Midterm: next Thursday, June 21

- Preliminary version of the midterm exam study guide is now posted online:
  http://www.utdallas.edu/~assmann/PSY3360/midtermguide.pdf
- Review session in class

Midterm Exam Review Benefit

- Extra credit assignment due by midnight, Thursday June 21 (same day as exam).
- Earn bonus points for your participation grade!
- No late submissions will be accepted.
- Upload link: https://elearning.utdallas.edu
- Instructions: see course web page
  http://www.utdallas.edu/~assmann/PSY3360

Vitalism vs. Mechanism

- Vitalism: living things share a vital force that cannot be explained by the physical sciences (Müller)
  “Willed behavior is instantaneous.”
- Mechanism: same laws apply to living and non-living things (Helmholtz)
- Principle of conservation of energy
Helmholtz’ studies of nerve conduction

- Measured speed of nerve conduction using a modified galvanometer
- Mild electrical stimulation of a frog’s leg produces muscle twitches.
- Conductance rate: ~90 feet/sec

Speed of nerve conduction

- Reaction times in humans: subjects pressed a button in response to tactile stimulus
- Response times ~165-330 feet per second
- Nerve transmission rate is finite (relatively slow)

Hermann Ludwig Ferdinand von Helmholtz (1821-1894)

- Helmholtz (1850) demonstrated experimentally in both animals and humans that the speed of nerve transmission was not instantaneous, nor even close to the speed of light, but in fact only around 50 meters per second (less than 100 mph).

Helmholtz' theory of perception

- Perception = active, unconscious, automatic, logical processes
- Unconscious inference
- Role of learning and memory in transforming sensory information
  - Experiments with distorted lenses
  - Motion pictures—succession of still images
  - Railroad tracks are parallel but seem to converge in the distance

Young-Helmholtz theory of color vision

- Newton (1672) – wavelength
- Trichromatic theory: human color vision involves three color receptors (RGB)
- Color receptors (cones) in the retina
- Laws of color mixing
- Color blindness

Munsell color system

- Hue: dominant wavelength
- Value: brightness
- Chroma: purity

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Auditory theory
Helmholtz proposed that the **cochlea**, part of the inner ear, is responsible for frequency analysis in hearing.

**Theory of hearing**
- Helmholtz proposed that the **basilar membrane**, housed within the **cochlea** of the **inner ear**, responds selectively to the different frequency components of sound waves.

**Place (resonance) theory of hearing**
- Cochlear fibers vary in length
- **Tuned** to vibrate at specific frequencies
- Different positions along the cochlea respond selectively to different frequencies to determine what **pitch** we hear

**Frequency analysis**
- **Fourier analysis**: mathematical decomposition of any complex waveform into simple sinusoidal components
- **Fourier synthesis**: any complex waveform can be reconstructed (synthesized) from sine waves.

**Response to a low-frequency sound**
Response to a high-frequency sound

On the sensations of tone
- Helmholtz invented the double siren to produce tones of any specified frequency.
- He used this device to map out the mathematical relationship between frequency and pitch.

Frequency and pitch
- Physical property: Frequency
- Psychological property: Pitch

Sine wave

Pitch Perception
- Helmholtz proposed that the location (place) of maximum vibration along the basilar membrane determines the pitch we perceive.

Pitch Perception
- Complex sounds have many components; the activation produced by the lowest one (called the fundamental frequency) determines the pitch.

Frequency analysis
Problem of the missing fundamental

- Helmholtz proposed that nonlinear interaction in the cochlea re-introduces the missing fundamental. (We now know this hypothesis was incorrect).

Musical tone

“First of all, what is a musical tone? Common experience teaches us that all sounding bodies are in a state of vibration … The sound becomes a musical tone, when such rapid impulses recur with perfect regularity and in precisely equal times. Irregular agitation of the air generates only noise. The pitch of a musical tone depends on the number of impulses which take place in a given time; the more there are in the same time the higher or sharper is the tone.” Helmholtz, 1865

Helmholtz’s contributions

- Principle of conservation of energy in biology
- Studies of the rate of nerve conduction
- Perception and unconscious inference
- Trichromatic theory of color vision
- Place theory of hearing
- Theory of musical pitch

Other developments in neuroscience

- Helmholtz (1850) demonstrated experimentally in both animals and humans that the velocity of nerve impulses was not instantaneous, nor even close to the speed of light, but in fact only about 50 meters per second (less than 100 mph).

Franciscus Cornelius Donders

- Dutch physiologist
- 15 years after Helmholtz’ study, Donders measured simple reaction time to visual stimuli

Franciscus Cornelius Donders

- Next Donders presented a series of stimuli and asked subjects to respond to only one, specified beforehand.
- The extra time provided a measure of the mental act of discrimination.
Franciscus Cornelius Donders

- **Subtractive method**: the time taken to discriminate the complex stimulus minus the time to discriminate the simple stimulus.

**Stimulus:**

```
A   B   C   D   E
```

**Response:**

```
\[\text{ABCDE}\]
```

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Franciscus Cornelius Donders

- **Choice reaction time**: several different stimuli are presented and the response to each one is different.

**Stimulus:**

```
A   B   C   D   E
```

**Response:**

```
\[\text{ABCDE}\]
```

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Franciscus Cornelius Donders

- The time required to make a choice is determined by subtracting both simple and discrimination reaction times from the choice reaction time.

**Stimulus:**

```
A   B   C   D   E
```

**Response:**

```
\[\text{ABCDE}\]
```

"mental chronometry"

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Emil du Bois-Reymond (1818-1896)

- du Bois-Reymond discovered the **action potential** in 1848
- An **action potential** (or nerve impulse) is a pulse-like wave of voltage that travels along the axon of a neuron.

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Other developments in neuroscience

- **Fritsch and Hitzig (1870)** showed that electrical stimulation of regions of the cortex in dogs produced specific responses of individual muscle groups (motor strip).

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Later developments in neuroscience

- **Lashley (1890-1959)** coined the term **equipotentiality** to describe the capacity of an intact part of the brain to take over the (memory) functions of a damaged portion.
Wilder Penfield (1891-1976)
- Brilliant neurosurgeon; leading authority on epilepsy
- Electrical stimulation of the cerebral cortex in awake patients (prior to surgery) could produce complex perceptions or motor actions
- homunculus (cartoon map of motor cortex)

Ernst Heinrich Weber (1795-1878)
- German physiologist
- Contemporary of Johannes Müller
- Studied tactile perception (pressure, temperature, pain) and kinesthesia (muscle sense)

Ernst Heinrich Weber (1795-1878)
- absolute threshold
- differential threshold
- just noticeable difference (jnd)
- Two-point threshold

Ernst Heinrich Weber (1795-1878)
- Weber found that the smallest perceptible change in a stimulus is a constant fraction of the magnitude of the original stimulus:
\[ \frac{\Delta I}{I} = k \]
Ernst Heinrich Weber (1795-1878)

- **Weber’s Law**: the jnd for detecting a change in intensity is proportional to the intensity of the standard stimulus.

Gustav Theodor Fechner (1801-1887)

- Theory and methods of psychophysics
- Double-aspect monism
- Mapping the functional relationship between physical and mental worlds.
- Quantitative measurement of mental processes.

Gustav Theodor Fechner (1801-1887)

- The Problem:
  - Physical objects and events are external, public, objective, open to direct measurement.
  - Mental processes are internal, private, subjective, and cannot be measured directly. Need for an indirect method.
- *Elemente der Psychophysik* (1860)

Gustav Theodor Fechner (1801-1887)

- Complementary colors and subjective afterimages
- Inner and outer psychophysics
- Fechner’s law of intensity:
  
  \[
  \text{Perceived intensity is equal to the logarithm of the stimulus intensity times some constant } k. 
  \]

Elements of Psychophysics

- Fechner discovered that the relationship between physical and perceived intensity had been previously described by Weber.
- He renamed it **Weber’s Law**.
  
  \[
  \Delta I / I = k
  \]

Elements of Psychophysics

- **Fechner’s Law**:
  
  \[
  S = k \log P
  \]
  
  where \( P \) is the physical stimulus, \( S \) is the perceived intensity, and \( k \) is a constant.
Elements of Psychophysics

- **Weber fraction**: just noticeable differences (jnd’s) correspond to constant ratios.

Psychophysical Methods

- Fechner developed three methods for measuring sensory thresholds:
  - Method of limits
  - Method of constant stimuli
  - Method of adjustment

Wilhelm Max Wundt (1832-1920)

- Established the world’s first laboratory for experimental psychology.
- Often referred to as the “Father of Experimental Psychology”

- Separate role for psychology—distinct from philosophy and biology/physiology
- **Voluntarism**: basic concept of the will.

Wilhelm Max Wundt (1832-1920)

- Dual approach: introspection and experiment.
- Goal: to relate mental events to objectively specified, measurable stimuli and responses.
  - To discover the basic elements of thought
  - To discover the laws by which mental elements combine into more complex mental experiences

- The mind is regarded as an activity, not a substance.
  - Stimulation of sense organs, transmission of signals through sensory neurons to higher brain centers, and from the central nervous system to muscle groups.
  - Parallel to this: mental events experienced through conscious awareness; can be studied only by introspection
  - Psychophysical parallelism
Wilhelm Max Wundt (1832-1920)

- **Perception**: A passive process determined by the physical stimulus, the anatomical makeup of the individual, and the individual’s past experiences.
- **Apperception**: An active, voluntary process that involves sustained attention to an aspect of the perceptual field.
- Apperception is a component of mental activity that involves the active participation of the will.

Wilhelm Max Wundt (1832-1920)

- **Creative synthesis**: Elements of conscious awareness can be arranged and re-arranged according to the will of the individual in ways that are unique and creative. Found in all acts of apperception.
- Schizophrenia as a breakdown of attentional processes.

Wilhelm Max Wundt (1832-1920)

- **Physiological Psychology (1893)**
- **Tridimensional theory of feeling**:
  - Pleasant versus unpleasant
  - Tense versus relaxed
  - Excited versus depressed
  - Any given feeling may be viewed as a combination of these three states

Wilhelm Max Wundt (1832-1920)

- Volkerpsychologie – scientific study of social institutions

Wilhelm Max Wundt (1832-1920)

- Among Wundt’s students:
  - James McKeen Cattell
  - Edward Tichener
  - Charles Spearman
  - Hugo Munsterberg
  - G. Stanley Hall