; "will"; initiative (initiator of appropriate action); social norms; insight, logic, feedback (ability to learn from error); consciousness (awareness of the external world/ awareness of one's own thoughts and actions); self-consciousness (awareness that I am aware that I am aware); personality. The essence of human existence is probably a result of the development of the frontal lobe. (EXECUTIVE control)

Temporal Lobe

1. Primary auditory cortex in the superior portion of the temporal lobe (Gyrus of Heschl)
2. Wernicke's area (receptive speech)
3. Short-term memory systems -- hippocampus; amygdala (?) .
4. The hippocampus (in green in image on right) is located in the infer-medial portion of the temporal lobe and then loops (like a rams' horns) toward the hypothalamus. The next image shows a view from a superior location. The hippocampus (in green) is located in an inferior location in the temporal lobe and then loops upward and toward the middle (medial) portion of the diencephalon. The *hippocampus* appears to be specialized for the storage of short-term memories. If the information is relevant enough, the hippocampus can allow for the transfer of short-term memories into permanent memory. If the hippocampi (the hippocampus is embedded in both the left and right hemispheres) is severed, the patient we will not be able to learn anything new. This is because the patient will be unable to transfer information from the short-term to permanent, long-term memory. (Images courtesy of genes to cognition online (www.g2conline.org)
5. Amygdala & limbic system (see later section for details)

Parietal Lobe

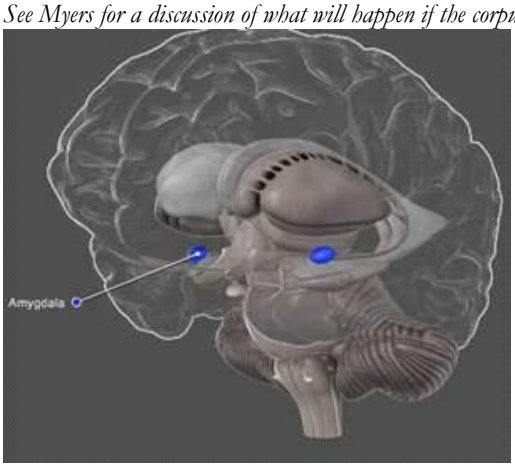
1. *Permanent memory* (or "long-term" memory) systems
2. *Switching of attention*. While the frontal lobe appears to be specialized for the focussing or "maintenance" of attention (this is called "vigilance" or "concentration"), when something novel occurs, we need to switch attention. This is a role of the parietal lobes.
3. *Hemi-neglect*. Patients who have damage to the right parietal lobe fail to attend to information arising on their left side. They thus "neglect" half of their universe. This tendency to neglect the left side occurs only when there is also information on the right side. Thus, if there is information on the left side and none on the other, the right parietal lobe patient will detect it. Thus, there is nothing wrong with the sensory systems. The patient can hear, see or feel information on the left side of their bodies. But if there is information on both the left and the right side, the patient will not see (or hear or feel) the information on the left. They thus attend to the information on the right side (that therefore is transmitted to the left hemisphere) and neglect information on the left side. This can lead to very bizarre behaviour. Patients may only dress half of their bodies and be completely unaware of it. They may claim that there is nothing at all wrong with them and can thus be very difficult to treat. If you are on the patient's left side and speak to them, she/he will hear you (since there are no sounds entering the right ear) but not see you (since they will also be seeing objects in the room on the right side). Patients may thus complain that they are hearing voices. At times, these patients are misdiagnosed as being "psychotic".

Hemisphere Differences

See Myers for further detail on this subject.

1. Dominant (Left) Hemisphere (for most right-handers and some left-handers). Functions include - language, mathematical operations (?), logic (?). But as the "?" indicates, classifying functions as belonging to the left or right hemisphere is overly simplistic.
2. Nondominant Hemisphere: spatial construction/block design; face recognition; tonality/emotional expression; perhaps music
3. Corpus Callosum. This is the major commissure of the brain. A commissure connects the left hemisphere to the right and the right to the left allowing the left hemisphere to communicate to the right and vice versa.

See Myers for a discussion of what will happen if the corpus callosum is severed.



Limbic System

Again, see Myers for further detail.

1. The anatomy of the limbic system is quite complex. The word "limbic" means circle or loop. The loop within the brain includes: the cingulate cortex- hippocampus/amygdala-hypothalamus circuit. In the image, the amygdala (involved in emotions such as defensive and offensive aggression) is displayed in blue. The amygdala is located immediately anterior and somewhat superior to the hypothalamus (in grey).
2. The limbic system plays an intimate role in the maintenance and expression of emotions. The role of the limbic system has been summarized as consisting of the 4 F's: feeding, fighting, fleeing, undertaking mating behaviour

Autonomic Nervous System

1. The autonomic nervous system appears to function "autonomously" from the cortex. The cortex may not be aware ("conscious") of what the autonomic nervous system is doing. The cortex may have only limited control or no control at all over the autonomic nervous system.
2. Controlled by the hypothalamus. It (the autonomic nervous system) consists of two branches, the sympathetic and parasympathetic.
3. *Sympathetic* branch - Increase energy available to the body. When under stress the sympathetic branch provides energy - increases the heart beat, respiration, dilate skeletal muscles; constrict arteries of skin (so that places that need the energy and nutrients carried by the blood - such as the brain - can get them); inhibit digestive system
4. *Parasympathetic* branch conserve energy -- slow heart beat, etc.

Sensation: General

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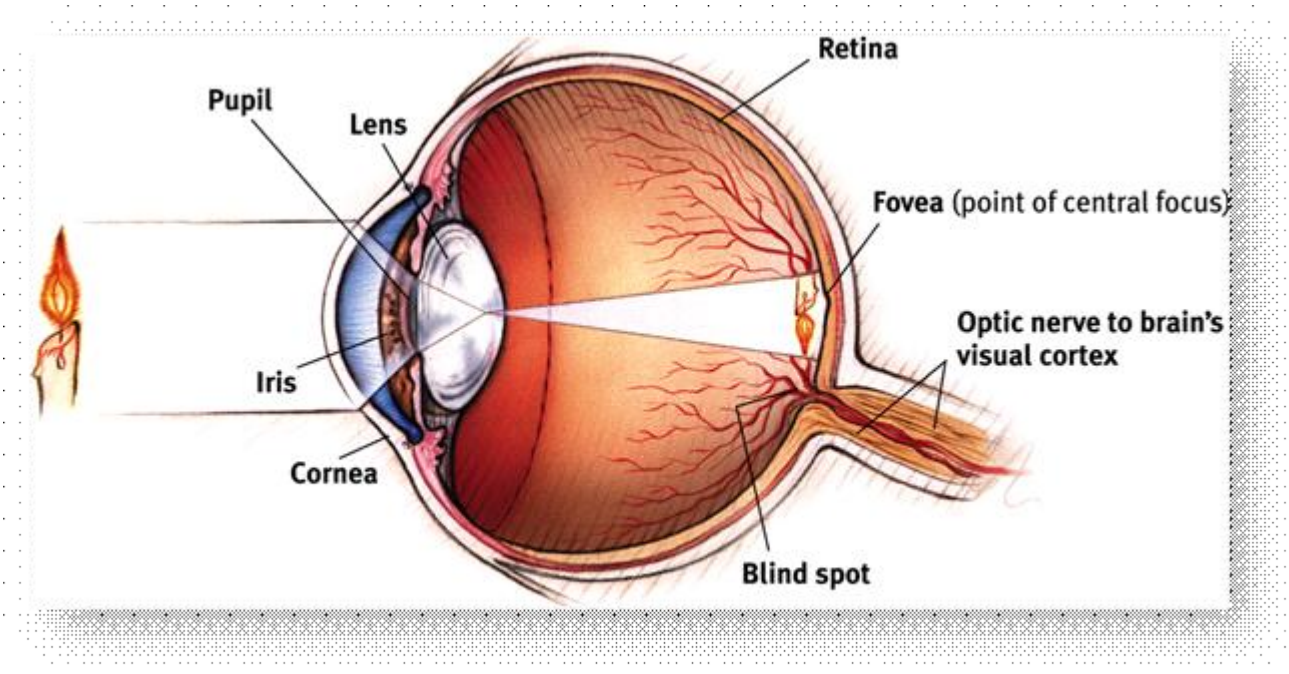
Vision

Physics of light

- Electromagnetic signal whose wavelength varies from 400 to 700 nanometers (this is called "light"). Short wavelengths (400-500 nm = violet-blue); Medium wavelengths (500-600 nm = green); Long wavelengths (600-700 nm = red). We thus perceive only a very limited amount of the electromagnetic energy in the universe (from 10^{-5} to 10^{15} nm).
- Colour. The wavelength of the light determines its physical hue which we perceive psychologically as "colour"
- Brightness. The amount of energy in the light wave (or its intensity) is perceived as "brightness".

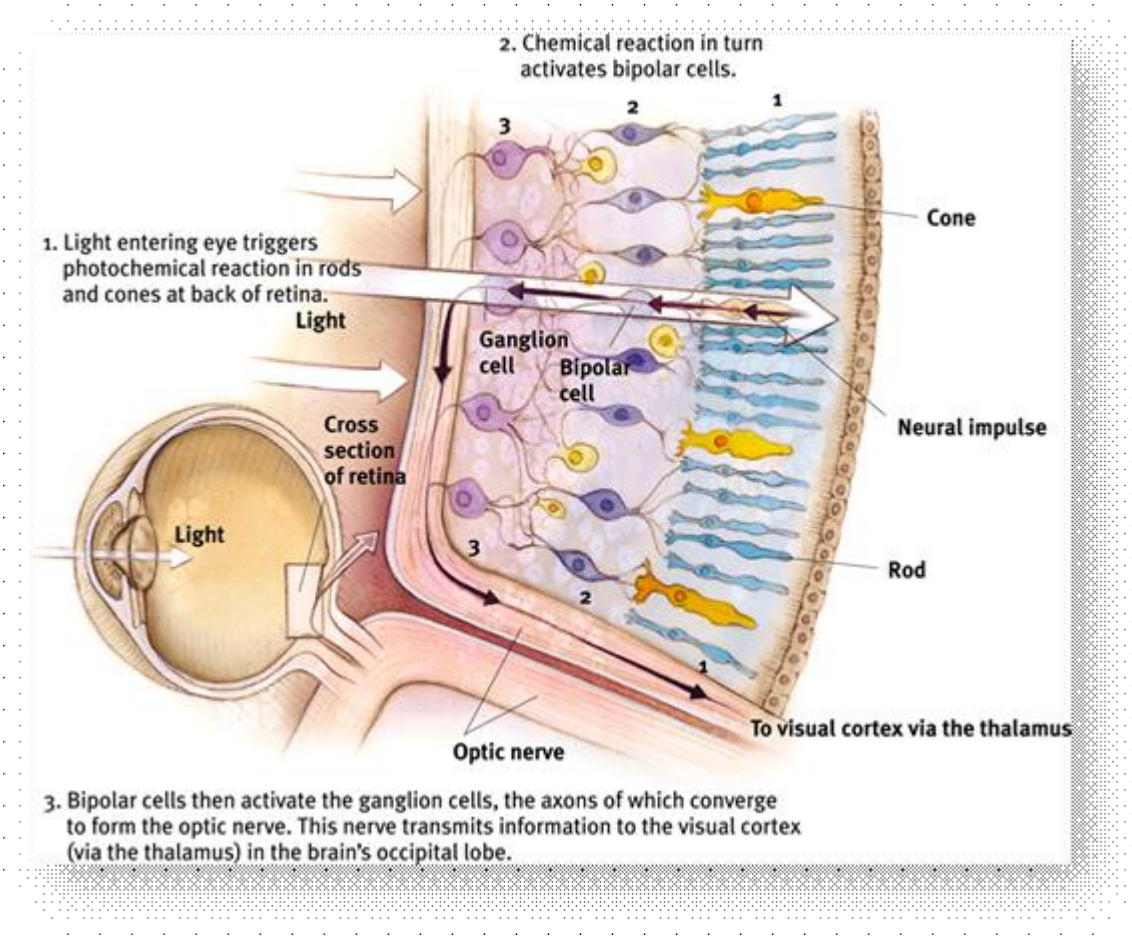
Anatomy of the Eye

- The Eye
- Cornea
- Lens
- Pupil
- Retina: rods and cones; fovea; blind spot



The Retina

- The retina consists of 3 layers
  - The rods and cones
  - The bipolar cells
  - The ganglion cells
- The light sensitive rods and cones are located in the back of the retina
- Light must thus pass through the other layers before striking the rods and cones
- The rods and cones have a chemical reaction to light.
- If the reaction is strong enough, the bipolar cells will be activated
- Bipolar cells activate the ganglion cells
- The axons of the ganglion cells converge at the "blind spot" to form the optic nerve.



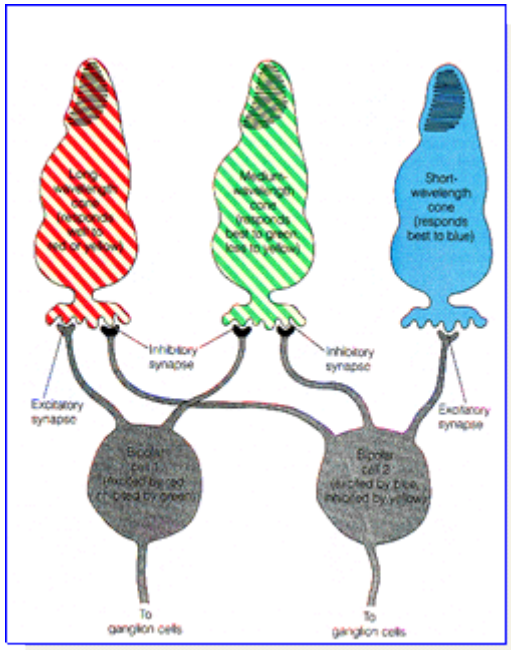
The Cones

- Cones - packed in the centre of the retina, near the fovea (where vision is most acute -- "acuity")
- Colour vision: three types of cones -- for red, green, blue
- A single cone may project to a single bipolar cell. Thus, the output of the cone will have to be very high in order for the bipolar cell to be activated. Need a great deal of light to see in colour.

The Rods

- Rods - in the periphery. There are many fewer rods than cones.
- Excellent for detecting movement.
- Not sensitive to colour
- Several rods project to a single bipolar cell. Thus, sensitive to very low levels of light.
- Sensitivity of rods and cones. The rods are much more sensitive than the cones. Therefore, in order to see colour, the light must be relatively intense. On the other hand, the rods are able to detect light at very low intensities. The rods are therefore used for "night" vision. Logically, we do not see colours well in darkness.

Colour Theory



3-colour theory

- All colours can be created through the mixture of three colours, red, blue and green.
- We therefore have 3 types of cones, one that is most sensitive to red, one that is most sensitive to blue and one that is most sensitive to green. A "red" cone synapses with a "red" optic nerve, a blue cone with a blue optic nerve, etc. All other colours are thus created at a higher level (probably the cortex) by measuring (or mixing) the number of optic nerves that carry each of the red, blue and green messages. A "yellow" light might thus stimulate an equal number of red and green cones. The mixture of red and green action potentials that occur in the cortex results in our experience of yellow. All other colours are similarly mixed and created by the "mind".
- Support: There actually are three types of cones (red, blue, green).

- Against: We can never see reddish-green; nor bluish-yellow. If the green and red cones are simultaneously activated, one should see reddish-green. In actual fact, red & green look yellow; while blue & yellow look white).
- Against: Adaptation studies -- in which subject looks at single colour for some time and then looks at a neutral surface. If one looks at a red colour for a period of time (thus causing adaptation for the colour red with the result that the red cone stops firing), then suddenly look at a white surface, one will see a green afterimage. How can one see green if the green cone has not been stimulated?
- Against: Colour blindness: One is never blind just to red or to green or to blue. Rather, red-green or blue-yellow

2-Colour Theory

- Also called "Opponent-Colour Theory"
- The theory claims that the red and green cones jointly synapse with a red-green detector (a neuron). It increases firing when red is presented but decreases firing when green is presented. Same thing for blue-yellow
- Support: Colour blindness. Colour adaptation studies. If a red circle is presented on a monitor and the observer asked to stare at it for some time (20-30 sec), the observer gradually adapts to redness. The firing rate gradually slows to the continually presented red colour. This slowing down of the firing rate is, however, not seen as an absence of colour (black). Rather, it is experienced as a different colour, green.
- Against: Any evidence that supports 3-colour theory.
- 2-colour opponent neurons probably operate at a higher level than the receptor (This is more of a psychological theory)

Pathway to the Cortex

- Half of the optic nerve crosses near the hypothalamus. The crossing point is called the optic chiasm.
- In the end, the left visual field (note, not the left eye) projects to the right visual cortex and right visual field to the left visual cortex.
- The optic nerve synapses at the thalamus.
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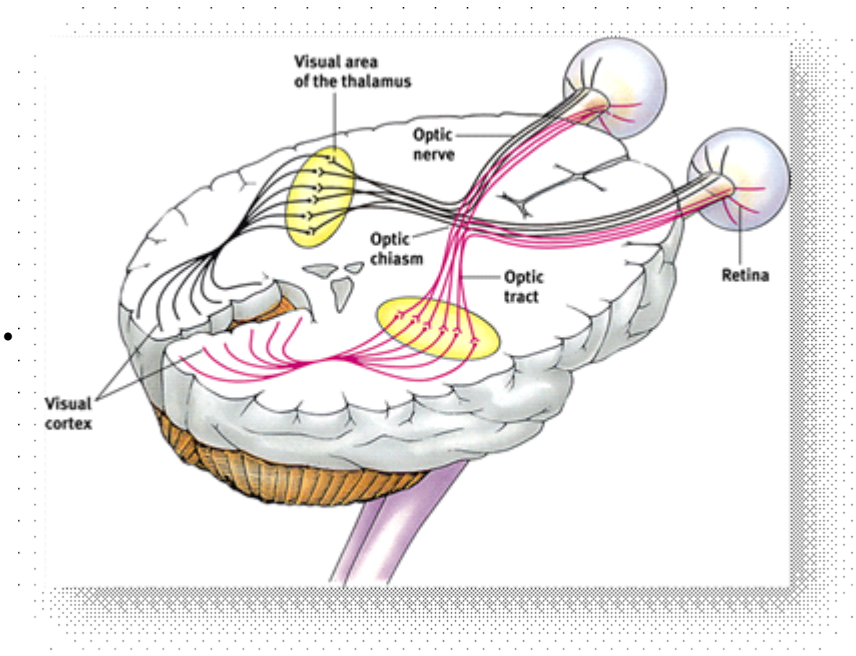
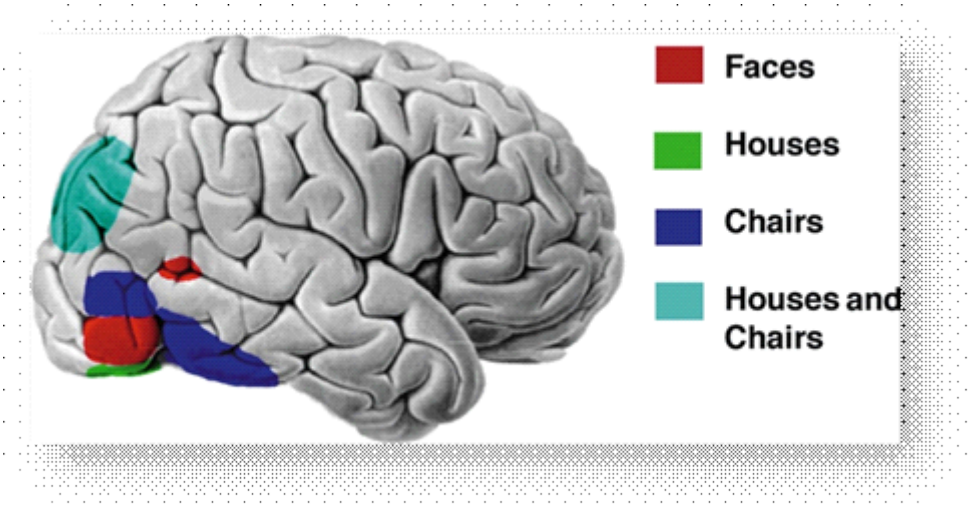
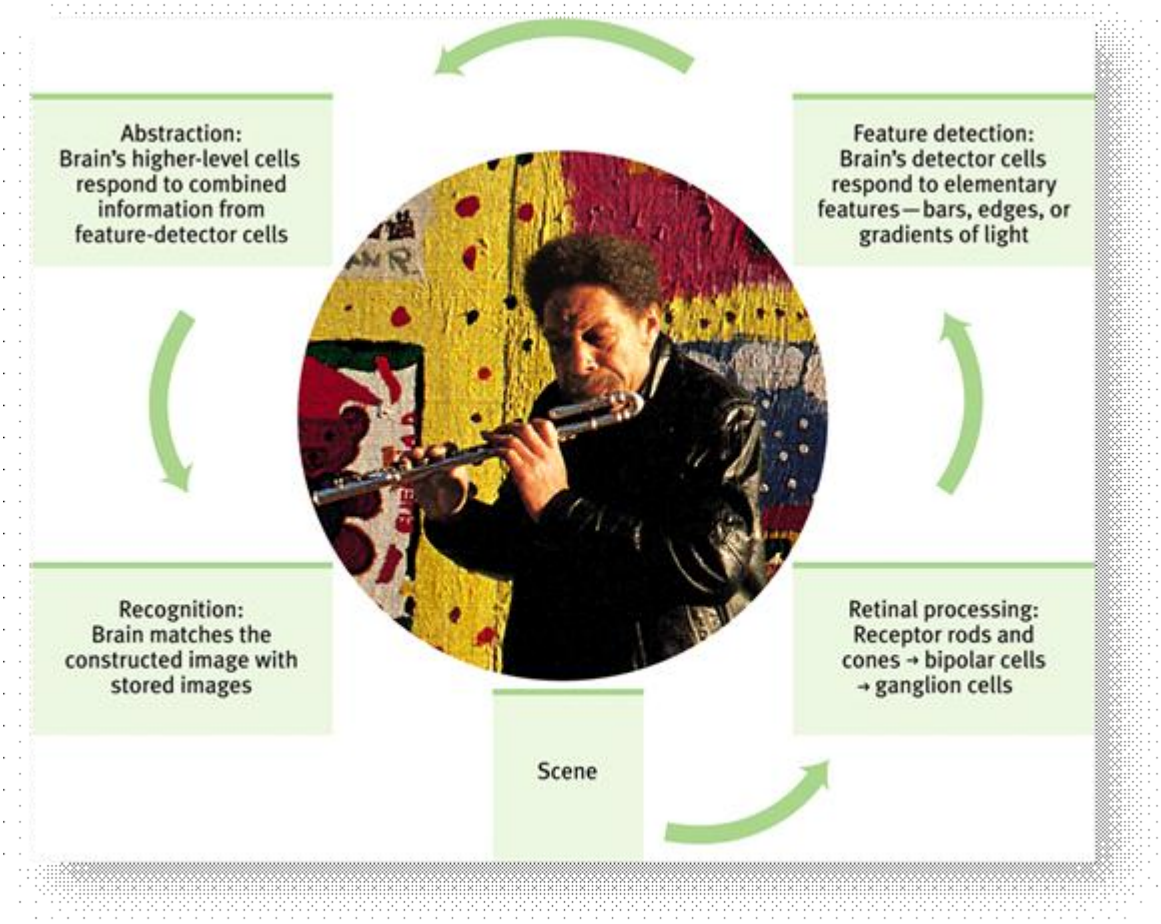


Feature Detection

- Single neurons in the primary visual cortex seem to be highly specialized for the detection of very specific features: -horizontal and vertical lines, lines at a very specific angle or perhaps a very specific length
- In the figure above, an electrode is implanted into a single neuron in the monkey's visual cortex. The monkey sees a line presented on a monitor. The single firing rate of the neuron is very rapid if the stimulus has highly specific features. It must be a straight line and must have a very specific length. It must also be at a very specific angle. In the middle portion of the figure, a vertical line at70 degrees (straight up and down) is presented. The single neuron is not specialized for detecting this feature (it is specialized for detecting a line like this and a line of this length but not at this angle). The firing rate decreases dramatically. In the right portion. Another line is presented but at a angle far different from that for which this single neuron is specialized to detect. The neuron therefore no longer is sensitive to this feature and does not fire at all.
- Farther away from the primary visual cortex, highly specialized regions detect very specific objects.
- Thus, if the single neuron above and another neuron that responds to say a line at a horizontal angle project to another common neuron (away from the primary visual cortex), then this cell might detect an "object" such as /_
- As we move farther and farther from the primary visual cortex, features become joined. So, the single neuron might detect rectangles or circles or ellipses. Regions of the visual-parietal cortex begin to be specialized for highly specialized objects. See example below:



Summary of Visual Processing of Specific Features:



Sensation: Pain

- Common to all senses. While there is an optic nerve and an auditory nerve, there is not a "pain" nerve
- No single stimulus (such as a visual, auditory or somatosensory) triggers pain. Rather, *any* stimulus that is intense enough to cause damage may cause the sensation of pain
- Phasic pain. This is the pain we feel immediately upon intense stimulation. Its role is protective. This phasic pain stimulus should interrupt processing of other information. It should automatically cause you to switch attention. The goal of this phasic pain sensation is for you to take action, to remove you from the source of the painful stimulus. When a painful stimulus is long-lasting, we will experience both phasic and tonic (see point 4) pain. But we will have two

phasic events. When the pain begins, we experience sharp, phasic pain. And when the pain ends, we experience a second sharp sensation of phasic pain. Our nervous system is carefully tuned to detect *change*.

- Tonic pain. This is the long-lasting "chronic" pain that we feel after the phasic pain has ceased. It serves to "remind" you of the immediate past and should thus assist you to learn to avoid the painful stimulus in the future. Tonic pain is more subjective. Its perception can be altered by psychological factors such as attention. This is why we shake our hand, jump up and down and utter politically incorrect words after bring pricked. Shaking your hand will set up another type of stimulus for your brain to interpret. If you attend to this stimulus rather than the tonic pain, you may become less conscious of the pain. Many so-called pain-killer drugs operate to decrease our perception of tonic pain.
- Memory for pain. We seem to have a much better memory for phasic than tonic pain. We remember the onset and the offset of pain much better than the long-lasting tonic pain.
- Different pain pathways for phasic and chronic pain.

Psychological aspects of Pain

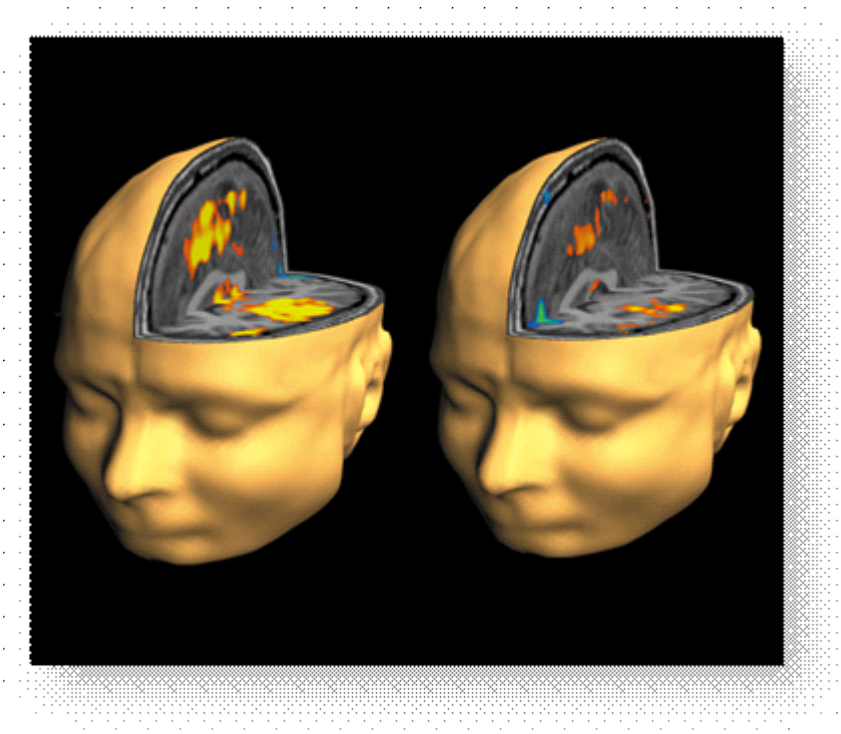
- Common to all senses
- Any stimulus that is intense enough to cause damage may cause the sensation of pain
- Phasic pain
- Tonic pain
- Different pain pathways for each
- Rapid pathway for phasic pain
- Slow pathway for tonic pain
-

  Pain is highly subjective. It can be controlled through attentional mechanisms and altered states of consciousness. Thus, there is nothing "objective" about pain. Various theories of pain perception have been postulated.

- Great deal of individual differences
- Perception can be easily modulated
- Highly psychological
- Strong placebo effects

- Gate control theory (Melzack & Wall) offers an excellent explanation of how pain can be modulated. See Myers for a more complete description of this theory.
- Selective attention: We can control pain by using a second stimulus. Thus, we stimulate the somatosensory (touch) system by shaking our hands when we crush our thumb with a hammer. This might cause us to attend to the somatosensory stimulus rather than the painful one (this is an example of bottom-up processing).
- Alternatively, a higher centre of the brain might wilfully block pain signals (perhaps by the release of endorphin neurotransmitters).

In the study illustrated in the Figure, a patient experiences chronic pain. An fMRI is used to scan the areas of the brain that are activated by the perception of pain and the extent to which these areas are activated. In the image on the left, a large number of areas are strongly activated. Now, the patient attends to visual stimuli (is placed in a virtual reality apparatus). Far fewer areas are activated and the strength of the pain activation is much reduced. The consciousness of pain has thus been modulated by directing attention elsewhere.



Perception

Sensation provides a myriad of "sensory" impressions. In vision, we might experience many different colours, shapes and forms. From this we need to form and integrated "whole" to arrive at a perception of our visual input. Perception involves an exceedingly complex interaction of many different brain regions. Some of these are specialized for the extraction of specific features of the stimulus. To detect the flight of a bird, we first must detect an object (the bird) against the background. In order to make the decision that the object is a bird and it is moving requires the extraction of additional features. The bird will probably appear as a distant object on the retina (it will be small). It should have distinctive features. We do not typically mistake a flying bird for a flying airplane. Why not? Birds are typically closer to the eye than airplanes. But airplanes are larger than birds. The size of the image of a bird on the retina and that of an airplane may not be all that different. Thus, there must be distinctive features that allow us to classify birds and airplanes as being different. We must be able to detect the distance that an object is from us ("depth perception"). How do we do this? Similarly, we do not have a problem distinguishing the flight of a baseball (or a Frisbee) from that of a bird. Certain areas of our visual cortex are specialized for distinguishing horizontal lines, vertical lines and perhaps a higher centre will detect curves (the combination of horizontal and vertical lines). Other cortical neurons might detect movement. In short, perception involves a complex feature extraction and integration process. We perceive the whole bird, not the parts of the birds. We do not see a head, eyes, a bill, wings, feathers, etc. We see a "bird". But we must also extract the features, the "parts" of the bird in order to perceive it as a bird as opposed to an airplane. Features that are extracted are then compared to what exists in permanent memory. Are the features that have been extracted consistent with my memory of a bird or an airplane?

How do we learn to perceive? How much of perception is inherited?

Most of this summary is taken from the Myers chapter on Perception. Please refer to it for more detail.

Visual Capture.

- Our sense of vision dominates other senses. When there is simultaneous stimulation of our receptors, vision "captures" our attention.

- An excellent example of visual capture is observed in the McGurk effect. McGurk found that people who watched videos of spoken phonemes could be fooled into misperceiving what they heard if the mouthing was actually different from what was spoken. If the person in a video mouthed "ga,"(the lips and tongue seem to say "ga") but was dubbed with a voice saying "ba," people usually heard "ga", even though that was not what was spoken. When viewers closed their eyes, they heard "ba" correctly. YouTube has some excellent examples of the McGurk effect.
- In a concert, if the loudspeakers are behind our heads, we still perceive the sound as coming from the singer's head in front of us, in spite of the fact that in reality, the voice is coming from elsewhere..
- Visual capture also works with other modalities. In the IMAX movie theatre, our eyes may tell us that we are dropping over a cliff, yet our vestibular system has not been stimulated. We still however sense dizziness and experience that we are dropping.

Perceptual Organization

- *Gestalt* psychology: Given a cluster of sensations, the perceiver organizes them into a "whole" or a "gestalt".
- *Figure-ground*. In order to perceive, we need to perceive a figure as being distinct from its surroundings, the ground. Edge Detection. See your textbook for details.
- *Grouping*: To bring order to our sensations, we logically group stimuli together -- rules of proximity, similarity, continuity, closure and connectedness. Again, see your textbook for details.

Depth Perception

- How do we perceive depth when an image falls onto a 2-dimensional retina? We see in 3-dimensions even though the receptor (the retina) has only 2-dimensions.
- The ability to see depth is at least partially innate. Visual cliff experiments. Infants will not crawl out beyond a "cliff". Newborns of all mobile species -- goats, cats, dogs, chickens also refuse to do so.

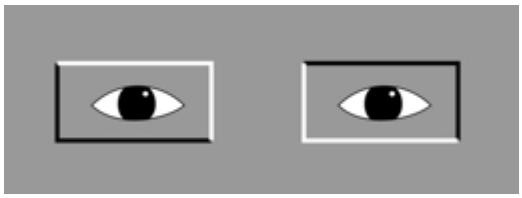
Binocular Cues

- The fact that we have two eyes does provide a cue for the third dimension, depth.
- Retinal disparity. The image that falls on our two eyes is not identical.
- 3-D movies are created by having two cameras placed a few cm apart film the scene. They imitate the eyes in that the images on the two cameras are slightly different.
- If we can force the eyes to see independently (so that the left eye sees something differently than the right), we will see vivid depth. *Stereograms* contain two different views of the same image.
- It is the brain that must integrate the two different images, and thus create depth.

Monocular Cues

- Even with one eye, we can still see in 3-dimensions. Many artists rely on the monocular cues for depth in order to paid realistic paintings that appear to represent objects that are close and far from the viewer. What are these cues?
- Relative size: Near objects are larger than far objects
- Relative height: Far objects are higher in the visual field
- Interposition: The near object will block a far object.
- Linear perspective. Parallel lines such as a railway track converge at a distance.
- Texture gradient: Near objects are more coarse and have a distinct texture. Far objects merge together and have an indistinct texture.
- Relative brightness (shading): Near objects reflect more light than far objects. Shading can be used by artists (and computer-types) to give the illusion of depth. Also the placement of shading (top or bottom) will alter our perception of whether an object is near or far. A push button on your computer screen creates the illusion of depth. In the real world, a button that is out casts a

shadow on the bottom and perhaps on the left side if the light source is coming from the top (almost always the case) and the right side. A button that is in casts the shadow differently. Now the shadow is at the top and on the right side. It is extremely easy to create the illusion of depth using this simple principle. Note that the rectangle on the left appears to be out. The black line (the shadow) is on the bottom and the white line at the top. The button is pushed in on the right. The black and white lines now change position.



The rectangle on the left has no shadow. A "shadow" (actually two grey lines) has been added to the bottom. This now creates the illusion of depth. The rectangle appears to be popping "out" from the monitor.

Motion Perception

- As light sequentially stimulates one retinal cell after another, we experience "movement".
- In short, a moving object will "move" across the retina, triggering neighboring retinal cells.
- Approaching objects become "larger" on the retina (as they trigger retinal cells that are farther and farther away from the centre of the object). Retreating objects become smaller (as they trigger cells that are closer and closer to the centre of the object).

Misperception of Movement (Apparent Movement).

- An object will also move across the eye as the eyes move from left to right (or up and down). However, in this case the object removes stable.
- Even though the object still triggers neigbouring retinal cells, our visual cortex does not experience movement. Our visual cortex somehow has "learned" (but perhaps the computation is inherited) to distinguish between objects that trigger firing in adjacent retinal cells because it is the object that moves and objects that trigger adjacent retinal cells because the eyes move.
- However, our eyes are constantly moving slightly and we are not conscious of these movements. In this case, the object will still trigger neighbouring retinal cells. But, in this case, we are not conscious (aware) that it is the eyes that are movement.
- We thus have an illusion (a misperception) that it is the object is moving.
- Illusions are thus errors of perception. The visual computation are erroneous.
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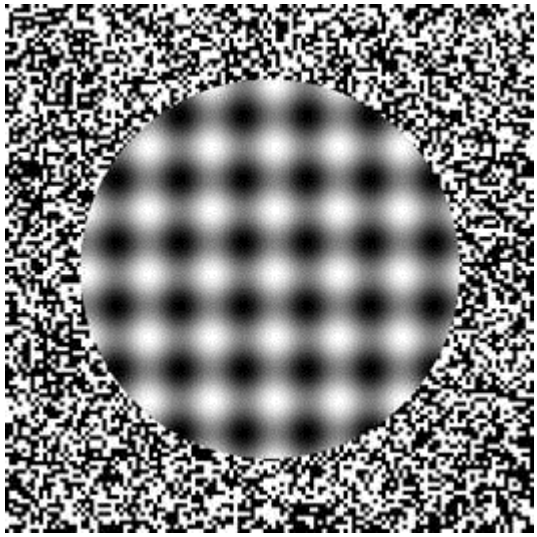

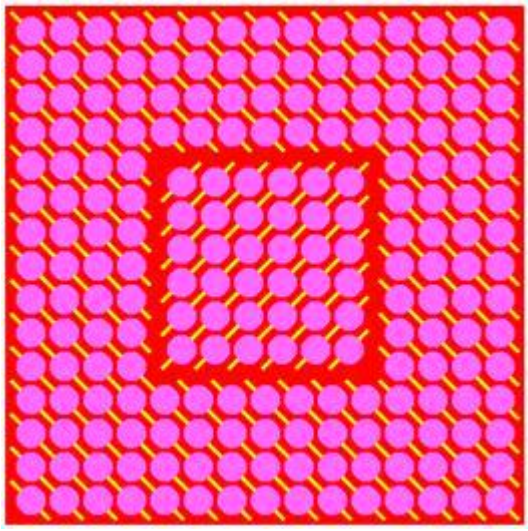

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- Stroboscopic motion. Still pictures whose image vary slightly in position will appear to move if flashed rapidly enough (about 24 times per sec).

Perceptual Constancies

- *Perceptual constancy* allows us to perceive an object as unchanging even though the stimuli that fall onto our receptors have changed (see text for details) .
- Shape constancy
- Size constancy.
- Lightness constancy. White objects reflects more light than black objects. Yet outside, a black object will reflect more light than a white object that is indoors. Yet the object still looks black. This is because of context or *relative luminance*. The black object that is perceived in bright sunlight still reflects less light than a white object that is outdoors.

Perceptual Context

- Context can influence how we perceive.
- Identical colours will not appear to be identical if presented in different background colours
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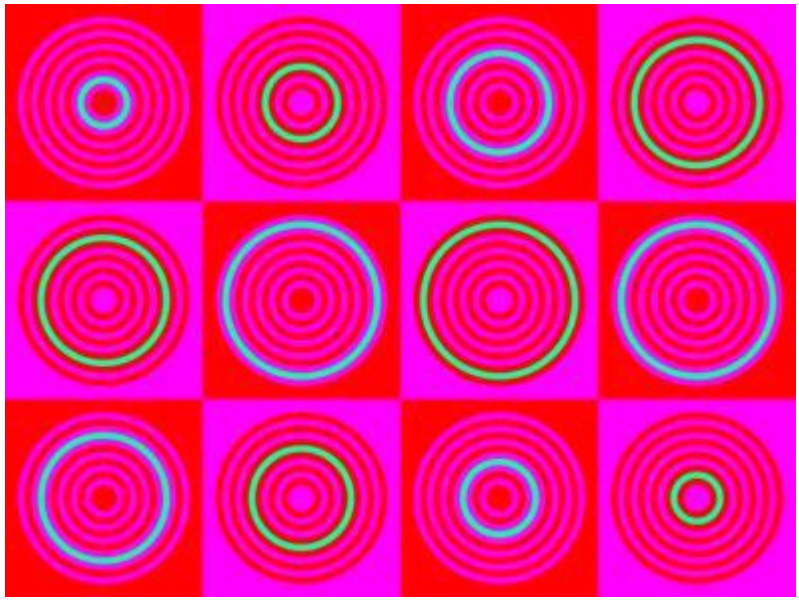
- 

- Lightness (brightness) context. Grey will appear to be darker if presented against a white background. The eyes of the girl drawn by Prof Kitakao seem to have different colours. Again, this is an illusion. The colours are identical. The right eye appears to be light grey because it is drawn in the context of a dark background. The eye colour of the right eye appears to be very dark because it is drawn against a light (white) background.

- Culture can also affect how we perceive objects (see text for details).
- Food is often coloured to fit our cultural context. Butter should be whitish (it is milk) and contains a great deal of fat (white). We have learned that fat is bad. Butter is thus coloured to be yellow. Margarine, which is not an animal product at all is similarly coloured to be yellow because we think that butter should be yellow (thus margarine is coloured to be yellow to look like butter which in itself is coloured to appear yellow). The canning process deprives peas of their colour. We thus colour them green. We add red dye to "red" meat to give the impression of freshness. We add yellow to batter (tempura). Thus, fish batter appears to be yellow.

Learning to Perceive

Clinical Studies.

- To what extent is perception inherited (i.e., unlearned) and to what extent is it learned?
- Test of hypothesis that visual perception requires learning: test people who although blind from birth have recovered their vision.
    - Patients could distinguish figure from ground.

- Patients could detect colour
- Patients could not recognize objects

True Experimental Studies

- Kittens raised in an environment consisting only of vertical or only of horizontal black-and-white lines (Blakemore and Cooper studies).
- Kitten raised in one environment could not perceive the other environment and could not learn to perceive the other environment as adults. There does appear to be a "critical period" for this form of perception to be learned early development. If the learning does not take place within this critical period, it will never take place later during adulthood. Thus, even detecting what appears to be a very simple visual feature… either horizontal or vertical lines does not appear to be inherited. We must learn to perceive them.

Perceptual Adaptation

Note that the use of the word "adaptation" in the context of perceptual adaptation is very different from the use of this word in the context of the adaptation of a receptor. Perceptual adaptation is required following a dramatic change in our perception. If you were deaf from birth and now received a cochlear implant, you could suddenly hear. *Sensation* may now be normal. But what would you hear (i.e., perceive)? Could you learn to perceive something as complex as language? You must now adapt to the new *perception* of sound.

This type of perceptual adaptation has been most often studied is that following medical surgery that allows a blind person to see (often involving the replacement of the cornea). Could these patients adapt? Could they "perceive" just as we perceive? Recall that the patients' retinas and their optic nerves are sending more or less the same message as any normal seeing individual's receptor would send to the visual cortex. But do the patients perceive the same thing? In order to perceive, what has to be learned in early childhood (or infancy)? What is inherited?

- If your visual world were suddenly changed -- could you adapt? The answer to the question may depend on the extent to which perception requires the complex computations that can only occur with the evolution of a large area of grey matter, the visual cortex. Often, these complex connections are only formed as a result of experience (i.e., as a result of learning).
- In experimental studies in non-mammals, (for example, reptiles or amphibian), the optic nerve of a newborn is severed (cut) and the eye rotated. The optic nerve must regenerate (and it does relatively easily in non-mammals) and the proper connections made again. What used to be perceived as being up is now perceived as being down. What is actually on the right is perceived as being on the left. Non-mammals cannot adapt (re-learn). An adult frog will starve to death because whenever it tries to eat; it misperceives the location of the food, trying in vain, lashing downward with its tongue to snarl food that is perceived to be in a downward location when it fact it is actually in an upward location. Thus, while these animals have the flexibility to regenerate the peripheral nervous system, their limited grey matter of their nervous system does not have the flexibility to relearn how to perceive location of visual objects.
- There is limited regeneration of the optic nerve in mammals. However, we can experimentally carry out a similar manipulation by rotating the image (rather than rotating the eye) by having the animal wear inverting goggles. What is up is perceived as being down is now up and vice versa. As you can imagine, climbing up or down stairs is terribly difficult. However…
- Kittens, monkeys and humans can re-learn (i.e., adapt) to the visual reversal, although it does take considerable time. They have the cortical power that allows for such flexibility. Amazingly after a couple of weeks of wearing inverted goggles, humans can carry out seemingly impossible tasks. Over time, with considerable adaptation, learning and experience, they can ride a bicycle, catch thrown objects, write…

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Sensation: Audition

October-14-10
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Sensation

How are sensation and perception different?

- Sensation -- sensory input and transmission
    - Transduction (at the level of the receptor). The body's sensory receptors are "sensitive" to only a very limited range of the earth's energy. The receptors are highly specialized. As an example, the ear is sensitive to energy in the form of air pressure. The eyes are sensitive to light energy. The role of the sensory receptor is to transduce a very restricted amount of the earth's energy (that required for the survival of the species) into something the nervous system can understand, an electrical signal. The ear translates one form of energy (air pressure) into an electrical signal that then travels along the auditory nerve as an action potential. The eye translates light energy into an electrical signal that travels along the optic nerve. Thus, the "message" that arises in a sensory neuron is always the same: a travelling electrical signal.
    - However, even though the message along the auditory, visual, somatosensory and olfactory nerves is the same (an electric signal), in the end, what we "experience" in the different modalities and within the same modality is quite different. When we have the experience of light, we say we "see" it. Similarly, we do not "hear" light. Philosophers ask very difficult and hard questions, the sorts of questions that even the wisest neuroscientist cannot answer. What is doing the seeing? Your eyes? Your visual cortex? Deprived of a visual cortex, you will be blind; you will not see. We do "see" green and red light. When I see a green light, do I experience the "green" in the same way as you? How could a scientist prove that what you experience is identical to what I experience? What philosophers mean by "experience" is somewhat similar to what psychologists mean by "perception". However, even here it is not this simple. Experience is a "holistic" experience. Thus, a psychologist might describe the stages of processing that would be required to perceive a rose. A philosopher would claim that the perception of a rose is not the same as the experience of it.
        - Sensation is objective (more or less. Sensation is probably similar in all humans and presumably all animals that share one or more of our specific receptors).
        - *bottom-up* processing
- Perception -- integration of sensory information with permanently stored memories to form "percept"
        - takes place at a "higher" level in the brain
        - Perception is very subjective (the mind's "I"). My perception of the world is very different from yours. Nevertheless, all humans (and again many of our animal ancestors) do perceive the world in a similar way. The cues we use to, for example, perceive depth, perceive motion, perceive smell, and so forth might be quite similar.

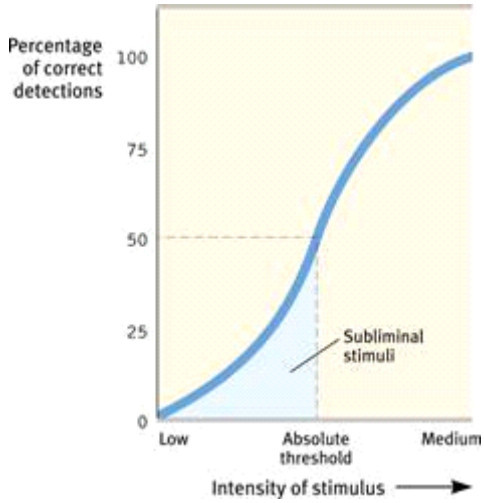
Physics of energy

- In all modalities, our receptors provide at least five critical features of the physical characteristics of a stimulus:
- its modality. What is the type of experience that is bombarding the receptor? Is it light energy? Air pressure (sound)?
- its frequency. How often is the receptor stimulated? (This will become clearer when we study the specific modalities). In audition, frequency is transduced into "pitch" while in vision, it is transduced into "colour".
- its intensity. How much energy is there? Is it loud? It is bright? As we will learn, very high

intensity in any modality may be experienced as "pain".

- its location. Where does the stimulus "come from"? What is the source of the stimulus in space (spatial location)?
- its duration. How long does the stimulus persist? When does is start (how much energy is necessary for it to be sensed?) When does it stop (how much must energy be reduced until it can no longer be perceived)?

Thresholds



- All receptors require a certain minimum amount of physical energy to result in an action potential in the sensory nerve. If the energy is not sufficient, the sensory nerve will not fire. It would thus be impossible to perceive the stimulus. This minimum energy is called the *threshold*. Note, however, that this is a *sensory* threshold. There are two types of thresholds that are typically measured:

- Absolute
    - the minimum amount of physical energy necessary to detect a stimulus on 50% of presentations (i.e. 50% of the time, the stimulus is detected; 50% of the time it is not).
- Difference Threshold... also called -- Just Noticeable Difference (jnd)
    - detection of minimum change in energy
    - Weber's Law states that deltaI/I = k. This means that the difference in Intensity (delta I) divided by the standard (or original). As an example, intensity is a constant (or k). Regardless of the actual magnitude of two stimuli, the two stimuli must differ by a constant proportion for their difference to be perceived. Thus, the difference threshold is not a constant addition (a constant is not added on) but a constant proportion. Let us assume you can just detect the difference between 100 and 200 grams. Half the time you detect the difference; half the time you do not. The mathematical difference is 100 grams. So, is your difference threshold 100 gm? But the ratio is 2:1. So, is your difference threshold 2x (2 times the weight of the "standard"). Now I have a 400 gm mass in my hand. By how much do I need to increase the mass in order to perceive it? To 500 or 800 gm? (Answer: 800 gm. I need to increase the weight by 2 x, not 100 gm).
- Signal detection theory: the measurement of a threshold (whether the absolute or the difference) requires the observer to consciously *perceive* a stimulus. Note that this is not sensation. Sensation is objective. Perception (and consciousness of perceiving) is subjective. The threshold is therefore highly subjective. Subjective, psychological factors will therefore affect the threshold. In short, part of my sensory threshold will indeed be determined by the objective, physical characteristics of the stimulus but, *subjective perception* will also affect it. Let's see how one subjective, psychological factor can affect the apparently objective threshold measure. The observer's strategy that is adopted plays a critical role. It is possible that the observer may have "felt" or "sensed" that a stimulus was presented, yet not claim that it was. This observer takes a conservative approach. When a stimulus is at a near-threshold level, the observer will not be

certain that the stimulus was presented (recall that 50% of the time, the observer will report that a stimulus was not presented, when it fact it had been). The observer must thus adopt a strategy to deal with this uncertainty. If the observer now adopts a very liberal strategy, claiming a stimulus was presented when it fact he/she was uncertain, then the threshold will appear to be very low (the observer would be thought to be able to detect a very minimal amount of energy). On the other hand, if the same observer is now very conservative, only reporting the presence of a stimulus when she/he was very certain of its presence, then the threshold will appear to be very high. Much more energy would apparently then be required to detect the stimulus. In signal detection methodology, a "catch" trial is included in which no stimulus is presented. If the observer detects a stimulus when in fact it was actually presented, this is called a "hit" (a true detection). But, if he/she signals the detection of a stimulus when in fact none was presented, this is called a "false alarm". The ability to *discriminate* a signal from no signal (in actual fact, there is always some noise in the system, either external noise or internal noise in the nervous system… neurons are never truly inactive) is the ratio of hits to false alarms. Many factors may affect the ability to discriminate signals. Obviously, the intensity of the signal is a major factor, but the psychological state of the observer also plays an important role. Some of these psychological factors include: strategy (as outlined above), level of attention (signals that are attended are detected easier than those that are ignored), motivation, and learning (a wine taster will have a much more acute sense of smell than I). Similarly, an expert musician will be able to detect much smaller changes in the pitch of a sound than I).

- Subliminal perception. The word "limen" means threshold. Thus, subliminal perception is the ability to perceive stimuli that are below threshold. This should mean that we could perceive stimuli that did not exceed a receptor's threshold. There have been claims (indeed, many hopelessly wild claims in the mass media) that it is possible to perceive stimuli that are below threshold. Think about how this is possible. Recall that we are measuring perception not sensation. An apparently subliminal stimulus must have enough energy to result in it causing a receptor to "fire". But…Recall that signal detection theorists claim that there is no such thing as an "objective" threshold. And also recall that what we are measuring is conscious *perception* not the threshold for sensation. It is quite possible that we might perceive a stimulus input yet not be conscious of the perception. These apparently unconscious inputs might, however, later be recalled or recognized.

Sensory Coding

How do we experience sensation? Why does a rose smell "sweet"? It has nothing to do with the name "rose". "A rose by any other name would smell as sweet" (Romeo & Juliet; W. Shakespeare). Why does a rose smell sweet? What we perceive as "sweet" is merely the name we give to the apparently pleasant experience of smelling the rose. If the rose were very poisonous to humans, it would probably not be described as smelling "sweet". Perhaps the major controversy in philosophy (indeed some would argue in the universe) is how my conscious experience is different from yours. Many roses are also red. The red rose appears to be red to most humans because the light energy that is reflected from the flower stimulates a red receptor. The leaves appear to be green because they stimulate the green receptor. However, both the green and the red receptors send messages to the visual cortex via the sensory nerve, the optic nerve. One group of nerves will carry the red message and another a green message. However, the action potentials that the nerves are sending are identical. Why is it that when the action potential arrives at the cortex from one group of nerves, we are conscious of "green". When the action potentials from the different group arrives, we then are conscious of "red". Another example: The action potentials in the auditory nerve are not different from those in the optic nerve, but action potentials in the auditory nerve when they are eventually transmitted to the auditory cortex are perceived as sound, not light. Why? How are action potentials in a "pain" nerve any different from those that correspond to light touch? Why is the action potential that codes pain in the cortex experienced as unpleasant and as something that cannot be ignored while other action potentials in other areas of the cortex are experienced very differently with very different emotional consequences?

We are far from answering these questions, but we do have some answers about how sensory information is coded. But these are answers to very simple questions nothing as philosophically complex as the ones posed above.

- Sensory modality is coded by the specific nerve that carries the neuronal message. This is called Muller's "specificity". The auditory nerve codes an auditory signal; the optic nerve, visual signals.
- Different qualities within a modality might also be coded by a specific nerve. There are indeed some optic nerves that carry the red code and others that carry a green code (they are "connected" to the red and green receptors in the eye). These red and green nerves then synapse at specific (but different) places in the thalamus and in the visual cortex. Other optic nerves may code the location of the visual stimulus. Similar "specific" nerves carry specific messages in all modalities.
- The experience of the perception of a stimulus almost always requires the cortex. A visual stimulus is experienced as light not because the visual receptors of the eye are stimulated but because the visual cortex has been stimulated. If the auditory neurons that eventually synapse in the auditory cortex were rerouted to the visual cortex, we would see what we hear. Thus, a specific sound might be perceived as red and another as green. Ultimately, the question always turns to why we experience what we experience. Why do we experience vision when the visual cortex is stimulated but sound when the auditory cortex is stimulated?
- Within any one modality, neuronal specificity cannot be possible to code all the sensations that we experience. This would require far too many sensory nerves. Humans can perceive more than 5 million colours. We do not have 5 million optic neurons devoted to the coding of colour. Many of these neurons code other features of the visual stimulus. To prevent this need for an overwhelming number of nerves, nature has simplified matters. A single nerve can code many different messages. A single telephone line can code very complex messages. It is not necessary to have a different telephone line for every intensity that humans can hear and different lines for every pitch that can be perceived. The coding of the action potentials within the neuron can serve to code many different features of a message. Or, different neurons may encode specific feature. Thus, one group of neurons might encode the intensity of a sound; another group the pitch of the sound. A single neuron could code, for example, location and intensity. A neuron arrives from the left ear (this encodes location); it also fires many times per sec; this might encode the intensity of the sound. This is called parallel processing. Thus, we might in parallel code

But recall that the action potential operates in an all-or-none manner.

- Limitations of neuron's the all-or-none law
    - Amplitude modulation not possible
- Frequency modulation is however possible. The message that is carried by a neuron is coded by how often (or how "frequent") the neuron fires. The maximum rate at which a neuron can fire is 1000 times/sec (i.e., 1000 Hz).

Adaptation

The firing pattern of the neuron can also code the duration of the stimulus. As will be seen in other sections of the course, it is critical that the observer become conscious of *change* in the environment. This saves a great deal of needless processing. As long as stimulation is constant (remains the same), it is only necessary to perceive the initial onset. There is no reason to have to continually perceive what is the same. This would only tie up the very limited resources of our cortex in the perception of what is repetitive. If redundant processing can be prevented, the limited resources of the cortex could be engaged in other more urgent matters. One means to assure this is through the process of adaptation. A long-duration stimulus (one that remains "on" for a long period of time) is not perceived after a period of time. The rate of neuronal firing slows and eventually stops altogether. When we enter a flower shop, the initial experience of the smell of the flowers is almost overwhelming. Yet after a brief period of time, we barely perceive the odours. This is because of adaptation… the olfactory nerve has ceased to fire. Our nervous system can easily detect the onset and the offset of a stimulus because these both represent a

change of energy.

- If a stimulus intensity remains constant, our sensory receptors *adapt* to it. We are no longer conscious of the stimulus, but why?
- The receptor no longer is capable of firing. This is due to *neuronal fatigue* (depletion of the "neurotransmitters").
- Contrast *adaptation* to *habituation*. Habituation occurs at a "higher" level in the brain. It involves a memory process and is claimed to be the simplest form of learning. Upon repetition of the stimulus, we soon are no longer aware ("conscious") of it. This may be due to adaptation or it may be due to the fact that a memory of the frequently occurring, but redundant (and thus irrelevant) stimulus has formed. As a result, the subject no longer needs to process what is now an irrelevant, repetitive stimulus. The incoming stimulus reaches a certain level of the nervous system (where the memory is stored). Its features are compared to what already exists in memory. If they match, processing ceases. If they do not match, novelty (or change) is detected, and further processing is warranted. In the case of habituation, the subject's receptor is quite capable of firing (thus, the lack of awareness of the stimulus cannot be due to adaptation). In both the cases of adaptation and habituation, the end result is the same. The subject is not conscious of the stimulus. How can one know if this phenomenon is due to adaptation or to habituation? If the failure to be aware of the stimulus is due to adaptation, the receptor is no longer capable of firing. If we change a property of the stimulus, the receptor still cannot fire, and we therefore are still not aware of it. However, if the failure to be aware of the stimulus is due to habituation, the receptor can fire. If we change the stimulus, we interrupt the habituation process. Since we present a "new" stimulus, there will be no memory for it. We thus become aware of this new stimulus.
- Adaptation is especially apparent in olfaction and somatosensory modalities. Habituation occurs in all modalities.

Audition

Physics of Sound

The ear transduces sound energy. This is a result of the collision of air (usually) molecules resulting in a compression and expansion of air "waves" quite similar to the ripples of a pond. Sound travels best when molecules are densely packed (as in a solid) and worse when molecules are loosely packed. Sound thus travels better through a solid than a liquid, and better in a liquid than in air. This explains why sea mammals can communicate across very long distances in the ocean whereas land-based animals cannot. The travelling sound wave varies in:

- Frequency (Hz). The time between waves determines the sound's wavelength. This is the sound's frequency. The time between waves is very short for a high frequency sound (there are many waves or peaks in a given unit of time, typically a second). The time between peaks is much longer for a low frequency sound. Our ear drum vibrates in accordance with the frequency of the stimulus. We are capable of hearing sounds from about 20 to 20,000 Hz. Thus, a frequency of 1000 Hz will cause the ear drum to vibrate (move back and forth) 1000 times/sec. The frequency of a sound is a physical measure. The psychological term is the sound's "pitch". We thus perceive (or experience) the pitch of a sound.
- Intensity (dB). The number of molecules that are put in motion is reflected in the strength or intensity of the sound. The intensity of the sound is a physical (or objective) measure. The psychological (or subjective) term is "loudness". The intensity of the sound is experienced as loudness.
- Not all frequencies are perceived equally well. The human ear is much more sensitive (thresholds are lower) to frequencies in the human speech frequency range (500-2000 Hz). In order to hear lower and higher frequencies equally as well, their intensities would have to be amplified. This is typically what is done by the "loudness" button on a stereo amplifier. It boosts low and higher frequencies that are not heard well by the human ear.

Intensity Scale

- decibel (dB). This is a log scale!

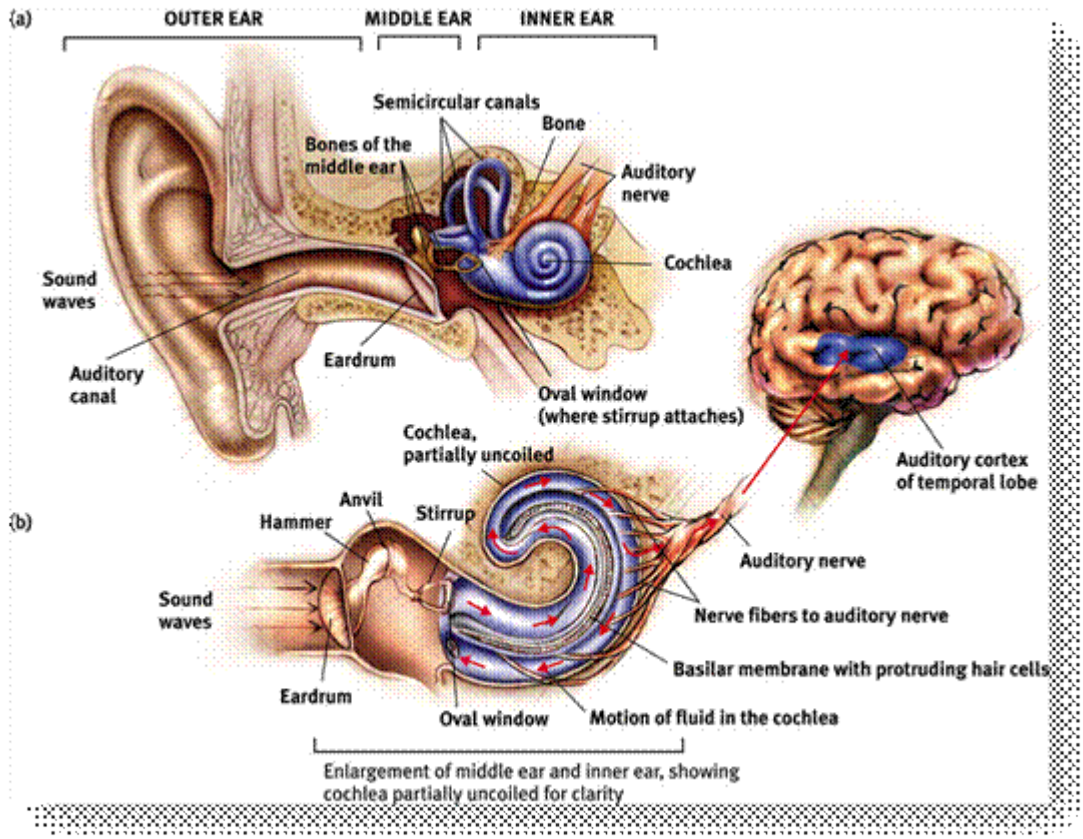
- measure of sound pressure level
- Again, this is a log scale. Thus,
    - 10 dB 10 (or 10^1) x pressure
    - 20 dB 100 (or 10^2) x pressure
    - 30 dB 1000 (or 10^3) x pressure
    - 40 dB 10000 (or 10^4) x pressure
    - 50 dB 100000 (or 10^5) x pressure
    - 110 dB 100,000,000,000 or 10^{11} x pressure
- Therefore going from 10 to 20 dB results in an increase of 90 units (10^2-10^1) of pressure on the eardrum. But going from 100 to 110 dB results in an increase from 10 to 100 billion or 90 billion units of pressure! However, we may experience the difference in loudness as being equal. So going from 30 t0 40 dB may be experienced as a slight increase in loudness. Similarly, going from 1000 to 120 may also be experienced as a slight increase in loudness. Unfortunately, it may also permanently damage your ear.

The Ear

- Outer Ear
    - pinnae
    - auditory canal
- Middle Ear
    - ear drum
    - hammer, anvil, stirrup
- Inner Ear
    - cochlea
    - auditory nerve

The Cochlea

See text for further info and graphic illustration



Please note that figure above is not quite accurate. In the lower part of the figure, an enlargement of the cochlea is shown. The auditory nerve emerges at this level. In the Figure, on the right side, it appears that the auditory nerve projects directly into the gyrus of Heschl in the superior region of the temporal lobe (i.e., the primary auditory cortex). This is not correct. The auditory nerve initially synapses in the medulla of the hindbrain, where information is extracted. It then makes other stops (or "relays") within the pons and midbrain before projecting to the thalamus. The thalamus then makes an elaborate analysis of the auditory message. It is only if this message is very relevant that it is forwarded to the auditory cortex.

Risks to Hearing

Any intense sound could damage hearing. A temporary hearing loss is reversible. A permanent hearing loss is not. In general, any sound that is experienced as painful can damage hearing. Another way of knowing whether a background noise is too loud – if you need to shout to be heard, the background noise is too loud and may damage your hearing. The more we are exposed to loud sounds, the greater the likelihood of damage. However, very intense sounds can cause immediate damage. Unfortunately, recall that we do not perceive sounds equally well. We do not hear very low and very high frequencies. At rock concerts, the singer's voice is heard with exquisite sensitivity. But we may require 40-60 dB of additional intensity just to hear the low and high frequency sounds (drums, bass, cymbals, guitar) If the singer's voice is amplified to be 100 dB (typical of rock concerts), the bass and treble sounds may be at an ear-splitting (or more correctly, ear drum severing or cochlea hair cell-ripping) 120-140 dB. This near deafening sound may instantaneously produce hearing loss. But typically, it requires prolonged exposure. This is why rock musicians often wear ear plugs. There is another cause for concern. Recall what you have learned about adaptation. We are less able to perceive a stimulus if it is continually presented. We adapt to it. Thus, the listener walking in on a rock concert will immediately be aware of the very intense and painful sound. After a short period, it is no longer perceived as being as loud. Yet, the damage to the sensitive ear mechanisms still occurs.

The damage may occur to the sensitive middle ear mechanical devices (the ear drum or the middle ears bones). This is called *conduction hearing loss*. Damage to the cochlea (or more specifically the cochlea's hair cells) or the auditory nerve is called *sensorineural hearing loss*.

Theory of Pitch & Intensity

How are pitch and intensity coded within the auditory system?

Frequency (Temporal) Theory

The frequency (or temporal) theory maintains that:

- The frequency (number) of times the auditory nerve fires codes frequency (i.e., 200 Hz frequency coded by 200 action potentials/sec).
- The frequency of firing of the nerve could not then code the intensity of sound. Intensity might be coded by the number of auditory neurons that carry the signal.

There are however problems for the frequency theory.

- Limit to the frequency at which a neuron can fire (upper limit is 1000 Hz)
- However, we hear frequencies up to 20,000 Hz.

Place Theory

- Frequency coded by place stimulated on basilar membrane
- Intensity coded by frequency of firing.

Support for the place theory comes from the fact that:

- Damage to basilar membrane will result in hearing loss to predictable frequencies

- Particularly the case for high frequencies
- Ageing results in deterioration of hair cells (perhaps basilar membrane) at predicted locations

But there are also problems with the theory:

- Low frequencies generate a general movement of the basilar membrane. We should therefore hear mixed frequencies, but we do not.
- Low frequency hearing loss is extremely rare.

Volley Theory

- Frequency theory cannot explain how higher frequencies are coded.
- Volley theory offers an explanation. A single neuron cannot fire at a rate higher than 1000 Hz. But if the neurons fire in a volley (like cannons), then higher frequencies can be coded.

Localization of Sound

We (and most other species) have two ears. We thus hear in "stereo". Having two ears assists in localising the sound in space. Is the sound coming from the front, back, left or right side or somewhere in between. How do we localize sounds in 3D space?

- Time difference between arrival of the sound. A sound occurring on the left side will arrive at the left ear before it arrives at the right ear. The difference in time of arrival is very short, about 300 to 600 μs (millionths of a sec; gives you an idea of the sensitivity of our hearing).
- Intensity difference between the ears. The sound occurring on the left side will be louder in the left than the right ear. In fact, the head will actually block and attenuate the intensity of the sound being transmitted to the right ear. This is often called a "sound shadow".
- What happens if the sound is in front or behind us, exactly equidistant from the ears? We have difficulty locating the sound.

Consciousness: Various States

November-04-10
11:56 AM

Introduction to Experimental Psychology

Consciousness (Chapter 3 in Myers)

Consciousness as a process:

The study of consciousness has a frustratingly long history in Psychology and for many centuries before that, in Philosophy. Many of the problems have arisen because no-one can seem to agree on just how to define consciousness. And as in any scientific endeavour, we need to operationally define what we hope to measure. To adequately define consciousness would require that all of us agree that whenever we observe a specific "conscious" action, behaviour or perhaps a brain response, we would all agree that this is consistent with "consciousness". Thus, an experimenter might present a tone that sounds like "beep". Every time it is presented, a volunteer participant is asked to push a button. Almost all of us will agree that if the participant does indeed push the button, she/he must have been conscious of the tone. The behaviour, the pushing of a button, can thus be used as evidence that the tone was detected consciously by the participant. But, was this actually the case? Was the participant actually *conscious* of the tone or did he/she merely "detect" it or was "aware" of it? Almost all agree that "detection" and "awareness" of the outside, "external" environment or the "internal", mental environment form part of the definition of what we call "consciousness". However they are not sufficient. A computer can detect external signals. A computer could have detected the tone that the experimenter presented. But we all agree that a computer is not conscious. However, if we defined consciousness as the ability to detect an external stimulus, then by this definition, the computer is conscious. Few of us would agree that a computer is "aware" of the outside world but many animals do seem to be aware of it, at least to a limited extent. Are animals conscious? Probably, at least my dog and cat seem to be conscious. Most however agree that while animal consciousness is different from computer consciousness, it is also probably different from human consciousness. There does seem to be something unique about human consciousness. For one, humans do demonstrate what is called "self-consciousness". Not only is a human conscious, it knows it is conscious. No other animal seems to show this form of consciousness. Or do they? Some monkeys and apes and maybe even elephants seem to show some form of self-consciousness. Still, humans just seem to be "more there". But "more there" is a rather vague scientific term. How is "more there" defined". What type of consciousness do we show more of (sorry about the dangling preposition)? We seem to "experience" our consciousness in ways that are not available to other animals. Unfortunately, terms like "self-consciousness", "more there" and "experience" are even more difficult to define. And, even if scientists could agree on how to define consciousness, how could it be measured? And complicating matters even more is the fact that the absence of consciousness – unconsciousness – also needs to be defined? As an experimenter, how would you know that your volunteer participant is not conscious? In the example above, suppose the participant fails to respond to the occasional presentation of the tone. Does this necessarily mean that he/she was not conscious of the tone? As a participant, how could you signal to the experimenter that you are conscious?

- We shall consider consciousness in two ways: as a state and as a process.
- The sleep-wake cycle is divided into a waking and a sleeping *state*. In the alert and waking state, the observer is aware of their environment and is thus said to be in a state of consciousness. During natural sleep, the observer is no longer (apparently) aware of their environment and is thus said to be in a state of unconsciousness. Sleep as a state of unconsciousness will be studied later in this section.
- While in the waking state, the observer, although conscious, is not conscious of everything. Rather it appears that the observer must restrict attention to only a very small portion of their

environment. This is called the selective attention *process* and permits the observer to become conscious of highly relevant stimulus input. However, this comes at a cost. The observer will not be conscious of less relevant input.

- Consciousness involves more than simply detecting and becoming aware of an external stimulus input. It also involves something abstract called *experience*. This perceptual experience is highly personal and subjective and can therefore be easily altered. We shall also discuss how various drugs can alter our conscious experience.

The Attentional Process: How we become conscious

- How do we manage to become aware of stimulus input that is relevant, yet banish from awareness that which is not relevant?
- One method, active attention, requires considerable cortical effort and considerable "focusing" in order to distinguish relevant input from irrelevant input. The observer *chooses* to become aware of that which is relevant.
- A second method, passive attention, requires no effort. Rather, certain highly privileged stimulus input will force the observer to switch attention away from whatever they were doing and now attend to the processing of something that is deemed to be much more relevant.

Active/Selective Attention

- The purpose of attention is to ensure that only the most relevant of stimulus input attains consciousness. The processing of that which is irrelevant should be inhibited and thus prevented from attaining consciousness.
- The selectivity of the attentional process would not be necessary if our cognitive processing systems had unlimited capacity. The reality is otherwise. In spite of the enormity and the complexity of the human cortex, we do appear to have a very much limited capacity to process information.
- Selectivity. We are free to select amongst all the stimuli that impinge on our receptors those that we wish to attend (those that we will process further). But we must choose! "Free choice"; "Free Will".
- One must choose to attend to only certain types of stimulus input (perhaps you are listening to a telephone conversation) but must also manage to ignore other input. *How is this done?*
- Active attention requires that the observer distinguish between what is deemed to be relevant (and thus should be processed further) and what is deemed to be not relevant (and thus can be ignored, at which point further processing should cease).
- Distinguishing between relevant and irrelevant input turns out however to be a rather complex task. Indeed, it requires a great deal of cortical "effort", focusing and vigilance. But how do we first decide what is relevant? What brain structure makes this decision?
- Active attention is modulated by a "central executive" (probably the frontal lobe). It is the central executive that decides what is relevant and how much cognitive capacity the task will require.
- A memory for the features (remember stimulus features if the section on Sensation & Perception) of what is relevant must be formed and stored in memory (presumably) in the working memory systems of the hippocampus).
- Incoming sensory messages are then compared to this memory to determine if they are relevant. If the features match, further processing is warranted. If they fail to match, further processing should cease (or be "inhibited"). Only relevant messages will thus be processed further.
- Active attention requires effort, concentration and vigilance. To be vigilant requires cortical *effort*.
- This is because working memory is maintained by *active, effortful* rehearsal.
- Because we must maintain effort (be "vigilant" and concentrate), if we are disturbed, we will

interrupt working memory. This results in what is called "distraction". Attention is distracted away from what is relevant.

- Fatigue. Active attention leads to cortical fatigue. If one is already tired, it is more difficult to remain attentive and to concentrate.
- Failure of selective attention: information overload
- Processing of ignored information. To what extent do we process information that was to be ignored? Does it attain full consciousness (i.e., are we aware of all the aspects of a stimulus?) If it does not attain full consciousness, does it attain partial consciousness? (Can the observer be aware of certain parts of the message but not other parts… Perhaps I might be conscious that an unattended sound was a male voice, that is was coming from my left but nothing else. I am not conscious of what was said, not even if the voice was speaking in English or French…)
- To what extent do we need to process the irrelevant to know it is indeed irrelevant?

Passive Attention

- A second method, passive attention, requires no effort.
- Rather, certain highly biologically relevant (or privileged) stimulus input will force the observer to…
- switch attention away from wh atever they were doing…
- and now attend to the processing of something that is much more relevant.
- Intrusion into consciousness
- This is called distraction
- Some researchers maintain that it is not just biologically relevant input (for example, a loud sound, or perhaps someone touching you) but also psychologically relevant information (perhaps your own name). This however remains disputed (and again, this is why we need the next generation of researchers…you!) to answer these controversies.

Two different types of theories have emerged to explain the waking attentional mechanism. Filter theory assumes that stimulus input is "filtered" into two different categories, the relevant and the irrelevant. Irrelevant must be inhibited (or "gated") somewhere in the brain from further processing. The structures of the brain that are responsible for the recognition of what is irrelevant and the subsequent inhibition of further processing have been much debated over the last 50 years. Capacity theory does not see the need to postulate the existence of filters. Rather capacity theories assume that what limits processing of stimulus input is the extent to which central processor's capacity has already been reached.

Filter Theory

- Filter theory: If irrelevant, ignored information is prevented attaining consciousness, processing must be inhibited ("filtered") somewhere in the brain.
- Cocktail party phenomenon. . D. Broadbent's "dichotic listening" task . A subject hears one message in the left ear and a different message in the right ear. The subject is asked to attend to one ear and ignore the message in the right ear.
- Manipulations: Many different aspects of the message can be manipulated. Nature of message; intensity; speed of presentation
- Again, to what extent can we process the unattended?

Capacity Theory

Capacity theory was developed by a group of psychologists including Daniel Kahneman, (Nobel Prize 2002 in Economics…yes Economics) regarded all cognitive processing as a "task" to be completed. Cognitive tasks make more or less demands on the limited "resources". Complex tasks make more demands on the limited capacity of the processing system than others than are less complex.

- We have a limited capacity to carry out cognitive tasks. This is because of
- Limited resources.
- A "central executive" must determine how these resources will be divided.

Controlled Processing

- Requires effort; uses processing resources.
- Processing of one task affects performance on another.
- Resources devoted to one task are not available to the processing of another task.
- *Serial processing*. In a strict serial task, the processing of a secondary task cannot begin until the processing of the first task has been completed.

Automatic Processing

- No effort; no utility of processing "resources"
- Several tasks can be carried out simultaneously
- Parallel processing
- Tasks that initially required considerable effort to complete can with practice become "effortless" or "automatic".

Automatic processing can conflict with controlled tasks

- when the processing of an automatic task interferes with the processing in another task
- If we could avoid processing the automatic task, performance would improve.
- Over considerable time, reading words become automatic.
- If the meaning of the word conflicts with what we are asked to do in another task, performance will deteriorate.
- Words in adults are named automatically
- Identify the colour of the following words (do not name the word!):

House
Door
Tiger
Sign
Eagle
Phone
Mloder
Country
Pencil

- Did you notice that one of the words was not a valid English word? How did you know this? Your task was to name the colour the word was printed it and not to name the word itself. But, you could not avoid naming the word because naming a word is an automatic process.

  The classic example of the interference caused by automatic processes is the Stroop task.In the Stroop task (named for the discoverer of the phenomenon, Stoop).The subject is printed with a list of words (colours)printed in different conditions:

  In one condition, the subject is asked to name the word (and ignore the colour in which the word is printed):

In the next condition, name the colour the in which the word is printed, but not the word. This is a much more difficult task. This is because you automatically also name the word and the name of the word conflicts with the colour.

Multitasking

- Multitasking and *Parallel processing:*
- Resources for carrying out controlled tasks are limited but…
- More than one task can be carried out simultaneously (i.e., in parallel) at no cost (i.e., detriment in performance on any of the tasks)…
- if sufficient resources are available.
- This is also called *divided attention*
- Often however, resources are not available.
- Then, the observer must decide which task to process
- The tasks are then carried out using *serial processing.*
- Note that the processing of one task must be *completed* before processing of the other begins.
- If the observer attempts true multitasking (i.e., parallel processing), there will be a cost.
- The observer might attempt to process one task and before finishing the task, switch to another, and then perhaps switch to yet another one. Again, this is not true multitasking
- Attention is paid to one task…
- and then quickly switched to another…
- (at which point performance on the first will deteriorate) and then attention is paid to a third task (at which point performance on the first and second will deteriorate).
- Why? An insufficient number of resources are being devoted to each task

Consciousness as a state (wake & sleep states)

- Sleep-wake states
- Conscious waking state
- Unconscious sleeping state
- What is sleep? How is sleep defined? Is sleep unique?
- Sleep in not unique.
- It consists of at least two divisions, NREM and REM?
- What is the purpose of sleep? What is the purpose of each?
- Sleep is rhythmic. What "clock" controls this?
- Do insects sleep? Do all animals sleep? Do all mammals sleep?

Recording Sleep in Humans

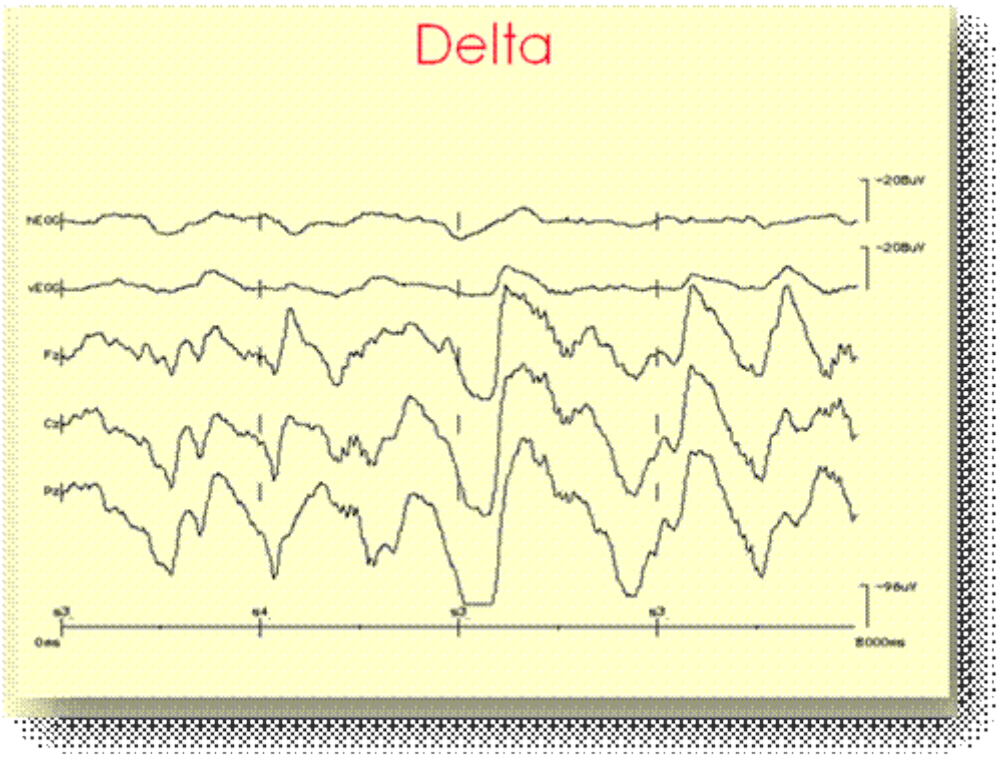
- electroencephalogram (EEG)
- electromyogram (EMG)
- electrooculogram (EOG)
- Other activity
    - Respiration
    - Heart beat/pressure
    - temperature

How does an experimenter know if a subject is conscious?

-
- Overt behaviour
    - Subject's signalled awareness
- Physiology
    - EEG
    - brain's response to stimuli (evoked potentials)

EEG Arousal

- beta (awake and alert) high frequency 15 Hz+, low amplitude EEG
- alpha (relaxed) 8 -12 Hz, rhythmic EEG
- theta (light sleep-drowsiness) 4-7 Hz EEG
- delta (deep sleep; coma) low frequency 1-4 Hz, high amplitude EEG

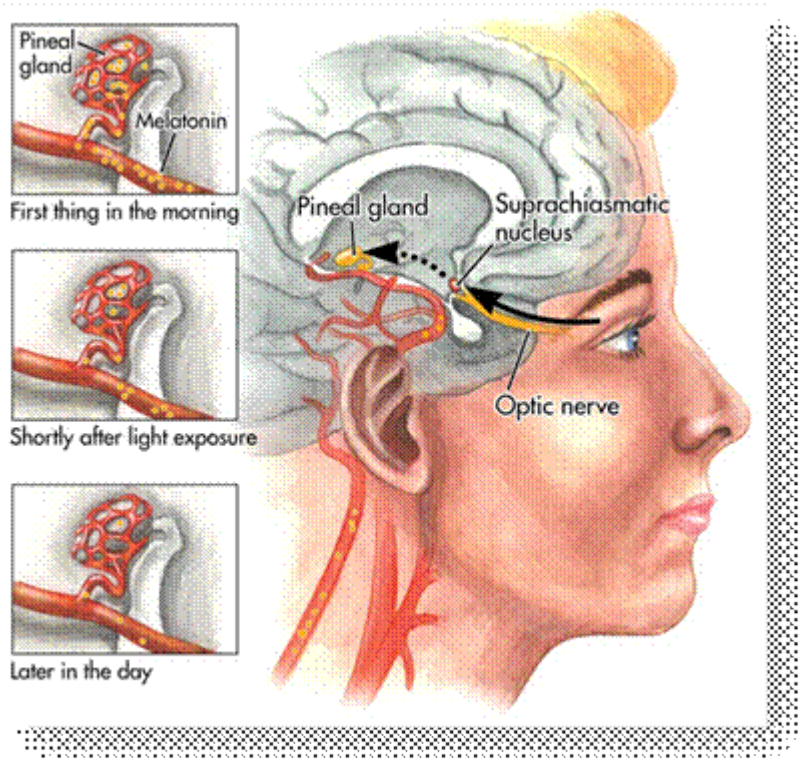


Biological Rhythms

- Circadian: every 24 hours (e.g., sleep-wake cycle)
- Ultradian: within 24 hours (e.g., eating cycle)
- Menstrual: (monthly cycle…more or less)
- Annual: (reproductive/mating cycles in many animals)
- In humans, sleep is a circadian rhythm
- The onset and offset of sleep is largely biological controlled by the detection of light-dark.

Suprachiasmatic nucleus & Pineal gland

- We normally sleep on a 24 hour schedule.
- This is regulated by the light-dark cycle.
- It is the suprachiasmatic nucleus (SCN) that detects lightness-darkness.The SCN is a group of nuclei in the inferior region of the hypothalamus, located immediately superior ("supra") to the optic chiasm (the place where the optic nerves crosses from the left to the right side and vice versa)
- The optic nerve sends information about light and darkness to the SCN. The SCN relays this information to the pineal gland, located superior (above) and posterior to the thalamus.
- The pineal gland is an endocrine gland and releases a hormone, melatonin
- Melatonin released upon detection of darkness.
- Melatonin is responsible for the "feeling" of fatigue/sleepiness



What is the effect of constant lightness/darkness?

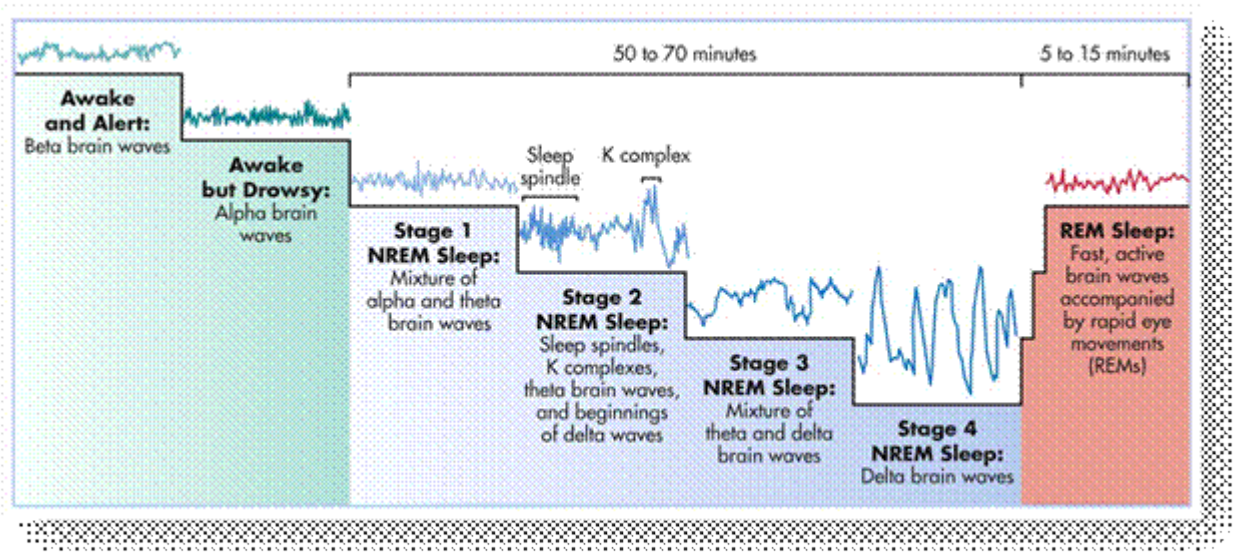
- What happens if the optic nerve is severed prior to SCN. The animal is now in constant darkness and because it no longer receives cues about the 24 light/darkness cycle, a new sleep-wake cycle develops.
- This cycle last about 25 hours in humans. The individual goes to sleep about an hour each day, for example at 23:00 one day, 00:00 the next day,)01:00 the day after, then 02:00 and so forth. Note that there is still a cycle but it is a 25 hour cycle.
- What happens if the optic track after the thalamus is severed (thalamo-cortical track)? Ligt-

darkness cues are still detected by the SCN. Thus, the sleep-wake cycle is 24 hours

- What happens if the suprachiasmatic nucleus is destroyed?

Stages of sleep

- Awake
- Stage 1
- Stage 2
- Stage 3-4 (Slow Wave Sleep or SWS)
- REM
- Stages 2, 3 and 4 are often combined to form non-REM (or NREM) sleep



Waking State

- EEG shows fast frequency, low amplitude (beta, maybe alpha)
- Subject is "conscious" and is aware of their environment.
- Most young adults spend about 16 hours awake.

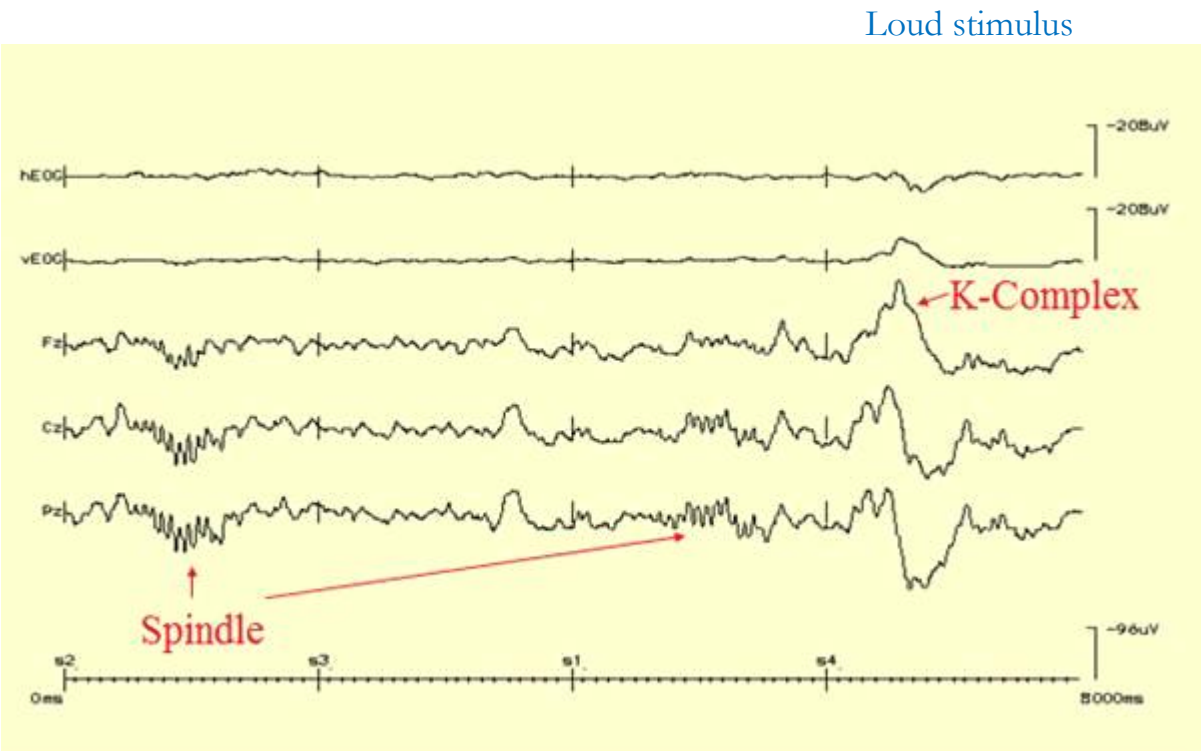
Stage 1 "Sleep"

- Brief period during the transition from a waking to sleeping state.
- EEG slows (less than 50% alpha)
- loss of muscle tonus
- EOG shows slow rolling movements
- hypnogogic reverie
- Subject begins to lose conscious awareness of external environment

Stage 2 Sleep

- EEG shows slower frequencies (theta, delta)
- presence of spindles and K-Complexes (also in stages 3&4)
- EMG lower
- very little conscious awareness of the external environment
- subject is definitely asleep

- occupies about 1/2 of our total sleep evenly distributed throughout the night



Stages 3 and 4 (Slow Wave Sleep, SWS)

- Stages 3 and 4 are usually grouped together
- EEG shows mainly slow frequency (1-3 Hz) high amplitude delta waves.
- EMG tonus very low
- very deep sleep
- subject may show no conscious awareness of external environment
- occupies about 25% of our total sleep
- Mainly occurs in the first half of the night
- Biological need for stages 3 & 4.

Non-REM (NREM) Sleep

- Stages 2, 3 and 4 show theta and delta EEG. Stage 2 has less delta and more theta while stage 4 has more delta and less theta.
- Period of profound unconsciousness?
- Loss of frontal lobe control?
- Sleep spindles; inhibitor of processing of external stimulus input.
- The K-Complex;? A means to detect stimuli during the night? Or a sleep protector?
- Night terrors; sleep walking (but sleeper is unconscious!) within stage 4

How does sleep develop over the night?

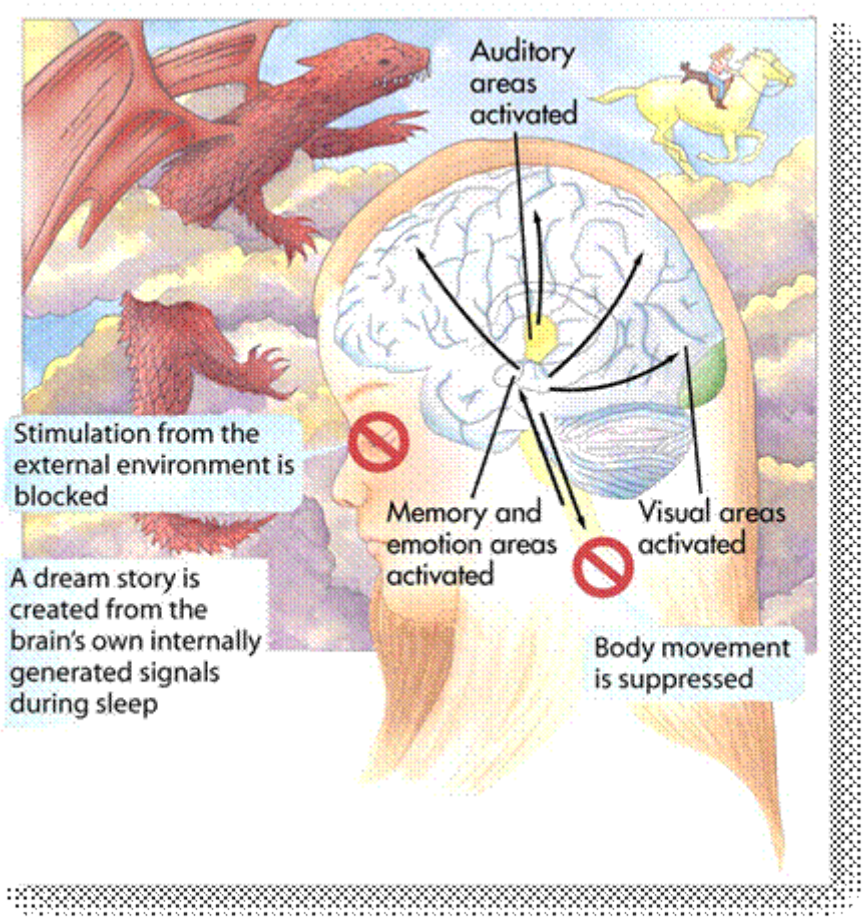
- 90 minute REM cycles
- REM lengthens with each cycle
- 75% of stage 3+4 spent in first half of the night.
- 75% of REM spent in the last half of the night
- Stage 2 develops evenly over the night (50% in 1st; 50% in 2nd half)

REM Sleep

- Aroused EEG (like stage 1 or Waking)
- But subject is very difficult to awaken (thus name "paradoxical sleep")
- 90 min cycle
- Most of stage REM at the end of the night
- Muscle inhibition (but not total)
- Rapid eye movements
    - Dreaming
    - Absence of frontal lobe functions
    - Period of profound unconsciousness?
    - However, lucid dreamers can signal they are dreaming. Moreover, an experimenter can influence the content of their dreams.
    - Inhibition of autonomic nervous system. Heart rate might be very fast or very slow. Respiration might be very fast or very slow; respiration may stop altogether. Temperature may rise or fall dangerously.

REM & Dreams

- Purpose of dreams?
- *Release of repressed desires/drives from the unconscious (Freud).*
- The actual content of the dream (its "manifest" content) is symbolic of our true (but repressed) desires (the "latent" content).
- Few psychologists (or psychiatrists) currently agree with the Freudian theory of dreams.
- One of the most opposed to Freudian theory is a neuropsychiatrist, Alan Hobson.
- *Activation-synthesis theory (Hobson).* See Figure below.

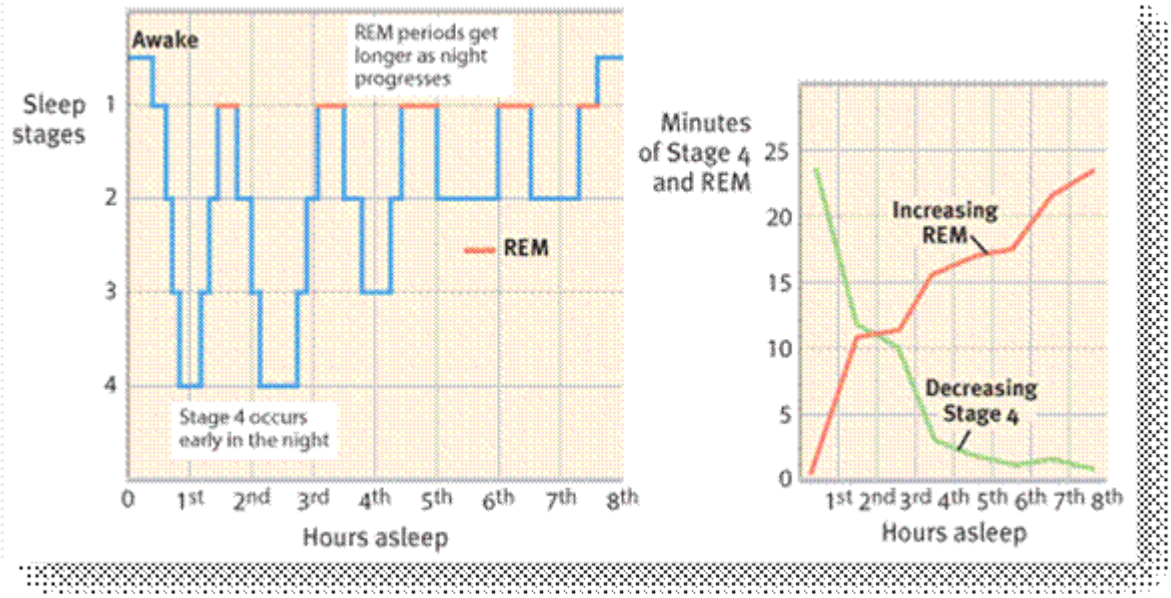


Role/function of REM? NREM?

- How does sleep develop over the night? Why is this relevant?
- Which develops first in humans? Why is this relevant?
- Which therefore is oldest? Which is most "primitive"?
- Is the role consistent with when each appears in evolution?
- Should evolutionary old animals (reptiles, amphibian, fish) have more REM or NREM? Do they need to sleep at all?
- Brain structures involved in each?
- Manipulation of amount of sleep. Effect of sleep deprivation?

Development of sleep over the night in humans

- 4 hours spent in stage 2. Half of stage 2 in the first half of the night.
- 2 hours spent in stage 3+4. Most of this is in the first half of the night. Biological drive for SWS
- 2 hours spent in stage REM. Most of this in the last half of the night.



How does sleep develop in humans?

- In young adult, 50% of sleep is spent in stage 2; 25% in stage 3-4; 25% in REM
- REM accounts for about 50% newborn's sleep and even more in premature infant. REM rapidly declines in % after birth. Reaches adult levels at 8-10 years of age
- Stage 3-4 ("delta") declines in elderly.

Phylogenetic development (development across species)

- Considerably more REM sleep in human infants than in adults
- Recapitulation theory: Ontogeny recapitulates (mimics) phylogeny.
- Therefore, one would expect REM to evolve first and to see it in the most "primitive" animals
- Unfortunately, it is not quite as simple as this. Sleep is also affected by many other evolutionary survival strategies. For example, the extent to which one is a prey or a predatory will also affect sleep. It is not a good idea to be frequently sleeping if one is being hunted. Thus, herding animals will not have the luxury of long sleep periods. But, a lion can. The metabolic rate (the rate at which energy is consumed at rest) will also affect sleep. If the metabolic rate is very high, the animal must almost constantly be seeking food, to replace the energy being burned. A number of small rodents seem to be constantly active seeking food. Sleep might be the only way for them to conserve energy and "recover". On the other hand, many larger herding animals (e.g., cows) have a very low metabolic rate. They are thus burning energy. The need for sleep to recover this lost energy is thus greatly diminished.
- Also, sleep is multifaceted. An animal might show the evolution of certain aspects of sleep (for example, an aroused EEG during REM) but not other aspects (absence of rapid eye movements during REM sleep). Thus, the animal might show an aroused EEG but few eye movements during REM. Is this still REM sleep? And in fact, how would we know the animal is sleeping at all? An aroused EEG is also characteristic of the waking state. Thus, what decision would the scientist make if it encountered an animal that showed only an aroused EEG and no eye movement for an entire 24 hour period? Does the animal sleep at all? Or, is the animal awake for a period of time and then it enters REM sleep, but without eye movements, for a period of time.
- Sleep is also associate with changes in motor activity, cortical arousal, eye movements, muscle atonia, changes in autonomic systems, temperature changes. It is possible to show certain changes but not others.

- Temperature/autonomic changes not incidental (e.g. warm/cold-blooded division). Temperature must be maintained at a certain minimal in warm-blooded animals. Temperature declines during sleep (as does the temperature in the environment at night). If the temperature declines too much, the animal must awaken. This is not a problem for the cold-blooded animals.

Sleep for conservation of energy

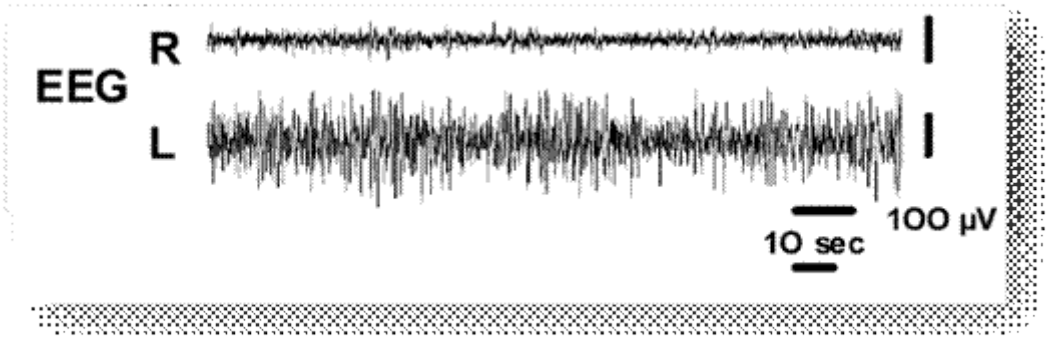
- Smallest animals have the highest metabolic rate (i.e. energy consumption per kg body weight):
- Small shrew eats its body weight each day. These animals are basically eating the entire time they awake. An elephant eats $1/20^{th}$ of its own weight each day.
- Animals with high metabolism have longest total sleep time (TST). These animals must eat just to replace the energy they are burning to gather food, in order to eat (A rather strange evolutionary option). . At the very least, sleep conserves energy.
- Thus, the ground squirrel and little brown bat sleep 16.6 and 19.9 hrs while…
- large animals such as the elephant and giraffe sleep 3.3-3.9 and 4.6 hours, respectively.

Predators/prey

- Predators have the luxury of being able to enjoy long hours of sleep, especially REM sleep
- Preys enjoy less REM sleep (recall that arousal thresholds are high during REM)
- Large herbivores such as the giraffe have a slow metabolic rate and thus have little SWS. They will also have little REM if they are hunted. Thus, reduced SWS and REM.
- Large animals who are predators, such as a lion or tiger, will have more sleep.

Mammals

- Mammals need to maintain a constant temperature.
- Mammals need to breathe.
- Sea mammals who are constantly at sea (for example, dolphins and whales; sea lions often sleep ashore) have a problem. If they sleep, they will experience muscle inhibition and will thus sink. If they sink below a certain critical level, the temperature of the ocean will fall below a level at which the animal can maintain a constant temperature. These animals also need to surface periodically to breathe or they will drown.
- Sea mammals have evolved a unique solution. One hemisphere sleeps but the other hemisphere is awake. Then, the process is reversed. In the upper image, the right hemisphere shows high amplitude SWS but the left hemisphere shows low amplitude wakefulness. Sometime later, this changes. The right hemisphere is now awake and the left hemisphere enters SWS.



Effects of total sleep deprivation

A means to experimentally determine the purpose of a basic need (eating, drinking, sex) is to deprive the organism of the need. If an animal is deprived of food or water, it will eventually die. If the animal is deprived of sex, it will not die (although the species may become extinct). If an animal is deprived of sleep for a long enough period, will the consequences be similar to those of food and water deprivation or will the consequences be similar to those of sex deprivation?

- Humans have been able to tolerate several days without sleep (and in rare cases more than 2 weeks!).
- Major effect: sleepiness; irritability. But fatigue is not uniform throughout the day.
- Frontal lobe functioning. It appears that tasks that are modulated by the frontal lobes are especially affected by total sleep deprivation. Attention (dependent on the executive functions of the frontal lobe) is difficult to maintain. Effortful processing (dependent on central executive resources) is difficult. Logic and the ability to plan and sequence is affected. The frontal lobes also control the emotions. Thus emotional display may be inappropriate. Individuals may act inappropriately.
- Animals kept awake will develop sores on their body and matting of fur.
- After a few weeks, they will die.
- Role of the immune system. It appears that the immune system is active in NREM sleep.
- Thus, individuals who are sleep deprived are at risk from infectious diseases. Those who are already ill will have difficulty fighting the disease.

REM sleep deprivation

- It is not possible to selectively deprive the sleeper of only NREM sleep.
- However, it is possible to deprive the sleeper only of REM. Every time the sleeper enters, REM, they are wakened. If they enter NREM (and they almost always do), they are permitted to sleep. But as soon as they enter REM, they are again wakened.
- Consequences?
- REM rebound. REM is normally on a 90 min cycle. Following, REM deprivation, the sleeper enters REM more rapidly. They enter REM earlier in the night. Importantly, the overall quantity of REM increases over the night.
- Many CNS depressants will cause moderate to severe loss of REM. Upon withdrawal from the medication, there are symptoms of REM rebound. There is more REM and it occurs earlier. Withdrawal even affects the nature of dreams associated with REM. They are often prolonged and intense and can appear with nightmares. During the day, withdrawal from long-term use (addiction) of certain CNS depressants (most notably alcohol) may be associated with frightful delirium tremours (DTs)
- Deterioration of performance on tasks learned the previous day (especially if the task requires frontal lobe involvement).
- REM might thus be associated with the storage of memories for the day's events.

Purpose of NREM sleep.

- Evolution - sleep protects animals from predators.
- First half of the night's sleep is spent in NREM sleep
- Recovery from day's activities. Regeneration of cells.
- The Figure displays the sleep of individuals for 4 days after having run a marathon (about 42 km). The control night represents the sleep prior to the marathon. A large increase in the amount of deep sleep (stages 3&4) is apparent on the first 2 nights after the marathon and to a lesser extent on nights 3 and 4.
- NREM sleep deprivation... animals become very ill and eventually die.

- *Immune system is especially active during NREM.*
- Release of growth hormone during NREM (for growth but also for cell repair)
- The elderly, who are less active than the younger adult have less stage 3+4.
- *Restorative function of NREM sleep*
- Perhaps a role in declarative memories *(*memories which can be consciously recalled such as facts and events).

Purpose of REM sleep.

- REM occurs at the end of the night. It thus seems to be a biologically luxury. If sleep is prolonged, then the sleeper will enter REM.
- It is not a biological necessity, whereas SWS does seem to be a biological necessity.
- information storage (memory)
  - Infants and young children have more REM than adults
  - Occurs mostly in 2nd half of the night (i.e., is not a biological necessity)
  - A number of studies have indicated that intense learning is associated with an increase in the amount of REM
  - REM deprivation will affect performance on tasks that have been previously learned, particularly those that involve procedural learning.

Cleanup of irrelevant material (Crick & Mitchison)

Learning

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Association

- All learning involves the formation of association between two formerly unrelated events.
- In this section of the course, we shall study two major types of learning, classical conditioning and operant conditioning.
- In classical conditioning, the association between two stimuli is learned.
- In operant conditioning, the association between a response to a stimulus and a subsequent consequence is learned

Habituation

- Upon repetition of the stimulus, the response to the stimulus becomes smaller and gradually decreases altogether. This process is called *habituation*.
- It is possible that the initial presentation of a stimulus was consciously detected. The observer became "aware" of the stimulus. With repetition of the stimulus, suddenly the observer is no longer conscious of it.
- Why was the observer aware of the stimulus initially but no longer is? The nervous system thus shows flexibility of responding.
- A memory for the stimulus has formed! With repetition of stimulus input, a memory for its features is formed. Psychologists call this memory a sensory "representation".
- The incoming sensory stimulus is compared to the model of that stimulus that exists in memory (the representation).
- If the sensory stimulus matches the memory, processing in the nervous system ceases. There is no need for the subject to continue to respond. The nervous system is specialized to detect *change*.
- This is perhaps the simplest form of learning. A change has occurred in the nervous system! It can occur in very simple invertebrates having fewer than 100 neurons (example: slugs, snails)
- Contrast this with sensory adaptation.

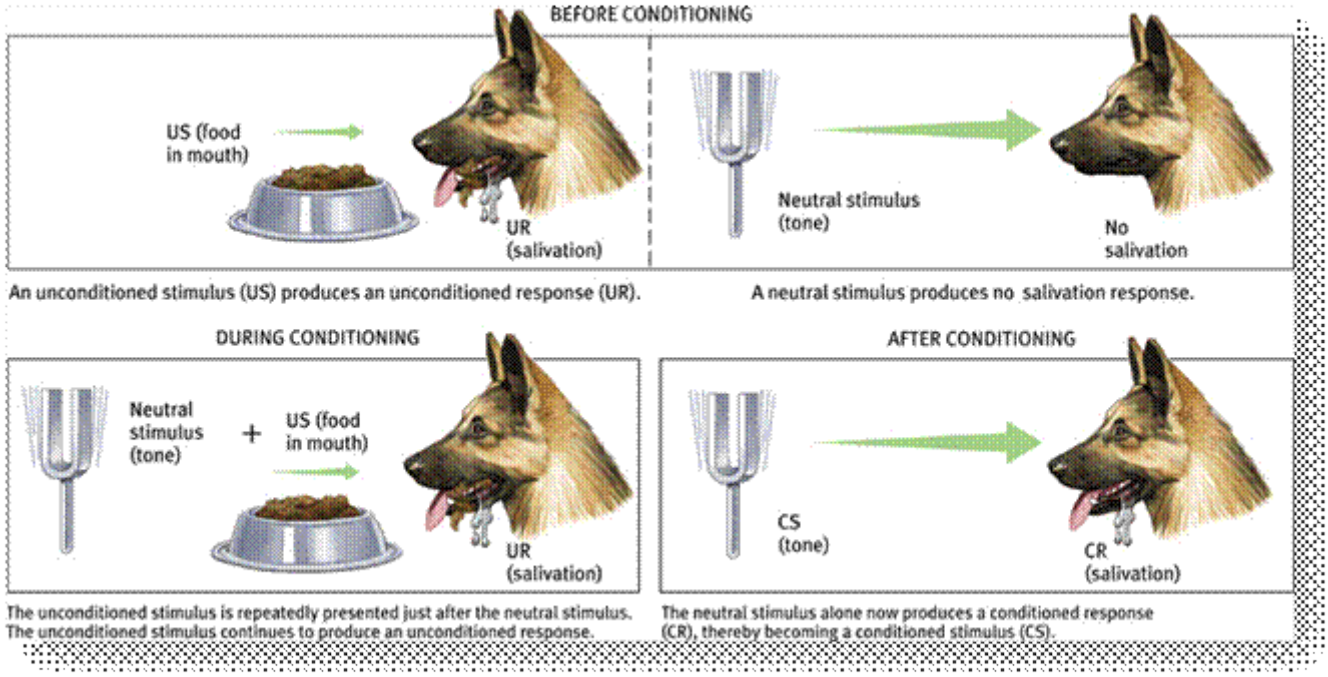
Classical Conditioning

- Principles first discovered by I. Pavlov in Leningrad in the USSR (now St. Petersburg, in Russia) in the early 1920s (note the historical and political implications!). You should be familiar with the following concepts:
- Unconditioned, Conditioned Stimulus (UCS, CS)
- Unconditioned, Conditioned Responses (UCR, CR)
- Acquisition
- Stimulus generalization; Stimulus discrimination
- Extinction; Spontaneous recovery
- Higher order conditioning

Learning & Classical Conditioning

- Unconditioned stimulus (UCS) triggers the unconditioned reflex (UCR). An electric shock (UCS) will cause a startle reflex (UCR) in humans.
- If a formerly neutral stimulus (one that did not previously trigger the UCR) is repeatedly paired with the UCS, the UCR is still triggered.
- Soon, the neutral stimulus alone will produce the response. In short, the neutral stimulus which never previously elicited the UCR now does so.

• Because the neutral stimulus has become associated with UCS, it is called the conditioned stimulus (CS). The CS produces the same, identical response as the UCS. However, because this response has been elicited following conditioning, it is called the conditioned response (CR).



Implications

• The conditioned response is the critical path to higher learning.
• A response to a stimulus that did not occur in the nervous system (the CR) now occurs. Why?
• Because of conditioning, new memories are formed. This series of steps is called *learning*.
• Somehow, the nervous system has been altered. Something in the nervous system has changed. Our responses to the external world are no longer genetically determined. We show flexibility of behaviour!
• This is the route to higher learning. Almost all neuroscientists agree that the way learning takes place in simple creatures is probably identical to the way that very complex creatures (such as humans) learn complex behaviours.
•

Acquisition (Learning Curve)

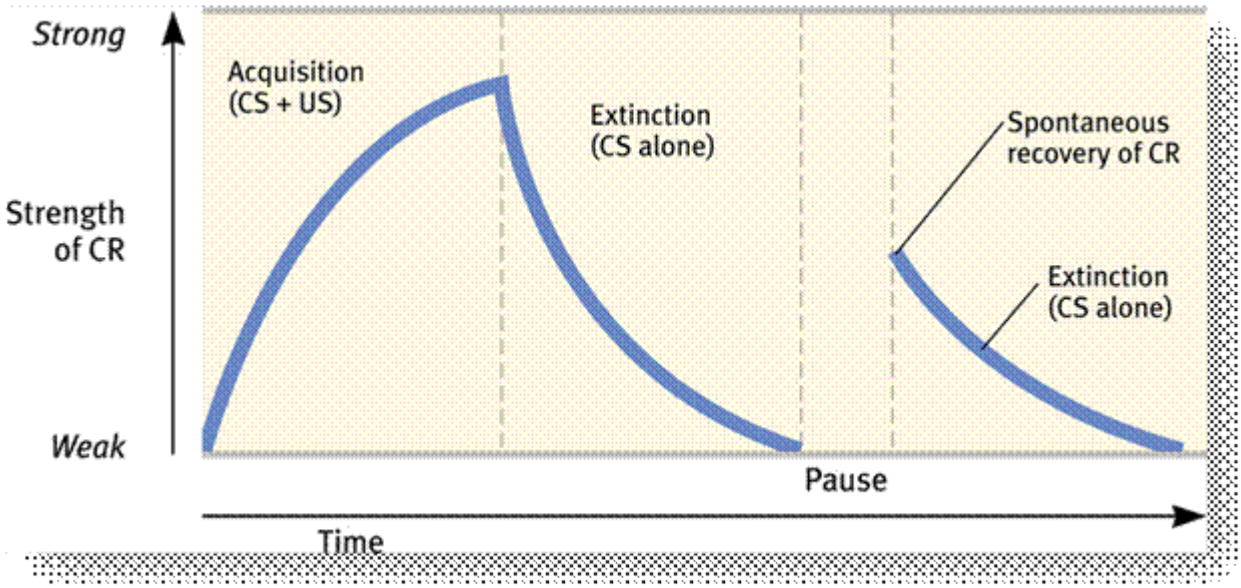
• Any learning takes time.
• The CR only occurs after a number of repetitions of the UCS-CS pairing.
• The acquisition of learning can be traced as a *learning curve*.

Extinction

• Remove UCS. Results: CR will gradually diminish. This process is called *extinction*.
• Over time, the CR will gradually fade away.

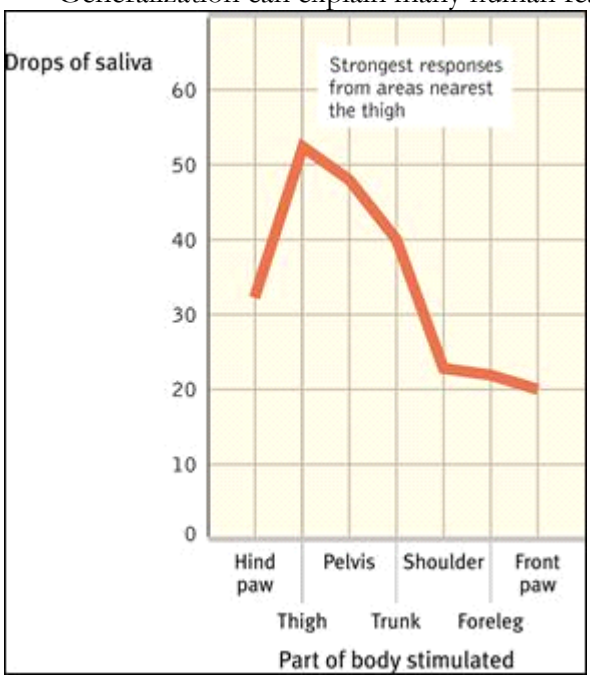
Spontaneous recovery

• After extinction and after some delay, CS (in absence of UCS) will elicit CR for a brief period of time. This CR rapidly extinguishes.



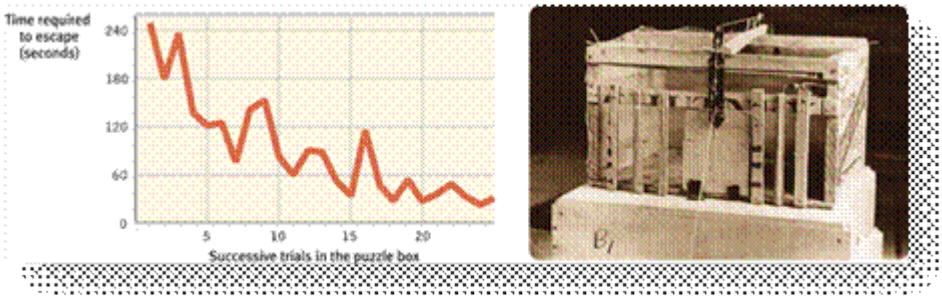
Generalization

- Following conditioning, other stimuli similar to the CS will also elicit the CR. The closer the new stimulus resembles the original CS, the greater the CR.
- Generalization can explain many human fears and phobia.



- In humans, because of generalization, to remove an inappropriate response, a complete "life style" may need to be changed.
- In the example on the right, an animal salivates (the UCR) when presented with food (the UCS). Now the animal is shocked (or perhaps touched) on the thigh. This does not elicit the UCR, salivation. After the food and the shock have been paired for a number of trials, soon the shock (now the CS) elicits the CS, salivation. However, shocking other parts of the body will also elicit the CR. This is called generalization. The CR has generalized to the stimulation of any body part. The strength of this CR will however not be as strong as the shock to the original body part, the thigh. The CR will be weakest the farther the body part is from the thigh.

Operant conditioning



- The school of psychology known as operant conditioning (later to become behaviourism) was founded by J. Watson. Over a period of almost 50 years, B.F. Skinner carried out extensive experimentation on the principles of operant conditioning.
- Strict operational definitions and observation of …
- Stimulus (S), Response (R) and the Consequences of Responding. In short, because psychology is a science, it should (like other sciences) studies only what can be observed. A stimulus, a subsequent response and the consequences of responding can all be observed. What is observed is behavior. Thus, Skinner (and many, many others) soon came to call psychology, the science of the study of behavior. In others words, psychologists should study why we act (or why we "behave") the way we do. But, this does not mean we should be speculating about hidden inner motives (as psychoanalysis had done).
- *If an organism continues to respond to a stimulus, there is a reason -- it is because it has been reinforced.* Note again, there is no need to speculate about hidden, repressed motives.
- The association between the response and the subsequent consequence has been conditioned.
- Again, if the organism responds, there is a reason. The organism has previously learned that if it responds, there will be a consequence of responding.
- Skinner Box. A highly controlled environment in which all aspects of behaviour are controlled.
- The dependent measure in any operant conditioning study is the rate of responding.
- Prior to conditioning what is the "baseline" rate of responding? Does rate of responding increase following learning? If the rate of responding does increase, the behaviourist can say why.
- What is the rate of responding before learning (i.e., when the stimulus is initially presented, how often does a response occur)?
- Shaping. The organism will normally not respond appropriately on the very first trial. The appropriate behavior (the response) has to be "shaped". Thus, successive approximations of the appropriate response are provided. Let us assume a behaviourist wants to have a rat push on a lever when a light is flashed. In the end, it will be reinforced (delivery of food) only when it pushes on the lever. However, initially, if the rat turns and looks at the light, a reinforcer will be delivered. Subsequently, it will not be enough to simply look at the light. Now the rat must approach the lever. If it does, it will be reinforced. Then, when it raises its paw, it will be reinforced, but only if the rat is in front of the lever. Finally, the rat will be reinforced only when it pushes on the lever and only when it pushes on the lever after the light is flashed.
- Stimulus(S)-Response(R)-Reinforcement (Contingent reinforcer…Cr).

In the example above, a seal is being conditioned to balance a ball on its nose. Seals do not do this behavior naturally. The animal's behavior needs to be shaped (more about this later) and when it does balance the ball, a reinforcer (food in this case) is delivered. The animal repeats behavior that is reinforced.

- Organism *learns* the association between S and R and that if it responds, it will be reinforced.
- Following learning, the rate of responding increases dramatically.

- Note that in classical condition the association that is formed is between two stimuli (the UCS and the CS). In operant conditioning, the association is quite different; it is between a response and the subsequent consequences of responding (whether the organism is reinforced or not).

Implications

- No need for speculating about inner mental events or "motives" that might have caused the organism to respond.
- Psychology as a strict science! Psychologists should only describe that which they can observe.
- We can only observe overt behaviour. This branch of psychology is therefore called behaviourism.

THE Principle of Operant Conditioning

- *Reinforcement is contingent on the organism's responding correctly. If the organism does not, it does not get reinforced!*

Types of reinforcers

- Anything that increases the rate of responding is called a reinforcer. Note the somewhat circular logic. How does one know if something will act as a reinforcer? If the rate of responding increases.
- Two types of reinforcers: positive and negative. *All* reinforcers result in behaviour being repeated.
- Positive reinforcement. Positive reinforcers are delivered *following* an *appropriate* response (example, food, water, sex, a salary, a pat on the back). Note that if the organism does not respond appropriately, no reinforce is delivered.
- Negative reinforcement. Negative reinforcers remove the organism from an aversive situation. A rat is continually shocked. It soon learns to push on a bar to turn off the shock. The removal of the shock following the appropriate response acts as a reinforcer. Note: a negative reinforcer is not the same thing as punishment. Punishment (in theory) should remove a behaviour. A negative reinforcer should cause the behaviour to be maintained. The purpose of punishment is to remove an inaapropriate response. A negative reinforce will cause the response to be repeated.
- Primary and secondary reinforcers. *Primary* reinforcers satisfy basic needs (food, water, sex). *Secondary* reinforcers allow us to obtain the primary reinforcer. Money acts as a powerful secondary reinforcer in humans. Advertisement on television tries to convince you that their

product will lead you to the primary reinforcer. Advertisement leads us to believe that men who drive fast cars and drink lots of beer will meet more women. Women who are unhealthily underweight and wear the latest fashion products will meet more men. In both cases, the secondary reinforcer leads to the primary reinforcer (sex).

Schedules of Reinforcement

- Normally, a reinforcer is not delivered on every trial. *Schedules of reinforcement* tell us when a reinforcer is delivered.
- These are either *fixed* (occur at predictable times) or *variable* (occur at unpredictable, random times).
- The reinforcer can be on a *ratio* schedule (it occurs after a certain number of appropriate responses) or on an *interval* schedule (occurs after a certain amount of time has passed).
- Thus, there might be a fixed ratio, fixed interval, variable ratio or variable interval schedule of reinforcement.
- The variable ratio and variable interval schedules are particularly powerful. They result in a very high rate of responding because the organism never knows when the reinforcer will actually be delivered. But, the organism does know that the reinforcer will only be delivered if it responds. Thus, it responds very frequently, but is reinforced very infrequently and unpredictably.

Extinction

- Responses (whether appropriate or inappropriate) occur because of the consequences of prior responding. The response has been reinforced.
- To remove a response, identify what is acting as a reinforce and then, remove the reinforcer.
- Over time, this will result in extinction of the response. The response should no longer occur.
- However, extinction can take a very long period of time. (Which reinforcement schedule would be most difficult to extinguish?)
- A father takes his child to the grocery store. The child wants him to buy a candy. The father always says "No". Each time, the child whines and finally starts screaming and yelling. The father then gives in to calm the child and ease his own embarrassment (what sort of parent would allow his child to scream, yell, cry, kick in a public place?). What has the father just done? Why will the behaviour now be so difficult to extinguish?
- Why are drug addictions difficult to extinguish? Why is it so difficult to "give up" (extinguish) smoking?

Removal of inappropriate responses

- Not all responses are appropriate. Example: children acting up in class.
    - Problem: Why are the children acting up?
    - Answer: Something must be maintaining the response. All responses are maintained by reinforcers.
- Solution: According to behaviourists… to remove an inappropriate response, identify the reinforcer and then eliminate it. Do not reinforce.
- The inappropriate response should then gradually extinguish.
- Of course, if it is rarely reinforced (i.e., if a variable schedule of reinforcement is employed), the response will be extremely difficult to remove.
- This is why schedules of reinforcement must be very consistent. Giving in to the whining child on only extremely rare occasions is counterproductive. It will result in a massive increase in the inappropriate response because a variable schedule of positive reinforcement is now being employed.

Punishment

- An alternative to extinction is *punishment*
- Definition: An inappropriate response is followed by punishment.
- The general, popular view of punishment is that it should weaken or eliminate R. It should result in extinction! In reality, this is not the case.
- Skinnerian (operant) theory: To remove the R, remove the reinforcer. This should then result in extinction of the R.
- Alternatively reinforce appropriate behaviour.

Disadvantages of Punishment

- Effects are not predictable. Alternative Rs are not provided. Appropriate R is not provided.
- What may be learned is how to avoid the punishment.
- Because effects are not predictable, secondary effects of punishment may appear: fear, dislike. Individual may stop responding altogether. Or individual may continue to have the identical response but outside of the punishing situation. The inappropriate response may occur elsewhere.
- The individual may learn that punishment is acceptable and thus learn that what is appropriate is to act aggressively toward those who are less powerful.
- Is punishment *ever* appropriate? Rarely. It can be used to remove a very undesirable and behaviour that threatens the safety of an individual. Although alternative behaviours are not provided, at least the very bad behaviour will stop. Mary does not look both ways before crossing a street.

Avoidance

- Animal learns to avoid an aversive situation.
- Example: A child goes to the dentist. The child experiences pain.
- *The avoidance of the aversive situation is reinforcing*.
- As soon as the child leaves ("escapes"), the dentist's office, the pain ceases. The child soon learns to avoid the pain.
- It is extremely difficult to extinguish avoidance learning.
- Not going to the dentist strengthens ("reinforces") the "no pain" association. Not going to the dentists acts as a negative reinforcer. Avoidance is repeated.

Observational Learning

- Some learning appears to take place by observation and imitation, in the absence of apparent reinforcement.
- Such observational learning is called *modelling*.
- Bandura's experiments in the 1960s demonstrated that children will imitate the behaviour of adults. In one experiment (Bobo doll), children would imitate the aggressive behaviour displayed by adults. Aggression is thus not only an inherited behaviour.
- Modern media (especially) television overly exposes aggression and violence, especially in children's programmes. Children imitate their television heros.
- The more television children watch, the more aggressive the tend to be.
- Incidence of violence has increased sharply with the introduction of violence in television.
- But recall that correlation is not causation!

Section One: Prologue

September-14-10
8:16 PM

When and how did psychology begin?

- 1879 Wilheim Wundt first psychology laboratory
- *Structuralism vs. Functionalism*
    - An introspection to explore the structural elements of the human mind
    - Focuses on how our mental and behavioural processes function

Psychology is the science of behaviour and mental processes

- Behaviour is anything an organism does
- Mental processes are the internal subjective experience we infer from behaviour

Psychological Science Develops

- S. Freud develops the idea of Magellans of the Mind - cross cultural figures that permeate all human conciouses
- *Behaviourists* - the scientific study of behaviour, because true science is based on observation
- *Humanistic psychology* - Rogers and Maslow emphasized the influence of current enivonrment on our behaviour (i.e. Social belonging etc.)
- *Cognitive psychology*- the important of how our mind processes information
- *Cognitive neuroscience* - the study of brain activity linked with mental acitivity
    - Expanded on these idea to explore brain processes via technology and inferring

Psychology's Biggest Question

- Nature-nurture issue - the controversy over the relative contributions of biology and experience
    - Are we born with traits or do we acquire them
- Originally debated by philosophers (Locke and Descartes) eventually became the domain of psychology
- However the concept of innate ideas raised by Descartes were seconded by Darwin
- Darwin's theory of **natural selection** (survival of the fittest) suggested that some ideas are ingrained in our psyche

NATURE WORKS ON WHAT NATURE ENDOWS

- Every psychological event is simultaneously a biological event

Biopsychosocial Approach

- Considers the influences of biological, social and psychological factors
- These levels are dependent on each other
    - Each level of psychology reveals some of the picture but each by itself fails to reveal the whole picture

Psychology's Subfields

- Biological - links between the mind and body
- Developmental - studying our mind state from womb to tomb
- Cognitive - experimenting with how we perceive and think about problems/issues
- Personality
- Social

Section One: Chapter 1

September-15-10
1:05 AM

- **Hindsight Bias** - finding that something has happened makes it inevitable
- **Critical thinking** - examines assumptions. Discerns hidden values, evaluates evidence and asses conclusions
- **The Scientific Method**
  - A **theory** explains through an integrated set of principles that organizes observations and provides the basis for predictions
  - A good theory provides testable predictions called **hypotheses**
  - **Operational definitions** - definitions of procedures and concepts for the purposes of an experiment
    - These definitions are created in an effort to allow others to replicate the experimental results
  - Theories are useful if they...
    i. Organize a range of self-reports and observations
    ii. Implies clear prediction that anyone can use to attempt to replicate
  - *Descriptive methods* describe behaviour citing studies and surveys versus *correlational methods* which associate different factors versus *experimental methods* which manipulate factors
- **Case Study -** Examines one individual in-depth in hopes of revealing things true of us all
  - Show us what can happen and suggest directions for further study
- **Survey** - looks at many cases in depth by asking a sample of people to answer questions
  - Wording effects and random sampling are techniques used in surveying
  - The best basis for generalizing is from a representative from a sample of cases
- **Naturalistic observation** - records behaviour in natural environments
  - As opposed to explaining behaviour it attempts to describe it
- **Correlation** - when two traits are related to each other they correlate
  - Coefficent of correlation helps us figure how tight this correlation is
  - Correlation does not always mean causation, it indicates the possibility of a relationship
  - *Illlusory correlations* - when we notice random correlations we may forget that they are random and perceive them as correlated
- **Experimentation**
  - Allows the researcher to focus on the effects of two or more effects by
    - Manipulating the factors of interest
    - Holding constant the other factors
  - **Random assignment** - allowing chance to dictate which group a subject falls into in the experiment
  - **Double blind procedure** - neither the participants nor the research assistants are aware of which group is receiving the treatment
  - **Placebo effect** - a fake treatment that attempts to document the effects of 'treatment' on a patient
  - *Experimental group* in which patients receive treatment versus *control group* in which patients do not receive any treatment
  - *Independent variables* which cannot be changed versus *dependent variables* which can be changed for the purposes of the experiment
- **Describing Data - measures of central tendency**
  - **A single score that represent a whole set of scores**
    - Mode the most frequently occurring score or scores
    - Mean the average of all scores
    - The median is the mid point, the 50th percentile
- **Measures of Variation**
  - **Range -** the gap between the lowest and the high scores
  - **Standard deviation** - gauges whether scores are packed together or dispersed, uses information from each score

$$\sqrt{\frac{\Sigma(X - \bar{X})^2}{(n - 1)}}$$

where:

X = each score
$\bar{X}$ = the mean or average
n = the number of values
Σ means we sum across the values

    - A bell shaped distribution is so typical we call it the **normal curve**
- **When is an Observed Difference Reliable?**
    - Representative samples are better than biased samples
    - Less-variable observations are more reliable than those that are more variable
    - More cases are better than fewer
- **A difference is statistically signifcant when the sample averages are reliable, and when the difference between them is relatively large**
    - Psychologists are generally conservative a reasonable doubt means less than an arbitrary 5%

Section Two

September-28-10

Chapter 2 - The Biology of Mind

- Biological psychologists : study the links between biological activity and psychological activity.
- We are systems composed of smaller and smaller systems)
- The body's information system is made up of neurons

Neural Communication

Building blocks = Neurons (nerve cells)

1. Sensory Neurons carry messages FROM body's tissues and sensory organs inward TO brain and spinal cord (for processing)
2. The brain and spinal cord send instructions TO body's tissue by motor neurons.
3. Between sensory input and motor output info is processed in the brain's internal communication system BY interneurons.

- Bushy dendrite fibres (Listener) receive info and send info to cell body. THEN, the cell's axon (Talker) passes the message along to neuron or muscles or glands.
    - Dendrites are short
    - Axon's are very long (sometimes several ft.)
- MYELIN SHEATH that insulates axons of some neurons and helps speed their impulses. it is lipid material, protects the axon.
- Action Potential is a brief electrical charge that travels down the axon.
    - Neurons generate electricity from chemical evens. (just like batteries)
    - The chemistry to electricity process involves the exchange of ions.
- Ions are electrically charged atoms.
    - The interior fluid of the axon is negatively charged ions while the exterior fluid is positively charged ions.
    - This positive/negative state is called the Resting Potential
- Axon's surface is Selectively Permeable : meaning it is very selective of what it lets in.
- Neuron firing changes this priority:
    1. the first bit of the axon open gates and lets positively charged ions flood through membrane
    2. this DEPOLARIZES that section of axon causing channel to open and do the same again and again.
    3. During the RESTING PAUSE (Refractory Period) the neuron pumps positively charged sodium ions back outside
    4. Then the cycle can begin again
- Signals are either inhibitory or excitatory
    - this combined signals trigger an action potential.
- action potential then travels down the axon --> which branches into junctions with other neurons.
- Stimulus increases the number of neurons but not the strength of the impulse

How do nerve cells communicate?

- Meeting point between neurons is called SYNAPSE
- Distance between a neuron and the receiving axon is the synaptic gap
- How do neurons send info across this tiny gap?*

  STEPS:
    1. when action potential reaches the "knoblike" terminals at axon's end --> triggers release of chemical messengers called neurotransmitters. [i call N.T for short]
    2. in 1/10000th of a second the NT molecules cross the synaptic gap and bind to receptor sites on the receiving neuron. (just like a key fits a lock)
    3. For an instant the NT unlocks tiny channels at the receiving sites.
    4. Then electrically charged ions flow in

5. This excites or inhibits the receiving neuron's readiness to fire.
6. Then a process called REUPTAKE --> which is sending neuron reabsorbs excess neurotransmitter.

How do neurotransmitters influence us? (how do they influence our motions and emotions?)

- a particular pathway in brain may use only 1 or 2 neurotransmitters.
    - Each can control an emotion or motion
- Acetylcholine (ACh) is a neurotransmitter. Role : learning and memory.
- ACh is messenger at every junction between motor and neuron and skeletal muscle.
- When ACh is released to our muscle cell receptors, muscle contracts.
- If ACh transmission is blocked (happens with some kinds of anesthesia) muscle cant contract and we are paralyzed
- Brain produces its own naturally occurring opiates.
- Body releases several types of NT molecules like morphine --> ENDORPHINS.

How drugs and other chemicals alter NT

- when flooded with opiate drugs (heroin/morphine) the brain may stop producing natural opiates
- Drugs and other chemicals affect brain chemistry at synapses. Either amplifying or blocking a NT activity.
- AGONIST molecule may be similar to mimic NT activity and effects OR it may block the NT reuptake. Ex: black widow spider venom --> floods synapses with ACh which leads to violent muscle contraction.
- Antagonists block NT functioning.

The Nervous System

- Central nervous system is formed by brain and spinal cord (CNS)
- CNS communicates with rest of body by peripheral nervous system (PNS)
- PNS travels through axons as we know as nerves.

The Peripheral Nervous System

- PNS has 2 systems : Somatic & Autonomic
    - Somatic nervous system : enables voluntary control of skeletal muscles (ex: turning the page)
    - Autonomic nervous system: controls muscles of internal organs (ex: heartbeat)
- Serves two main functions.
    i. Sympathetic nervous system : Arouses and expands energy (ex: if something alarms you, your heart rate will accelerate...)
    ii. Parasympathetic nervous system: Produces opposite effects... calms you down.

The Central Nervous System

- Neurons organized into neural networks - control our response to stimuli
- Neurons network with nearby neurons (they have short/fast connection)
- Spinal cords connects PNS to brain
- Ascending neural fibres send info and descending fibres send back motor control info.

The Endocrine System

- interconnected with your nervous system
- Uses and secretes HORMONES.
- Some hormones identical to N.T.
- Endocrine system and nervous system are like cousins: both produce molecules that act on receptors elsewhere.
- Endocrine messages transmit slowly but outlast neural messages
- When the body feels threatened adrenal glands release hormones to increase heart rate and blood pressure providing us with more energy.
- Pituitary gland controlled by hypothalamus controls growth

The Brain

How do neuroscientists study the brain's connections to behaviour and mind?

- Recording the brain's electrical activity
    - Electrical activity in the brain is recorded by an electroencephalogram (EEG).
- Neuroimaging Techniques
    - to see the inside of a brain we use the PET (positron emission tomography) scan. it shows brain activity by showing each bran area's consumption of its chemical fuel.
- MRI (magnetic resonance imaging)
- fMRI (functional MRI): can reveal brain's functioning as well as structure.

The Brainstem

- oldest region of the brain just above the spinal cord
- Two parts:
    i. 'swelled' area is medulla controls heartbeat and breathing
    ii. above medulla is pons : helps coordinate movements

The Thalamus

- Top of the brain stem
- Receives signals and routes it to higher brain regions who specialize in certain sense
- Also receives some of the higher brain's replies which it then goes to medulla and to cerebellum.

The Cerebullum

- Rear of brainstem is cerebellum.
- Responsible from non-verbal learning/memory , judge time, emotion, sounds and textures
- Also coordinates voluntary movement

The Limbic System

- Located between the brains older parts and the cerebral hemispheres (2 halves of brain)
- Main component hippocampus processes memory

Amygdala

- Two bean sized neural clusters that process emotional memories
    - It influences aggression and fear

The Hypothalamus

- Located below thalamus
- Contains neural clusters than influence hunger, thirst, body temperature and sexual behaviour
- monitors blood chemistry and takes orders form other parts of the brain.
- it provides the brain centre with a pleasurable reward.
- also present in goldfish,dolphins and monkeys
- we as humans have limbic centers for pleasure.
- researches believe that addictive disorders may stem from reward deficiency syndrome.

The Cerebral Cortex

- Cerebrum enables our perceiving, thinking and speaking.
- cover of both hemispheres (like bark of the tree) is cerebral cortex
- body's ultimate control and info processing center.

Structure of the cortex

- left and right hemispheres are filled with mainly axons that connect the cortex to the brain's other regions
- Glial cell provide nutrients and insulatemyelin, guide neural connections and mop up ions and neurotransmitters
    - glia may also play role in learning and thinking.
- With increase of intelligence in species proportion of glia to neurons increases.
- cortex, each hemisphere divided into four lobes.

i. front of brain moving over the top are the frontal lobes
ii. behind forehead is parietal lobes
iii. at back of your head is the occipital lobes.
iv. above ears are the temporal lobes

Motor Functions

- Fritsch and Hitzig made discovery of what is now called motor cortex.
- by stimulating parts of of parts of left and right hemisphere caused movements of specific body parts on the opposite side of the body.
- the brain has no sensory receptors
- discovery that body areas requiring precise control, such as fingers and mouth, occupied greatest amount of cortical space.

Sensory Functions

- where does the cortex receive the incoming messages?
- cortical area that specializes in receiving info from the skin senses and from the movement of body parts.
- this area, front of parietal lobes and behind motor cortex is called the sensory cortex
- any sound we hear is processed by our auditory cortex in temporal lobes.

Association Areas:

Definition - areas of the cerebral cortex that are not involved in primary motor or sensory functions. Rather they are involved in higher mental functions such as learning, remembering , thinking and speaking.

- neurons in association areas integrate info and link sensory inputs with stored memories (very important part of thinking)
- association areas interpret, integrate and act on info processed by the sensory areas.
- found in all four lobes.
- frontal lobes enable judgement, planning and processing of new memories.
- frontal lobe damage can cause alter personality.

The Brain's Plasticity

- brains are sculpted by our genes and our experiences.
- brain's plasticity : ability to modify itself after some types of damage
- neural tissue can reorganize in response to damage.
- blindness or deafness makes unused brain areas available for other uses.
- plasticity is especially evident after serious damage. (if a slow-growing left hemisphere tumor disrupts language, the right hemisphere may compensate.
- humans can generate new brain cells.
- monkey brains illustrate neurogenesis by forming thousands of new neurons each day.

Splitting the Brain

- in 1961, neurosurgeons, Philip Vogel and Joseph Bogen speculated that major epileptic seizures caused by an amplification of abnormal brain activity bouncing back and forth between the two cerebral hemispheres.
- corpus callosum : the wide band of axon fibers connecting the two hemispheres and carrying messages between them.
- Split Brain: a condition resulting from surgery that isolates the brain's two hemispheres by cutting the fibers connecting them
- the right hemisphere understand simple requests , perceives objects, and is more engaged when quick, intuitive responses are needed.
- Right hemisphere damage - disruptions of emotional processing and social conduct

Right-Left differences in the intact brain

- studies reveal that just as hearing people usually use the left hemisphere to process speech, deaf people use the left hemisphere to process sign language.

- to brain, language is language, whether spoken or signed.
- right hemisphere also helps modulate our speech.

Brain Organization and Handedness

- nearly 90% are right handed.
- almost right handed process speech primarily in left hemisphere (tends to be the larger hemisphere)
- left handed are more divers, they can process on both hemispheres.
- genes or some prenatal factors influence handedness
- left-handers are most numerous among those with reading disabilities and migraine headaches.
- left more common among musicians ,mathematicians, professional sports players, architects and artist

Introduction to Experimental Psych

October-18-10
12:20 PM

Nature of Psychology

- Study of the mind's mental processes and physical actions
- Mental processes difficult to define because they cannot be observed and must be inferred
- Psychology should be the study of overt behaviour

Divisions in Psychology

- Experimental began in the mid-late 1800s with William Wundt
- Structuralism: Edward Titchner: isolate basic elements of the mind
    - Introspection: asked research participants to state what they were experiencing
    - Unreliable - results vary from person to person
- William James "Father of American Psychology"
    - Cognitive psychology
    - Pragmatism = Capitalism (materialism versus idealism)
    - Functionalism: how our mental and behaviour processes function and enable us to adapt
- Clinical psychology: counselling/psychotherapy - founded by Sigmund Freud
- Applied ": social, developmental, educational, industrial
- Psychoanalyst: trained in psychoanalysis - could by psychiatrists
- Psychiatrist: M.D., psychological disorders: mental illness, medicinal model, drug therapy and psychotherapy
- Clinical psychology: research degree (Ph.D) research and clinical practice, abnormal behaviour treated by counselling
- Experimental psychologist: researcher, not trained in clinical practices, no psychotherapy/counselling
- Counsellor/therapist: not trained in clinical psychology: no Ph.D in clinical psychology

Schools of Psychology

- Three main branches further divided into schools

Cognitive

- Memory, attention, decision-making, language
- Infer mental states based on patterns/performance
- Pictures processed automatically, words are not
- Not scientific because guessing
- Branches
    - Cognitive: performance and decision-time infer brain functions
    - Cognitive neuroscience
        - In cognitive psychology cannot directly observe functions (must infer)
        - Modern brain imaging techniques permit experimenter to observe changes in the brain activity during cognitive tasks
    - Neural/Cognitive Modelling
        - Using computers to mimic cognitive info processing
        - How many decisions must a computer/brain make to arrive at a solution

Biological

- Manipulate psychological state (attention, memory, decision-making) and effects on brain activity
- Manipulate brain (stimulate, lesion, drugs) and effects on psychology

Behavioural

- Began with J. Watson and his criticism of cognitive psychology
- B.F. Skinner = Behaviourism
    - Psychology should be objective science that studies behaviour without reference to mental processes (only behaviour can be assessed)

- Deterministic: all behaviour is determined by consequential events (reinforcement(repeated)/punishment)
- All behaviour is learned
- Clinical and psychotherapy do not equal principal behaviour

Social

- Based on animal behaviour (ethology)
    - Social environments and effects, social learning
- Branches
    - Socio-biologist: behaviour is genetic/evolutionary
        - Opposite of behaviourism
    - Social neuroscience is the study of social phenomena

Psycho Analytical

- Originated by Sigmund Freud
- Role of the unconscious in determining behaviour
    - Behaviour and emotion are repressed and dictate personality and behaviour
- Deterministic: behaviour that is determined by unconscious drives

Phenomenological/Humanistic (Clinical Psychology)

- Humanistic Theories: current environment influences on our growth potential
- Subjective and thus unscientific experience

Scientific Method

October-18-10
12:46 PM

- Epistemology: the study of the methods used to obtain knowledge
  - Devine insight: gain knowledge through communication with higher, wiser, non-physical being
  - Pure logic (Aristotle): logical in our own reasoning thus deducing our own knowledge
  - Scientific manipulation: varies and observes effects of variables thus knowledge

Materialism versus Idealism

- Pure materialists believe that universe exists in physical form (atheism)
- Pure idealists do not believe in physical reality
- The laws of science dictate a physical existence
- Love, have, mind, consciousness are non-physical

Scientific Process

- Observation of the Universe: what don't we understand?
- Development of a Theory: possible answer to question being asked, lots of research on known knowledge, possible explanations are logically deduced
- Hypothesis: prediction (short term memory only)
- Definition of Variables:
  - Measure/quantification of Variables: more or less manner
  - Testing hypothesis: (unbiased, objective), design a study to answer questions/resolve controversy
  - Data Collection: Run the study
  - Analysis of data: using stats
  - Interpret data: is hypothesis supported, update theory
  - Experimental manipulation: manipulate independent variable which might cause change in dependant variable

Research Issues

- Stability versus change: whether a quality will vary of stay the same over time
- Rationality versus irrationality: actions/behaviour is inherited/deterministic
- Nature versus nurture: controversy over the contribution that genes/experiences make to the development of psychosocial traits/behaviours

Theories/Hypotheses (Hypothesis Testing)

- Hypothesis: stated expectations based on fact
- Specific enough to be proven wrong
- Define variables of interest
- Means of measuring variables of interest

Logical Positivism

- Every scientific theory must be potentially falsifiable
  - Freudian theory of unconscious (deep in mind does not mean wrong
  - Assume theory to be wrong (null hypothesis)
  - Can prove positive, not negative

Theory

- Theory: predicts behaviour or events
- Theory versus speculation: theory formed after research (not a biased opinion)
- Must be testable
- Others should be able to replicate and get same results: universal knowledge

Types of Studies

Case Studies

- One or more people obtain data true to everyone
- Exceptional cases (ex. Brilliant mathematician)
- Generalizations, exceptions to the rule

Sampling

- Need to select certain individuals representative of population
- Population: whole group you wish to study
- Sample: random (every member of the population has a chance)
  - Representative: small but representative rather than large and unrepresentative)

True Experimental Studies

- Factor (variable) of interest is manipulated or independent
- Assume null hypothesis
- If the theory is valid then the independent variable causes the dependant to change
  - Cause and effect relationship
- Measure dependant variable
- Some variables are constant
- When you don't know why a variable changes you are ignorant
- We can explain: variance between groups

- Can't explain: variance in each group/individual difference

Statistically Significant

- Determined by comparing the ratio of explained variance (effects of dependant) by unexplained variance (individual differences) knowledge versus ignorance
- If the ratio is large than the correlation is statistically significant

Experimental Design

- Control and experimental groups
  - Central condition: the experimental condition is compared with no experimental variation
- Random Assignment: control or experimental
  - Whatever differences between the two groups may be chance
  - Use the same groups of participants in repeat conditions

Placebo

- Examines the effects of treatment
- Placebo effect: symptoms reduce over time, patients thought they were being treated
- Placebo condition (sugar pill), double blind (both the researches and patients do not know what treatment they are giving/taking)

Problems with True Experiments

- Small sample size
- Lab setting is not representative of the real world

Quasi Experiments

- Not possible to manipulate independent variable (sex, race, age)
- Assumed that differences are caused by independent variables (controversial)

Natural Observation

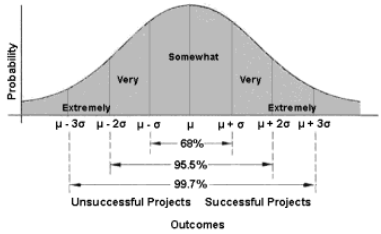
- Carried out in a natural environment to limit generalization
- Difficult to control

Surveys

- Participants asked to report behaviour, attitude, belief
- The word is crucial as the survey can be quasi/true

Measures of Central Tendency

- Mode: score occurs most often
- Mean: average of all scores
- Median: score which half individuals score above/below



The Normal Curve

- Distribution of scores is that demographic representation of the number individuals that got a particular score
- Psychological measures are distributed by bell shaped "normal curve"
- Most score on the mean
- In a perfect normal curve, the mode, mean and median are identical

Correlational Studies

- Correlation: a statistical measure of the extent of the relationship between two variables
  - Allows scientists to predict scores on one variable if another variable is known
  - Vary from -1.0 to +1.0
    - Vergative correlation, one variable up and the other down
    - Positive correlation, both variables up
    - Closer to 1.0 the closer the association, no relationship is 0.0
  - Does not prove causality (must carry out true experiment)

Neurosciences: Neuronal/Synaptic Transmission

October-18-10
7:25 PM

http://www.garyfisk.com/anim/neurotransmission.swf
http://thebrain.mcgill.ca/flash/i/i_01/i_01_m/i_01_m_ana/i_01_m_ana.html
http://www.pbs.org/wnet/brain/3d/

- Dendrites: receive messages from other sources
- Cell body: contains nucleus
- Axon: carries information from cell bodies to synaptic terminals
  - Long axons are myleinated and appear white
  - Short axons are unmyleinated and appear grey
- Terminal endings store neurotransmitter

Types of Neurons

- Sensory neurons: transmit from sensory receptors to the Central Nervous System (CNS)
- Motor neurons: CNS to muscles/glands (efferent)
- Interneurons: receive from sensory and send to motor neurons, communicate with each other (memory, learning)
- Resting potential: negative inside (potassium) positive inside (Sodium) -70mv
- Depolarization: stimulated by NT, sodium channels open and sodium rushes in to change the charge

Action Potential

- The cell reaches -54mV threshold, Action Potential occurs and a neuron fires
- Sodium channels open along axon, called propagation
- This could influence another neuron to fire

All or Nothing Response

- Entire length of axon, cannot change amplitude of AP
- Long axons myleinated, thus the charge cannot escape instead it jumps from node to node (nodes of Ranvier) faster than short axons

Release of Neurotransmitters

- Into synaptic cleft, post synaptic neuron, might not make it all the way (tone agents) either excitatory or inhibitory effects

Drug Interaction

- Block NT release
- Block storage NT in pre-synaptic stages
- Release excessive NT
- Stimulate/block NT receptor on post
- Attack enzymes that break down NT
- Block reuptake

Neurotransmitters

- Acetylcholine: skeletal muscle contractor
  - Muscle paralysis
    - Botulin blocks ACH release, nerve gas
  - Muscle convulsions (venom)
  - Alzheimer's --> Ach depleted
- Norepinephrine (NE) Noradrenaline (NA) OPPOSITES
  - Synthesized from epinephrine (released from adrenal glands)
  - controls alertness/mood
  - Cocaine and amphetamines prolong NE (stimulant)
  - Lithium speeds down breakdown (depressed mood)
- Gamma-Amino Butyric Acid (GABA)
  - Inhibitory NT - sedative, sleep and antianxiety (Benzodiazepines)
- Dopamine (DA)
  - Inhibitory, attention, decision making (ADAD)
    - Insufficient: Parkinson's Excess: Psychosis
- Serotonin (S-HT)
  - Sleeping, dreaming, eating, mood, pain
    - Drugs that mimic are hallucinogens (LCD)
    - Over release (ecstasy) causes S-HT to be depleted and leads to withdrawal
- Endorphins
  - Natural plates, similar chemical structure to heroin, morphine
  - Inhibit pain, increase mood and pleasure

Neurosciences: Anatomy and Functions of the Nervous System

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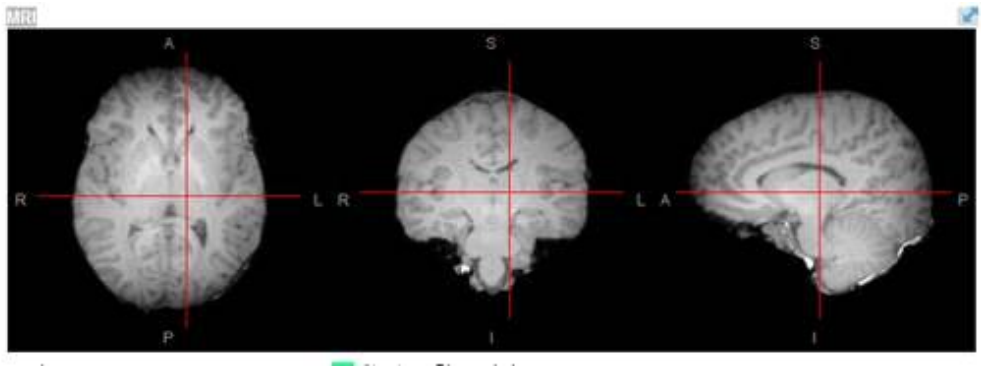

Orientation

- Medial-lateral --> middle of body/side of body
- Anterior-posterior --> front of head/back of head
- Superior-inferior --> upper portion/lower portion

- Horizontal --> A-P, M-L
- Coronal (ear to ear) --> S-I, L-M
- Sagittal (nose to back of head) --> A-P, S-I
- Mid-Sagittal --> equally in half

Imaging Techniques

- MRI --> high resolution, macrostructure of human brain
  - Static (image of structure but not what the function of that structure is) very expensive
- PET (3D)
  - What areas of the brain need glucose to complete task, deoxidized glucose injected into blood, invasive, slow and expensive
- fMRI (blood flow + MRI)
  - Changes in structure (blood flow) as the brain is engaged in a task, faster the PET, still slow and expensive
- EEG
  - Electrical activity of the brain, evoked potentials measure response to stimuli, cheap, poor resolution, fast

Divisions of the Nervous System

Peripheral Nervous System

- Sensory and motor neurons that connect CNS to rest of body
- Somatic --> voluntary control over skeletal muscles
- Autonomic --> controls glands and muscles of internal organs (heartbeat/digestion)
- Sympathetic --> mobilizes body in stressful situations
- Parasympathetic --> when stress subsides, heart rate and blood pressure decrease

Central Nervous System

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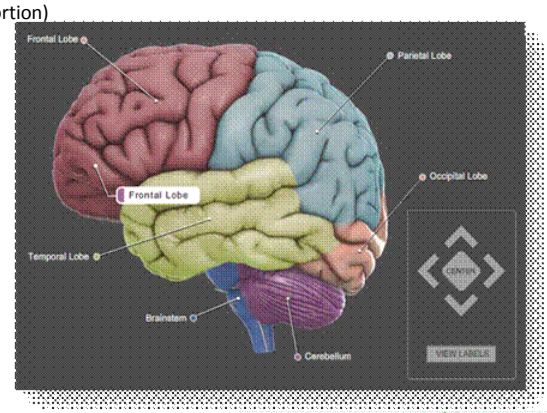
http://www.pbs.org/wnet/brain/3d/

The Spinal Cord

- Central Grey Region: greyish color, packed neurons surrounded by myelin sheath, elaborate intern-neural communication yields flexibility in complex behaviour
- White Surround Region: surrounds grey region
  - Ascending sensory pathway from spinal cord (DORSAL region)
  - Descending motor pathway that descends from brain to spinal cord (VENTRAL portion)
- Flexibility of behaviour is plasticity and soft wired
- Hard wiring is genetically wired and is not alterable
- Monosynaptic reflex
  - Only motor neurons and sensory neurons (one/mono synapse)
- Polysynaptic reflect
  - Interneurons communicating (lots/poly synapses)

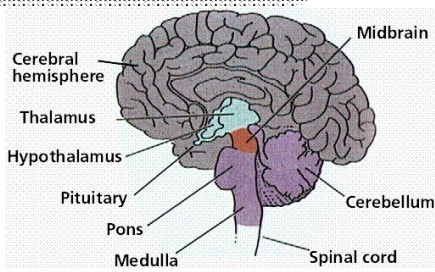


Divisions of the Brain

- Hindbrain - medulla + pons
- Midbrain - medulla+ pons + midbrain = brain stem
- Forebrain - diencephalon, cerebrum

The Brainstem

- Vision, hearing, taste, smell
- Eyes, ear movement, facial muscles, tongue lips
- Temperature, heart, respiration
- Sleep/wake cycle
- Reticular activating system is the general arousal of the brain



The Diencephalon (Thalamus, Hypothalamus, Pituitary)

- Thalamus directs messages to the sensory receiving areas in the cortex and transmits replies to the cerebellum and medulla, filters which sensory afferents are relevant
- Hypothalamus: located under thalamus, many subdivisions that control needs/drives of organism (Eating/drinking/temperature regulation) monitors blood circulation, part of the ANS (unconscious), monitors blood circulation, connected to base of pituitary gland and controls it
- Pituitary gland: inferior to hypothalamus, "master gland" of endocrine system (releases hormones into blood), hormonal communication is slow and lasting
- Hypothalamus monitors endocrine levels then tells pituitary to increase or decrease output of hormones

Neocortex

- Sulci (crevices) gyri (6 layers of grey matter)
- Subdivided in frontal, parietal, occipital, temporal
- Longitudinal fissure separates left and right hemisphere
- Central fissure separates frontal and parietal
- Lateral fissure separates front and parietal from temporal
- Corpus callosum --> thick band of white matter that connects left and right hemispheres
- Complex interaction yields new synapses, the old ones must alter. The neocortex is not genetically determined

Types of Cortices

Motor

- Arch shaped region located at the back of the front lobe
- Runs ear-to-ear at the top of the brain
  - Stimulation comes from movement of specific body parts on opposite sides of the body, precise control (fingers/mouth)
  - Send motor output into peripheral via efferent system

Sensory

- Front of parietal lobe, parallel and behind motor cortex
- The more sensitive the body region, the larger area of sensory cortex it takes up
- Receives input about sensory info via thalamus
- Olfactory system bypasses thalamus
  - Visual is 50% of the occipital
  - Auditory is the gyrus of Heschl (superior part of temporal)
- Somatosensory (posterior to central fissure)
  - Touch, temperature

Association

- No contact with outside world
- Neither sensory or motor, receives information after processed
- Small interneurons with elaborate interconnected ions
  - Behaviour, learning, memory
  - Behaviour flexibility

Frontal Lobe

- Motor functions
  - Motor cortex in pre-central gyrus
  - Broca's area/speech
- Psychological functions
  - Higher mental functions - concentration, will, initiative, insight, feedback, consciousness. Self consciousness,

personality

Temporal Lobe

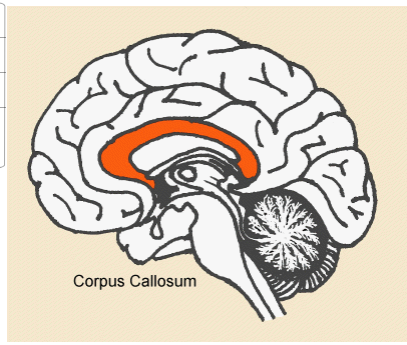
- Short term memory systems: hippocampus and amygdala
- Hippocampus
  - Storage of short term memories
  - Can transfer to permanent memory
  - If severed cannot learn anything new
- Amygdala and limbic system

Parietal Lobe

- Permanent memory systems
- Switching of attention
  - Frontal lobe controls concentration, is something novel occurs, this is the role of the parietal lobe
- Hemi-neglect
  - Damage to the Right parietal lobe means they cannot attend to information on the left side (neglect half their universe)
  - If there's stimulus on both sides, they will only see/hear/attend to the Right side
    - If only on left side will attend to it
    - Misdiagnosed as psychosis

Hemisphere Differences

Left Brain	**Right Brain**
• Speaking/calculations	• Perceptual task
• Quick literal interpretations of language	• Inferences, modulate speech, orchestrate sense of self
• Right handed, left hemisphere dominant (prevalent)	• Left handed, is more diverse --> increase of reading disabilities, allergies and migraines



- Non-dominant hemisphere correlates with spatial construction, face recognition, tonality, emotional expression

Corpus Callosum

- Connects hemispheres allows them to communicate
- Splitting the brain (severing the corpus callosum) stops communication between two hemispheres

Limbic System

- Limbic means circle or loop (hippocampus and amygdala)
- Amygdala: aggression and fear
  - Perception of processing of mental memories
  - 4 F's: feeding, fighting, fleeing, "mating behaviour"

Autonomic Nervous System

- Cortex has little or no control over ANS
- Controlled by hypothalamus

Sensation and Perception

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Sensation

- Sensory input and transmission
- Sensory receptors only sensitive to limited amounts of Earth's energy and must transfer it into something the nervous system can understand (electrical signal)
    - The objective is bottom up processing
    - Analysis that begins with sensory receptors and works up to the brain's integration of sensory information

Perception

- Integration of sensory information with permanently stored memories
- Higher level of the brain
- Subjective thought

Physics of Energy

- Receptors provide 5 features of the physical characteristics of a stimulus
    - Modality - what type of experience is at the receptor
    - Frequency - how often is receptor stimulated
    - Intensity - how much energy is there
    - Location - what is the source of stimulus
    - Duration - how long does stimulus persist

Thresholds

- Minimum amount of energy to stimulate an action potential threshold
- Absolute
    - Minimum amount of energy needed to detect a stimulus 50% of the time
- Difference
    - Detection of minimum change in energy
    - $\frac{\Delta I}{I} = k,$
    - Where I is the original intensity of stimulation, ΔI is the addition to it required for the difference to be perceived (the **jnd**), and *k* is a constant
    - Must differ by constant proportion for their difference to be perceived

Signal Detection Theory

- Predicts when we will detect weak signals
- Has to do with psychological state
    - Experience, expectations, motivations alertness
- Ability to discriminate a signal from no signal
    - Ratio of hits to misses
        - Intensity, strategy, level of attention

Subliminal Perception

- Ability to perceive stimuli below threshold
- May perceive stimulus input but not be conscious of the perception
    - Unconscious inputs are recalled later

Sensory Coding

- Coded by specific nerve that carries the neuronal message (Muller's specificity)
- Perception of stimulus requires a cortex
- Single nerve can code for many different messages

Parallel Processing

- Brain divides scenes into sub dimensions
    - Color, movement, form, depth
- Frequency modulation: message carried by neuron coded by frequency that neuron fires
    - Max: 1000 times/second

Adaptation

- As long as stimulation is constant it is only necessary to perceive initial onset
- Allows cortex to be engaged in other matters
- Long stimulus is not perceived after a period of time, rate of neuronal firing slow, then stops
    - If the intensity is constant then we adapt
    - If the receptor cannot fire the neurons fatigue
        - No more neurotransmitters
- Habituation: higher level in brain (memory)
    - Repetition of stimulus leads us to be no longer conscious of it
    - Incoming stimulus reaches level of nervous system where memory is stored
    - Compared to what's stored
        - Match: no more processing
        - No match: change --> further processing

Audition

Physics of Sound

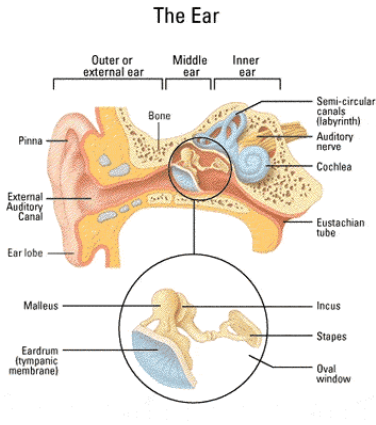
- Sound is the collision if air molecules resulting in compression and expansion of air waves sound varies in..
  - Frequency (Hz): the time between waves determines wavelength, ear drum vibrates based on frequency
  - Intensity (dB): number of molecules put in motion depend on intensity, experiences as loudness
- Ear is more sensitive to human speech frequency (500-2000 Hz)

Intensity Scale

- Decibels are based on a logarithmic scale and measure sound pressure
  - 10 dB = 10^1 x pressure, 20db = 10^2 pressure

Ear

- Outer ear: pinnae and auditory canal
- Middle ear: ear drum, hammer, anvil, stirrup
- Inner ear: cochlea, auditory nerve
  - Auditory nerve synapse in medulla where information is extracted then to pons/midbrain, then to thalamus
  - Thalamus analyzes and decides if its sent to the auditory cortex



Risks to Hearing

- Damage to middle ear --> conduction hearing loss
- Cochlea/auditory nerve --> sensor neural hearing loss

Frequency (Temporal) Theory

- Rate of nerve impulses travelling up the auditory canal matches frequency of a tone, thus we can sense pitch

Place Theory

- Frequency coded by place stimulated on basilar membrane
- Intensity coded by frequency of firing
- Damage to basilar membrane leads to hearing loss in predictable frequencies
- Problems: the lower the frequency, the general movement of basilar membrane should hear mixed frequency, but we don't
- Lower frequencies lead to hearing loss, RARE

Volley Theory

- Frequency theory does not explain how and why the higher frequencies are coded
- A single neuron cannot fire at the rate of greater than 1000Hz
- If neurons fire in a volley (like cannons) the frequency increasing

Localization of Sound

- We hear in a stereo
- Time difference between arrival of sound
  - Coming from the Left side --> arrives at left ear first
- Intensity different between ears
  - Sound coming from front and side = louder in left ear than right ear
- If sound is behind us or equidistant it is difficult to locate the sound

Midterm 2 Notes

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Sensation and Perception

Vision

- Our eyes receive light energy and transduce it into neural messages that our brain then processes into what we consciously see
- Light: an electromagnetic signal who's wavelength (distance form one peak to the next) varies from 400-700 nanometers
- This wavelength determines the color, and the amount of energy determines brightness
- Light enters the eye…
    - Through the **cornea** which protects the eye and bends the light for focus
    - The **pupil** (an adjustable opening) is surrounded by the
    - **Iris** which adjusts light intake by dilating or constricting
    - Behind the pupil, the **lens** focuses incoming light rays by changing curvature to project the imagine onto
    - The **retina**, a multi-layer tissue on the eye's inner surface

The retina

- Three layers: rods/cones, bipolar cells, ganglion cells
    - Rods and cones are the outer layer, lighter energy triggers chemical changes that spark neural signals
    - These signals are passed onto the bipolar cells
    - Which in turn pass the signals on to the ganglion cells, axons of ganglion cells make the optic nerve which carries the information to the brain
    - Where the option nerve leaves the eye there are no receptors, this is the **blind spot**
- Cones
    - Cluster around the fovea (area of central focus) and are the most acute
    - Cones allow for a direct route to the brain, carrying precise information and the ability to detect fine detail
    - Allow for the ability to perceive color but are not effective in dim light
    - There are three tpyes of cones for red, green and blue
    - A single cone needs to transmit to a single bipolar cell in order for the bipolar cell to activate you need intense color and light
- Rods
    - Share bipolar cells with other rods, and thus send combined messages
    - Enable black and white vision
    - Effective in dim light and at detecting movement
    - More sensitive than cones, but light must be relatively intense
    - The ability to see at low intensities is thus responsible for night vision as there is no color in the darkness
- The retina processes information before it goes onto the thalamus
- These retina cells are triggered by pressure
- Neurons in the occipital lobe's isual cortex receive information from individual ganglion cells (feature detector cells) which are able to respond to a scene's specific features (edges, lines angles, movements
    - Single neurons in the primary visual cortex seem to be highly specialized for the detection of very specific features (ex. horizontal versus vertical lines)
    - As we move farther and farther from the primary visual cortex, features become joined. The single neuron might detect shapes, or specialized objects

Three Color Theory

- All colors can be created through the mixture of three colors: red, blue and green
- There are three types of cones and optic nerves - one for each red blue and green to synapse

by. All other colors are created by the cortex via a mix of each synapse
- Support: there are three types of cones: red, blue and green
- Counterargument: we can never see reddish-green or bluish yellow - we should if these cones are activated simultaneously
- Counterargument: if one looks at a cone color for long enough, and then looks at away (after red adaptation occurs) a green after image appears - how can this be if the green cone was not activated?
- Counterargument: color blindness: one is never blind just to red or to green or to blue, but rather combinations of red-green or blue-yellow

Two Color Theory OR Opponent-Color Theory

- This theory claims that red and green cones jointly synapse with a red-green detector neuron. This firing increases when red is presented but decreases with green, same thing for blue-yellow
- Support: color blindness and color adaptation studies
- Counterargument: three color theory
- 2 color opponent neurons operate at a higher level than the receptor (psychological theory
- Color processing occurs in two stages
    - The red, blue and green cones of the retina respond in varying degrees to different stimuli (three color theory)
    - Signals are then processed by the nervous system opponent-process cells on the way to the visual cortex

Pathway to the Cortex

- Half of the optic nerve crosses near the hypothalamus, this crossing point is called the optic chiasm
- In the end, the left visual field (NOT EYE) projects to the right visual cortex, and the right visual field to the left visual cortex
- The optic nerve synapses at the thalamus

Sensation

Pain

- Common to all senses, while there is an optic nerve and an auditory nerve there is not a pain nerve
- Nocicipetors: sensory receptors that detect hurtful temperatures, chemicals or pressure
- Spinal cord contains neurological gate that blocks or passes on pain to the brain
    - This gate is opened by the activity of pain signals travelling up small nerve fibres and is closed by activity in larger fibres or by the brain (gate control theory)
- We are distracted and soothed from pain by the release of endorphins
- Pain is highly subjective, it can be controlled through attention mechanisms and altered states of consciousness. There is nothing objective about pain.
- Selection attention: we can control pain by using a second stimulus. This we stimulate the somatosensory (touch) system bt shaking our hands when we crush hurt out fingers. This forces us to attend to somatosensory stimulus as opposed to the pain (bottom up processing)
- A higher centre of the brain might wilfully block pain signals via the release of endorphins
- Phasic pain
    - We feel this immediately upon intense stimulation - has a protective role
    - Interupts processing of other information and forces you to switch attention
    - Makes us take action and remove you from the source of the pain
    - We experience both phasic and tonic pain: we experience phasic and the beginning and end of pain - our nervous system is carefully tuned to detect change
    - We have a much better memory of phasic as opposed to tonic pain
- Tonic pain
    - This is the long term pain that occurs after phasic pain ceases
    - Teaches us to avoid painful stimulus in the future and as such is much more subjective
    - Perception of this type of pain is altered by psychological factors (ex. Attention)

- Each type of pain has its own pathway

Perception

Perceptual Organization

- **Gestalt** psychology: given a cluster of sensation the perceiver organizes them into a whole (gestalt)
- **Figure-ground**: in order to perceive, we need to perceive a figure as being distinct from its surroundings, the ground. This relationship continually reverses, we organize the stimulus into a figure against a ground, emphasizing the important of edge detection
- **Grouping:** to bring order to out sensations, we logically group stimuli together, by proximity, similarity, continuity, closure, and connectedness
- **Depth Perception:** seeing objects in 4 dimensions, we estimate the distance from us (babies with visual cliff)

Binocular Cues

- The fact that we have two eyes does provide a cue for the third dimension, depth
- **Retinal disparity:** the image that falls on our two eyes is not identical, there is often a discrepancy between what each eye sees
- If we can force the eyes to see independently, we will se vivid depth. **Stereograms** contain two different views f the same image
- It falls to the brain to integrate the two images and thereby create depth

Monocular Cues

- Even with one eye, we can still see in three dimensions. What are the cues that represent the depth of objects?
    - Relative size
    - Relative height
    - Interposition: the near object will block a far object
    - Linear perspective: parallel lines such as a ralway track converge at a distance
    - Texture gradient: near objects have a distinct texture, whereas far objects merge textures
    - Relative brightness: near objects reflect more light than far objects

Motion Perception

- As light sequentially stimulates one retinal cell after another, we experience movement as neighbouring retinal cells are triggered
- Approaching objects become larger on the retinal as they trigger retinal cells farther away from the centre of the object
- Retreating objects become smaller as the trigger cells closer to the centre of the object

Misperception of Movement (Apparent Movement)

- An object will also move across the eye as the eyes move horizontally or vertically even though the object is stationary
- Even though the object triggers neighbouring retinal cells, our visual cortex does not experience movement - it has adapted to the movement of our eyes
- Our eyes are constantly moving slightly, and we are not conscious of the movements
- We thus sometimes incur a misperception that the object is moving, this is the responsibility of perception not the object itself

Perceptual Constancies

- **Perceptual constancy:** allows us to perceive an object as unchanging even though the stimuli that fall onto our receptors have changed
- **Shape constancy:** we perceive the form of similar objects as constant even while our retinal image of it changes
- **Size constancy:** we perceive objects as having a constant size, even while our distance from them varies

- **Lightness constancy:** white objects reflect more light than black objects, this is relative to the environment hence **relative luminance**
- **Color constancy:** perceiving familiar objects as having consisten color, even if changing illumination alters the wavelengths reflected by the objects

- Context can influence how we perceive
- Identical colors will not appear to be identical if presented in different background colors
- Culture affects how we perceive objects

Consciousness

Attention

- Consciousness is both a state and a process
- The sleep-wake cycle is divide in sleeping and waking cycles within which the observer is not aware, or is aware of their environment respectively
- The selective attention process permits the observer to become conscious of only highly relevant stimulus input, and ignore less relevant stimulus
- Consciousness involves more than a stimulus, it involves personal and subjective experience which is consequently easily altered in the form of drugs

- Consciousness is our awareness of ourselves and our environment
- **Cognitive neuroscience:** the interdisciplinary study of the brain activity linked with our mental processes
- **Dual processing:** information is often simultaneously processed on separate conscious and unconscious tasks
- **Selective attention:** the focusing of conscious awareness on a particular stimulus
- **Cocktail effect:** the ability to attend to one voice amongst many
- The selectivity of the attention process would not be necessary if our cognitive processing systems had unlimited capacity
- Must choose to attend to certain stimuli and ignore others using cortical focus
- **Active attention:** modulated by frontal lobe which decides what is relevant and the amount of capacity the tasks requires - this is stored in the hippocampus
- Incoming sensory messages compared to memory to see if relevant, a match leads to further processing
- If we are in a state of panic attention is taken away from what is relevant
- Active attention leads to cortical fatigue, failure of selective attention leads to information over load

Passive Attention

- Requires no effort - privileged stimulus will force the person to switch attention away from current actions and attend to the intrusion to consciousness
- **Capacity theory:** Daniel Kahneman - all cognitive processing is a task that makes demands on the limited resources
    - **Controlled processing:** requires effort, processing of one task influences the performance of another, resources currently in use cannot be allocated to another task
    - **Serial processing:** secondary tasks cannot be processed until the first task has been fully processed
    - **Automatic processing:** no effort, parallel processing - tasks that initially require a lot of effort become automatic and effortless
    - **Multi-tasking/divided attention:** more than one task can be processed simultaneously without detriment in performance to the other if sufficient resources are available , if not then serial processing occurs
- **Circadian rhythm:** the biological clock, regular body rhytms that occur on a 24 hour cycle
    - Bright light activates light-sensitive retinal proteins trigger signals to the SCN (suprachiasmic nucleus) which causes the pineal gland to decrease melatonin in the morning and increase it at night

Sleep Stages

- During sleep different parts of the cortex stop communicating and consciousness fades
- The sleep cycle lasts 90 minutes
- **Alpha waves:** occur during awake stages, relaxed slow brain waves
- Transition to sleep marked by slowed breathing and irregular brain waves **(Stage 1)** may experience hallucinations
- **Stage 2:** 20 minutes, sleep spindles (bursts of rapid rhythmic brain-wave) activity, awakened without difficulty
- **Stage 3:** transitional large slow delta waves
- **Stage 4:** large slow delta waves, 3/4 last 30 minutes. It is difficult to wake during this stage as you have entered deep sleep
- **REM:** after an hour of sleep you ascend from initial sleep dive and after stage 3 you enter REM
    - 10 minutes consist of rapid saw tooth waves typical of stage one
    - Heart rate rises, breathing becomes rapid/irregular, and every few minutes the eyes make a darting movement
    - The brain's motor cortex is active but the brainstem blocks its messages, therefore muscles are relaxed and almost paralyzed
- As the night goes on, stage 4 becomes shorter and then disappears
- REM and stage 2 become longer, 20-25% of sleep becomes REM
- **NREM Deprivation:** sleep deprivation suppresses immune cells that fight off viral infections and cancer
- **REM deprivation:** unable to selectively deprive the sleeper of only NREM sleep, REM deprivation causes the sleeper to enter REM more rapidly and early in the night. Central Nervous System depressants loss of REM and a REM rebound upon withdrawal
- **Chronic sleep debt:** alters metabolic and hormonal functioning in ways that mimic aging and are conducive to hypertensions and memory impairment

REM and Dreams

- **Freud:** dreams are the release of repressed desires/drives from the unconscious
- The actual (manifest) content of the dream is symbolic of our true but repressed desires (latent content)

- Predators sleep considerably more than prey because of the disparity in the need to conserve energy

- Purpose of NREM sleep: recovery from day's events, regeneration of cells, immune system activity, release of growth hormones, declarative memories
- Purpose of REM sleep: biological luxury, not a necessity - information is stored and the clean-up of irrelevant material takes place

Sleep Disorders

- **Insomnia:** frequent inability to fall asleep/stay asleep
- **Narcolepsy:** inability to stay awake, failure of the release of hypothalamic-related hormone "orexin"
- **Sleep Apnea:** cessation of breathing during sleep (usually in obese sleeping prone men) muscle inhibition causes the tongue to block the airway - an air pump is used as a solution

Consciousness-Drugs

Tolerance

- Develops after repeated use, an individual needs more drugs to produce the same effect
- During withdrawal you have cravings, and a physical/psychological dependence
- One part of the brain requires more while another part cannot handle the increase in dosage (overdose)

Type of Psychoactive Drugs

- Depressants (downers) inhibit neural functions
    - Alcohol: depresses frontal lobe control (logic, consequences, social behaviour), effects

short term memory and inhibits REM sleep
    - Barbiturates: induce relaxation and sleep, impair memory and judgement and are lethal in combination with alcohol
    - Opiates: similar structure to endorphins, depresses sympathetic nervous system and the frontal lobe, the brain stops producing endorphins forcing the user to increase the dose
- Stimulants (uppers) excite neural functions
    - Cocaine/crack: rapid rush and then a crash leads to increased focus and mental alertness
    - Ecstasy: release of serotonin and then blocks reabsorption of neurotransmitters leading to depression, and hallucinations
- Hallucinogens: alter perception and evoke sensory images
    - Cannabis: cannabinoid receptors in the brain. CBD and THC are produced and an increase in THC leads to relaxation and inhibition
    - LSD: similar in structure of 5-HT, distortion of perception with a small dose and has long lasting effects

Learning

- **Classical conditioning:** association between two stimuli is learned
- **Operant conditioning:** association between a response to a stimulus and a subsequent consequence is learned
- Repetition of a stimulus yields a lower response and habituation
- Incoming sensory stimulus is compared to stimulus models in memory

- Classical conditioning
    - Unconditioned stimulus (UCS) triggers the unconditioned reflex or reaction (UCR)
    - If a formerly neutral stimulus is repeatedly paired with the UCS the UCR is triggered
    - Soon the neural stimulus alone will produce the response
    - The neural stimulus has become associates with the UCS it is called the conditioned stimulus (CS). The CS produces as the UCS but is more conditioned
    - A conditioned response is the path to higher learning and a response to stimulus that did not occur in the nervous system
- **Acquisition:** learning takes time, and numerous repetitions of the UCS-CS pairing via a learning code
- **Extinction:** removes the UCS and the CR will diminish
- **Spontaneous Recovery:** after extinction the CS will elicit the CR for a short period
- **Generalization:** other stimuli similar to the CS will elicit the CR. The closer the new stimulus to the original the better the CR - this explains fears and phobias
- **Operant Conditioning (behaviourism - Watson)**
    - Cause and effect learning based on the law of effect
    - Stimulus (S), Response (R) and the Consequences of Responding
    - The organism continues to respond to the stimulus as it is being reinforced
    - **Shaping:** the organism will normally not respond appropriately on the first trial, it takes multiple efforts
    - Organism learns the association between the stimulus and the response and that a correct response leads to reinforcement
    - Following learning the rate of responding increases dramatically
    - In operant conditioning the association is between a response and the consequences of responding
    - Reinforcement is contingent on the organism's responding correctly. If the organism does not, it does not get reinforced
- Anything that increases the rate of response is a re-enforcer
    - **Positive re-enforcers:** are delivered following the correct response
    - **Negative re-enforcers:** remove the organism from an aversive situation
    - **Primary re-enforcers:** satisfy basic needs (food, water, sex)
    - **Secondary re-enforcers:** allow us to obtain the primary re-enforcer
    - Schedule of re-enforcement tells the body hen the re-enforcer will be delivered (Fixed or variable)

    - Can be on a ration schedule, or an interval schedule
- **Extinction:** to remove a response, identify what is acting as a reinforce and then remove the re-enforcer
- **Removal of inappropriate responses:** the solution, according to behaviourists, is to identify the re-enforcer and eliminate it - do not reinforce
- **Punishment:** an alternative to extinction, an inappropriate response is punished in an effort to eliminate the response
    - Disadvantages
        - Effects are not predictable as alternative and appropriate responses are provided
        - What may be learned is how to avoid the punishment through fear and dislike
- **Avoidance:** of the averse situation via reinforcement, it is difficult to extinguish avoidance learning
- **Observational Learning (modelling):** influences through the media, this is often correlation and not causation.

Motivation

- **Motivation:** a need or desire that energizes and directs behaviour
- **Instinct:** a complex behaviour that is rigidly patterned thoughout a species and can be unlearned
- **Drive reduction theory:** the idea that a physiological need creates an aroused tensions state that motivates an organism to satisfy the need
- **Incentive:** a positive or negative environmental stimulus that motivates behaviour - there are objects and directions to this motivation

Drive Reduction

- **Drive reduction theory:** there are basic physiological needs
- Internal physiological needs create an aroused state that drives the organism to reduce the need
- **Homeostasis:** maintenance of internal balance
- The hypothalamus is involved in most if not all of the brain's set points

Incentives

- **Incentive:** external events or stimuli that pull us in an appropriate direction
    - Objects/direction of motivation
    - Primary and secondary re-enforcers

Social Biology

- Many animal and human behaviours are inherited - these used to be called instincts but this term is not used in psychology
- **Social biology and ethology:** this theory maintains that much of behaviour is due to evolutionary principles and that this behaviour has evolved from other animals

"Value" of Actions

- Pleasure is a basic psychological motivator
    - Is associated with the stimuli that enhance our biological wellbeing
    - Pain is associated with events that threaten our survival
- Reinforcing consequences of an action determine if it is worth repeating

"Pleasure" Centres of the Brain

- Mesolimbic dopamine system
    - Many different stimuli will activate this system
    - Perhaps common to all pleasure (food, drink, sex, etc.)
    - Drugs also activate this system
    - It may not result in a pleasure experience but rather a desire to create a repeat sensation

Hunger

Hunger Drive and Motive

- The basic need to seek calories (sweet food) and to avoid toxic agents (bitter food)
- Learning and conditioning, we like certain foods and drink more than other
- We strive to maintain the homeostatic motive - a sufficient of energy
- Incentive value of food - as a re-enforcer
- Is this triggered by a peripheral or central signal?

- Peripheral trigger
    - If the stomach is filled with air, we still experience hunger
    - People who have had their stomachs removed still experience hunger
    - Stomach and intestines do signal food intake, mainly the liver
    - The feel of hunger depends on the extent of the 'full' feeling of the stomach
- Central trigger
    - Neurons in the hypothalamus are sensitive to glucose levels
    - Stimulating the hypothalamic centres will induce hunger even in animals has just eaten
    - Injecting the hypothalamic chemicals (orexin) that induce hunger into other animals has the same effect
- **Lateral hypothalamus:** when animal is food deprived it releases the hormone orexin - this stimulation results in over eating, whereas lesions result in an animal refusing to eat
- **Ventromedial hypothalamus:** stimulation results in starvation, and lesions in this area cause animals to eat huge quantities. Several hormones may be released in the periphery signalling fullness

Problems with Hypothalamic Theory

- Other sites signal emptiness or fullness
- There is a set point in lateral hypothalamic animals if force-fed. Animals will not starve but rather eat a small amount of food to reach the lower set point
- Set point in ventromedial animals, they eat large amounts of food until the upper set point is reached
- **Metabolic rate:** animals on a semi-starvation diet reduce activity to conserve energy limiting weight loss

Psychological Factors in Eating Behaviour

- **Taste preferences:** some preferences are universal and genetic (sweet/salty) while others are conditioned
- **Ecology of Eating:** we tend to eat more in the company of others, and if presented with larger portions

Anorexia

- **Anorexia:** when the individual's weight is at least 15% less than normal
- Occurs in a small population of predominantly young, white and high socio-economic status
- Total obsession with calorie, food and weight count
- Causes
    - Biological or genetic function - there may be a hypothalamic dysnfunction
    - Slight tendency for identical twins to share the disorder than fraternal twins
    - Societal pressures

Obesity

- Genetic factors in weight extremely important - identical twins have nearly the same weight regardless of environment
- The number of fat cells and their size is enormous in the obese
- With dieting, the fat cells may shrink but cannot be eliminated
- Metabolism
    - Dieting does not always work because the metabolic rate drops
    - The individual is less active and fat is not burnt off

- Calories do not always translate into weight

Dieting (losing weight)

- Has the potential to directly affect the appetite thereby lowering the set point
- Can lead to anorexia
- Dieting rarely works in the long-term as the high set point is not necessarily changed

Problems

- Weight loss for other cells including muscles, this is not a good thing as muscles themselves burn off calories
- There must be a balance of calories, fat and protein in order to ensure that weight loss can be maintained
- Social factors: we eat more under stress, and the taste/appearance of food is something we are sensitive to

Bulimia

- Reccurent episodes of binge eating with no way gain due to laxatives or vomiting
- Causes: biological/genetic, personality, and social

Sex

Surveys of Sexual behaviour

- These surveys are the only way to study sex, and are difficult to interpret. Moreover, samples are not representative and thus we cannot generalize
- Initiation in non-primates
  - Female sexual activity is dictated by the hormone oestrogen
  - The female is in heat and most receptive during the ovulation period
  - Testosterone and thus sexual activity in males is far more constant
- Initiation in primates
  - Hormones play much less of a role particularly in humans
  - Social biologists insist that this is not true, that humans instead are following principles of evolution
  - Females engage in behaviour when they cannot possibly become pregnant
  - Thus social and not biological causes are associated with sex - love, marriage

Biology of Love

- There are stages of initial attraction - mainly lust
- Higher levels of oestrogen, testosterone, dopamine, serotonin and noradrenaline during initial attraction
- Testosterone influences the female, large changes in the male will increase male interest in the female

Gender Differences in Sexuality

- Men initiate sex more often than women
- This applies both socially, and biologically
- Age and gender differences
  - Most studies carried out with young adults and yield consistent results indicating the male's sexual dominance
  - Males engage in sex far later than women

Sexual Orientation

- Homosexuals are always a minority
- Almost all heterosexuals have had homosexual fantasies
- Sexual orientation cannot be changed by willpower nor psychotherapy
- Causes:
  - Unusual parental relationships

    - Childhood sexual experiences
    - Unusual early peer relationships
    - Poor early initial dating experiences with a member of the opposite sex
    - Sexual choice is biologically or genetically determined
- Cultures and race play a large part in the outlook towards homosexuality