Chapter 20: Development and Neuropsychology

In this chapter, we will review a few specialized research methodologies that apply to research across human age range. Research with young children or infants depends on many of the basic experimental design techniques discussed previously but requires some additional consideration of the kinds of dependent measures that are available and the ethics of research with “vulnerable populations.” In addition, research comparing changes across age introduces methodological terminology contrasting cross-sectional and longitudinal designs.

Neuropsychological research might initially appear to be a quite different subdomain of psychological research but is often directed at older adults with cognitive challenges and can depend on similar methodological ideas. This type of research also illustrates the method of case study research which has been highly impactful in connecting cognitive functioning to the neural basis of cognition, the foundation of cognitive neuroscience. In addition, some modern approaches to the broad idea of cognitive change with age have come to see development as “across the lifespan” and to connect ideas from building cognitive function at a young age to contrasts with declines associated with older age.

# Developmental Research

Developmental research often refers to experimental methodology applied to young children. Obviously, the operational definitions for this kind of research need to account for the participant population. The research protocol and especially any task instructions need to be prepared to be age appropriate so that the participants understand the experiment details. The dependent variable needs to be a task that the children can perform.

In research with very young infants, measuring behavior can be challenging. Infants can indicate preference or in some cases familiarity by measures of preferential looking. In these paradigms, the infant is presented with a display that contains two different kinds of information, e.g., on two sides of a display. The infant is carefully observed to identify which direction they are looking or for how long they look. This can be used to infer babies’ understanding of the physics of the world around them by demonstrating that they look longer at displays constructed to contain apparent physical violations of collisions or violations of numeracy.

Among the challenges of implementing this technique is the need to make subjective ratings of the direction of looking. This is often done with a blind-rater technique where a camera records the direction of looking from an angle where the rater cannot see what is visible to the infant. The rating process done this way avoids any potential bias in rating based on knowing what the infant was supposed to do based on the experimental hypothesis. This research is still challenging to carry out because of the potential for many extraneous variables unrelated to the experiment affecting looking. These studies also frequently have a challenge in accumulating enough participants to support robust statistical inference. Not every child is comfortable in the experimental situation and research is often highly restricted to very specific age ranges (e.g., 3-6 months), making the available population very limited.

An additional practical challenge is that in many of these procedures, it is necessary to have the implicit participation of an adult who is a parent or guardian of the child. It is common in these paradigms to have the child seated on the lap of a parent in order to maintain comfort so that behavior can be observed. However, this can introduce concerns about the child’s behavior being biased by parental expectations. The parent has effectively become part of the research staff and needs to try to act in a consistent, unbiased manner so that behavioral differences solely reflect the child.

## Cross-Sectional, Longitudinal, and Cross-Sequential Studies

When psychologists wish to study change over time (for example, when developmental psychologists wish to study aging) they usually take one of three non-experimental approaches: cross-sectional, longitudinal, or cross-sequential. Cross-sectional studies involve comparing two or more pre-existing groups of people (e.g., children at different stages of development). What makes this approach non-experimental is that there is no manipulation of an independent variable and no random assignment of participants to groups. Using this design, developmental psychologists compare groups of people of different ages (e.g., young adults spanning from 18-25 years of age versus older adults spanning 60-75 years of age) on various dependent variables (e.g., memory, depression, life satisfaction). Of course, the primary limitation of using this design to study the effects of aging is that differences between the groups other than age may account for differences in the dependent variable. For instance, differences between the groups may reflect the generation that people come from (a cohort effect) rather than a direct effect of age. For this reason, longitudinal studies, in which one group of people is followed over time as they age, offer a superior means of studying the effects of aging. However, longitudinal studies are by definition more time consuming and so require a much greater investment on the part of the researcher and the participants. A third approach, known as cross-sequential studies, combines elements of both cross-sectional and longitudinal studies. Rather than measuring differences between people in different age groups or following the same people over a long period of time, researchers adopting this approach choose a smaller period of time during which they follow people in different age groups. For example, they might measure changes over a ten year period among participants who at the start of the study fall into the following age groups: 20 years old, 30 years old, 40 years old, 50 years old, and 60 years old. This design is advantageous because the researcher reaps the immediate benefits of being able to compare the age groups after the first assessment. Further, by following the different age groups over time they can subsequently determine whether the original differences they found across the age groups are due to true age effects or cohort effects.

Research across the lifespan also needs to be sensitive to the implementation of best ethical practices across age ranges. Participants under the age of 18 cannot provide written consent to participate in research but are generally consulted in addition to a parent or guardian consenting to their participation. The research protocol still needs to be arranged to acknowledge that the child still understands that participation is voluntary. Interactions between parents and children can be complex to anticipate, especially for older children such as adolescents who have different expectations about their preferences for research or privacy of data. All participants under 18 are considered “vulnerable populations” and oversight of research practices is elevated compared with research on cognitively healthy adults.

Research that aims to understand changes in behavior or cognition as a result of clinical syndromes is often termed **neuropsychological research**. Much of this work is done at the other end of the lifespan development with older adults. This work can be done as systematic research across groups of patients with clinical syndromes such as Alzheimer’s disease or Parkinson’s disease (and also with younger patients for syndrome such as schizophrenia). The cognitive impairments associated with some neuropsychological or neurological research means that these patients are sometimes also treated as vulnerable populations, requiring consent of guardian, etc. In general, these studies just require attention to the basic element of respect for persons for these older adults and acknowledgement of their challenges. This area of research is also one where the method of **single case studies** has been used to characterize particularly interesting single patients with unexpected patterns of cognitive function.

# Neuropsychological Research

## **Case Studies**

A case study is an in-depth examination of an individual. Sometimes case studies are also completed on social units (e.g., a cult) and events (e.g., a natural disaster). Most commonly in psychology, however, case studies provide a detailed description and analysis of an individual. Often the individual has a rare or unusual condition or disorder or has damage to a specific region of the brain. These studies can bear some similarity to non-experimental research approaches that are qualitative or observational.

Like many observational research methods, case studies tend to be more qualitative in nature. Case study methods involve an in-depth, and often a longitudinal examination of an individual. Depending on the focus of the case study, individuals may or may not be observed in their natural setting. If the natural setting is not what is of interest, then the individual may be brought into a therapist’s office or a researcher’s lab for study. Also, the bulk of the case study report will focus on in-depth descriptions of the person rather than on statistical analyses. With that said some quantitative data may also be included in the write-up of a case study. For instance, an individual’s depression score may be compared to normative scores or their score before and after treatment may be compared. As with other qualitative methods, a variety of different methods and tools can be used to collect information on the case. For instance, interviews, naturalistic observation, structured observation, psychological testing (e.g., IQ test), and/or physiological measurements (e.g., brain scans) may be used to collect information on the individual.

## Memory and patient H.M.

HM is one of the most famous case studies in psychology. HM suffered from intractable and very severe epilepsy. Epilepsy is a syndrome noted for severe seizures that result from neural dysfunction that often arises from a specific brain region, or foci, that sets of a brain-wide electrical storm. In severe cases where pharmacological treatment is ineffective, surgical resection (removal) of the foci region is sometimes done to reduce or eliminate subsequence seizure activity. This surgical approach is still used today in some cases and is preceded by an extensive set of assessments aimed to identifying the specific foci region and to carefully avoid removing any “eloquent” (still functioning) cortex.

HM’s surgical treatment predated the modern understanding of critical brain regions for specific cognitive functions and the tools to do very careful mapping of still-functioning cortical regions. As a result, Scoville & Milner (1957) described a large, bilateral resection of cortical regions around the medial temporal lobe brain regions. For the epilepsy and subsequent seizure activity, the treatment was a success, however it soon became clear that HM’s cognitive function had been substantially altered. HM exhibited a pattern of memory impairment that came to be called anterograde amnesia, reflecting an inability to form new memories. Almost all other aspects of standard cognitive function were completely intact. He could carry on conversation, carry out problem solving and decision-making exercises. His knowledge of language and basic semantic information about the world was fully functional. Nothing about his experiences after the surgery was stored, resulting in the peculiar experience that if you left the room and returned, he was unaware that he had ever seen you before. Almost all his previously acquired knowledge and memories were intact, but nothing new could be added to his memory store.

This case was revolutionary in the understanding of the organization of memory in the brain as prior to the description of HM, it had not been thought possible for memory acquisition to be separate from the rest of the basic functions of memory. In the decades after the case study of HM, many other patients with similar patterns of memory impairment were identified. Most of which have deficits not as severe as HM, but the characterization of his pattern of intact and impaired functions provided important ideas in understanding the neural organization of the brain’s memory systems. The study of patient HM also inspired a range of further research looking for other cognitive processes that could be strongly connected to specific brain regions, an area of research known as **cognitive neuropsychology**.

## Case studies as illustrating descriptions

The history of psychology is filled with influential cases studies, such as Sigmund Freud’s description of “Anna O.” Sigmund Freud used the case of a young woman to illustrate many principles of his theory of psychoanalysis (Freud, 1961). (Her real name was Bertha Pappenheim, and she was an early feminist who went on to make important contributions to the field of social work.) Anna had come to Freud’s colleague Josef Breuer around 1880 with a variety of odd physical and psychological symptoms. One of them was that for several weeks she was unable to drink any fluids. According to Freud,

She would take up the glass of water that she longed for, but as soon as it touched her lips she would push it away like someone suffering from hydrophobia.…She lived only on fruit, such as melons, etc., so as to lessen her tormenting thirst. (p. 9)

But according to Freud, a breakthrough came one day while Anna was under hypnosis.

[S]he grumbled about her English “lady-companion,” whom she did not care for, and went on to describe, with every sign of disgust, how she had once gone into this lady’s room and how her little dog—horrid creature!—had drunk out of a glass there. The patient had said nothing, as she had wanted to be polite. After giving further energetic expression to the anger she had held back, she asked for something to drink, drank a large quantity of water without any difficulty, and awoke from her hypnosis with the glass at her lips; and thereupon the disturbance vanished, never to return. (p.9)

Freud’s interpretation was that Anna had repressed the memory of this incident along with the emotion that it triggered and that this was what had caused her inability to drink. Furthermore, he believed that her recollection of the incident, along with her expression of the emotion she had repressed, caused the symptom to go away.

As an illustration of Freud’s theory, the case study of Anna O. is quite effective. As evidence for the theory, however, it is essentially worthless. The description provides no way of knowing whether Anna had really repressed the memory of the dog drinking from the glass, whether this repression had caused her inability to drink, or whether recalling this “trauma” relieved the symptom. It is also unclear from this case study how typical or atypical Anna’s experience was.

Case studies are useful because they provide a level of detailed analysis not found in many other research methods and greater insights may be gained from this more detailed analysis. As a result of the case study, the researcher may gain a sharpened understanding of what might become important to look at more extensively in future more controlled research. Case studies are also often the only way to study rare conditions because it may be impossible to find a large enough sample of individuals with the condition to use quantitative methods. Although at first glance a case study of a rare individual might seem to tell us little about ourselves, they often do provide insights into normal behavior. The case of HM provided important insights into the role of the hippocampus in memory consolidation.

However, it is important to note that while case studies can provide *insights* into certain areas and variables to study, and can be useful in helping develop theories, they should never be used as evidence for theories. In other words, case studies can be used as inspiration to formulate theories and hypotheses, but those hypotheses and theories then need to be formally tested using more rigorous quantitative methods. The reason case studies shouldn’t be used to provide support for theories is that they suffer from problems with both internal and external validity. Case studies lack the proper controls that true experiments contain. As such, they suffer from problems with internal validity, so they cannot be used to determine causation.

## Phineas Gage

When case studies are based on known specific damage to brain regions provide some ability to draw a causal inference – damage to that area leads to the observed impairment – the difficult question to answer is about generalizability. It can never be fully determined if the same damage to any brain region will end up having the same impact for everybody else. Essentially, we cannot tell with current methods how similar brain organization is across people. The power of case studies is the ability to document even for one person that the observed pattern of damage and intact function is possible to occur.

Another particularly impactful case study for this idea is the case of Phineas Gage. In the mid-19th century, Phineas Gage suffered an injury in a factor that led to an iron bar being blasted through part of his skill causing the loss of an eye and damage to the prefrontal cortex just above the eye. He survived the injury and additionally surprisingly exhibited very little impairment in general cognitive function. He did not exhibit difficulty in speaking (aphasia), recognizing objects (agnosia) or any pattern of motor impairment that is often associated with brain damage due to stroke (that impact motor control regions). However, reports at the time documented a very robust change in his personality and mannerisms. His behavior became extremely rude, marked by gross profanity and he appeared to unable to follow plans.

Unlike HM, other patients with damage to the general region impacted by Gage’s injury do not exhibit precisely the same pattern of impairment. Deficits like Gage are termed problems with “comportment” that do occur in some syndromes associated with prefrontal cortex damage. Modern studies of cognitive neuroscience have found a wide range of cognitive operations that depend on this brain region and also documented that there is great variety across individuals in how this system is organized. This part of the human brain is also notable as being the most distinct from all other great apes, likely reflecting the parts of the brain most greatly changed in the evolution of modern humans. As a case study, Gage clearly indicates a relationship of comportment and planning to these regions and then served to motivate studies since to identify the neural basis and operation of these processes.

## Cognitive Neuroscience and Neuroimaging Methods

The field of Cognitive Neuroscience reflects research on the understanding of the relationship of the neural operation of the brain to human cognitive processes. Many modern studies of this relationship have been inspired by case studies of specific damage and constrained patterns of cognitive impairment. Some of this research is done with neuropsychological methods of looking for new cases with similar patterns or differing patterns associated with damage to similar brain regions. A great deal of this research aims to build from the neuropsychological studies to studies of cognitively healthy operation using methods of neuroimaging.

Neuroimaging methods are techniques for collecting data about brain function noninvasively from humans. Examples of these techniques include functional magnetic resonance imaging (fMRI), electro-encephalography (EEG) and transcranial magnetic stimulation (TMS). Detailed discussion of these methods is beyond the scope of this text but depends on the same underlying research method processes used here. Constructs must be implemented as precisely defined operational definitions that are suitable for use in neuroimaging contexts. Extraneous variables are controlled via constancy or counterbalancing to the greatest extent possible. The measured operational definitions of the dependent variables is often quite different, reflecting data collection from thousands of neuroimaging “voxels” or hundreds of EEG electrodes. Inferences drawn from these data are done, however, in exactly the same way we draw inferences from simpler behavioral measures in the experimental psychology methods described here.