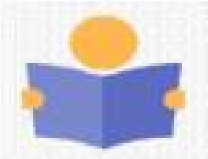
1.Definitions of Individual Differences.

"Variations or deviations from the average of the group, with respect to the mental or physical characters, occurring in the individual member of the group are individual differences."

https://www.youtube.com/watch?v=Cg8HrChyq0A

"Individual differences are found in all psychological characteristics physical mental abilities, knowledge, habit, personality and character traits."



According to Skinner, "Today we think of individual differences as including any measurable aspect of the total personality." It is clear from this definition of individual differences that it comprehends every aspect of human personality which is in some manner measurable.

2.Types of Individual Differences

That the persons may differ in one type or more of ………………such as :

1. Physical differences:

Shortness or tallness of stature, darkness or fairness of complexion, fatness, thinness, or weakness are various physical individual differences.

2. Differences in intelligence:

There are differences in intelligence level among different individuals. We can classify the individuals from super-normal (above 120 I.Q.) to idiots (from 0 to 50 I.Q.) on the basis of their intelligence level.

Wechsler (WAIS–III) 1997 IQ test classification

IQ Range ("deviation IQ")	IQ Classification
130 and above	Very superior
120–129	Superior
110–119	High average
90–109	Average
80–89	Low average
70–79	Borderline
69 and below	Extremely low

3. Differences in attitudes:

Individuals differ in their attitudes towards different people, objects, institutions and so on.

4. Differences in achievement:

It has been found through achievement tests that individuals differ in their achievement abilities. These differences are very much visible in reading, writing and in learning mathematics.

These differences in achievement are even visible among the children who are at the same level of intelligence. These differences are on account of the differences in the various factors of intelligence and the differences in the various experiences, interests and educational background.
And there are another types such as motor ability , gender, and so on .
3.Causes of Individual Differences

These causes may be , as we will say later:

Some of the main causes of individual differences are as under:

1. Heredity:

One of the most significant and chief causes of individual differences is heredity. Individuals inherit various physical traits like face with its features, color of eyes and hair, type of skin, shape of skull and size of hands, colour blindness, baldness, stub-finger and tendency to certain diseases like cancer and tuberculosis, mental traits like intelligence, abstract thinking, aptitudes and prejudices. Now it is an admitted fact that heredity differences result in the quantity and rate of physical as well as mental development being different and different individuals.

2. Environment:

Environment significantly influences individual differences. Changes in child's environment are reflected in the changes in his personality. Psychologically speaking, a person's environment consists of sum total of stimulation which he receives from conception until his death.

Environment consists of physical, intellectual, social, moral, political, economic and cultural forces. All these forces cause individual differences. Modern psychologists believe that individual differences are caused by both heredity and environment. Personality is the outcome of mutual interaction between heredity and environment.

3. Influence of caste, race and nation:

Individuals of different castes and races exhibit very marked differences. It is generally seen that son of a Kshatriya has a more of courage in him while the son of a trader has the traits of business.

Similarly individuals of different nations show differences in respect of their personality, character and mental abilities. These are the outcome of their geographical, social and cultural environment. Many studies have shown the existence of differences between Americans and Negroes, Chinese and Japanese, English and Indian individuals.

4. Sex differences:

Development of boys and girls exhibits differences due to difference in sex. The physical development of the girl takes place a year or two earlier than the boys. Between the age of 11 and 14, girls are taller and heavier than the boys. After 15, boys start winning the race.

Girls are kind, affectionate, sympathetic and tender while the boys are brave, hard, choleric, efficient and competent.

And there are other causes that are limited to the mental , social , cultural , and so on.

Task1: Express in your own words the causes of individual differences

One of the important objectives of modern education is the complete development of the individual. Individuals have different goals, different interests, different emotional problems and different abilities. We cannot afford to ignore these individual differences in imparting education to children. Since school work is planned on group basis it presents a formidable challenge to all teachers.

Hence some practical procedures for adapting school work to individual differences are suggested:

1. Limited size of the class:

Generally there are 50 or more than 50 students in a class. In such a large class, it is not possible for the teacher to pay individual attention to the students. The size of the class should be small. It should be divided into various units so that after class-room work their various difficulties may be found out.

2. Proper division of the class:

Now there are separate classes for the students, who have different intelligence. While bringing about this classification, the teacher should keep in mind the difference in age, interests, emotional and social qualities.

3. Home task:

The teacher should assign home task to the students while keeping in view the individual differences.

4. Factor of sex:

Boys and girls are to play different roles in society. Hence the factor of sex should be kept in mind.

5. Curriculum:

The curriculum should be modified to suit the needs of all types of children. A large number of subjects should be included in the curriculum so that education can be provided to each child according to his interests, needs and abilities. Curriculum should not be rigid but it should be flexible.

6. Methods of Teaching:

Methods of teaching should be chosen on the basis of individual differences. It is not advisable to use the same method of education in the case of all children-gifted or backward.

7. Educational Guidance:

Teacher should impart educational guidance to the students while keeping in view their individual differences. He can assist them in the selection of educational career, selection of subjects, selection of books, selection of hobbies and co-curricular activities and in many other areas connected with education.

Chapter 8

Memory

In this section we will consider the two types of memory, *explicit memory* and *implicit memory*, and then the three major memory stages: *sensory*, *short-term*, and *long-term* (Atkinson & Shiffrin, 1968). [1] Then, in the next section, we will consider the nature of long-term memory, with a particular emphasis on the cognitive techniques we can use to improve our memories. Our discussion will focus on the three processes that are central to long-term memory: *encoding*, *storage*, and *retrieval*.

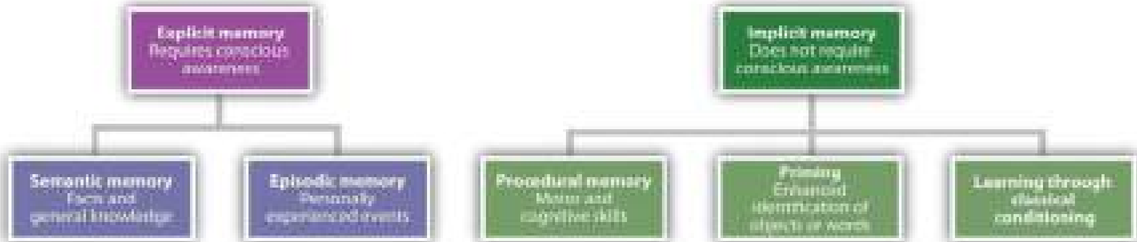
Table 8.1 Memory Conceptualized in Terms of Types, Stages, and Processes

As types	Explicit memory
	Implicit memory
As stages	Sensory memory
	Short-term memory
	Long-term memory
As processes	Encoding
	Storage
	Retrieval

Explicit Memory

When we assess memory by asking a person to consciously remember things, we are measuring *explicit memory*. Explicit memory refers to *knowledge or experiences that can be consciously remembered*. As you can see in Figure 8.2 "Types of Memory", there are two types of explicit memory: *episodic* and*semantic*. Episodic memory refers to *the firsthand experiences that we have had* (e.g., recollections of our high school graduation day or of the fantastic dinner we had in New York last year). Semantic memory refers to *our knowledge of facts and concepts about the world* (e.g., that the absolute value of −90 is greater than the absolute value of 9 and that one definition of the word "affect" is "the experience of feeling or emotion").

Figure 8.2 Types of Memory



Explicit memory is assessed using measures in which the individual being tested must consciously attempt to remember the information. A recall memory test is *a measure of explicit memory that involves bringing from memory information that has previously been remembered.* We rely on our recall memory when we take an essay test, because the test requires us to generate previously remembered information. A multiple-choice test is an example of a recognition memory test, *a measure of explicit memory that involves determining whether information has been seen or learned before.*

Your own experiences taking tests will probably lead you to agree with the scientific research finding that recall is more difficult than recognition. Recall, such as required on essay tests, involves two steps: first generating an answer and then determining whether it seems to be the correct one. Recognition, as on multiple-choice test, only involves determining which item from a list seems most correct (Haist, Shimamura, & Squire, 1992).[2] Although they involve different processes, recall and recognition memory measures tend to be correlated. Students who do better on a multiple-choice exam will also, by and large, do better on an essay exam (Bridgeman & Morgan, 1996).[3]

A third way of measuring memory is known as *relearning* (Nelson, 1985).[4] Measures of relearning (or savings) *assess how much more quickly information is processed or learned when it is studied again after it has already been learned but then forgotten.* If you have taken some French courses in the past, for instance, you might have forgotten most of the vocabulary you learned. But if you were to work on your French again, you'd learn the vocabulary much faster the second time around. Relearning can be a more sensitive measure of memory than either recall or recognition because it allows assessing memory in terms of "how much" or "how fast" rather than simply "correct" versus "incorrect" responses. Relearning also allows us to measure memory for procedures like driving a car or playing a piano piece, as well as memory for facts and figures.

Implicit Memory

While explicit memory consists of the things that we can consciously report that we know, implicit memory refers to knowledge that we cannot consciously access. However, implicit memory is nevertheless exceedingly important to us because it has a direct effect on our behavior. Implicit memory refers to *the influence of experience on behavior, even if the individual is not aware of those influences.* As you can see in Figure 8.2 "Types of Memory", there are three general types of implicit memory: procedural memory, classical conditioning effects, and priming.

Procedural memory refers to *our often unexplainable knowledge of how to do things*. When we walk from one place to another, speak to another person in English, dial a cell phone, or play a video game, we are using procedural memory. Procedural memory allows us to perform complex tasks, even though we may not be able to explain to others how we do them. There is no way to tell someone how to ride a bicycle; a person has to learn by doing it. The idea of implicit memory helps explain how infants are able to learn. The ability to crawl, walk, and talk are procedures, and these skills are easily and efficiently developed while we are children despite the fact that as adults we have no conscious memory of having learned them.

A second type of implicit memory is classical conditioning effects, in which we learn, often without effort or awareness, to associate neutral stimuli (such as a sound or a light) with another stimulus (such as food), which creates a naturally occurring response, such as enjoyment or salivation. The memory for the association is demonstrated when the conditioned stimulus (the sound) begins to create the same response as the unconditioned stimulus (the food) did before the learning.

The final type of implicit memory is known as priming, or *changes in behavior as a result of experiences that have happened frequently or recently*. Priming refers both to the activation of knowledge (e.g., we can prime the concept of "kindness" by presenting people with words related to kindness) and to the influence of that activation on behavior (people who are primed with the concept of kindness may act more kindly).

Research Focus: Priming Outside Awareness Influences Behavior

One of the most important characteristics of implicit memories is that they are frequently formed and used *automatically*, without much effort or awareness on our part. In one demonstration of the automaticity and influence of priming effects, John Bargh and his colleagues (Bargh, Chen, & Burrows, 1996) [5] conducted a study in which they showed college students lists of five scrambled words, each of which they were to make into a sentence. Furthermore, for half of the research participants, the words were related to stereotypes of the elderly. These participants saw words such as the following:

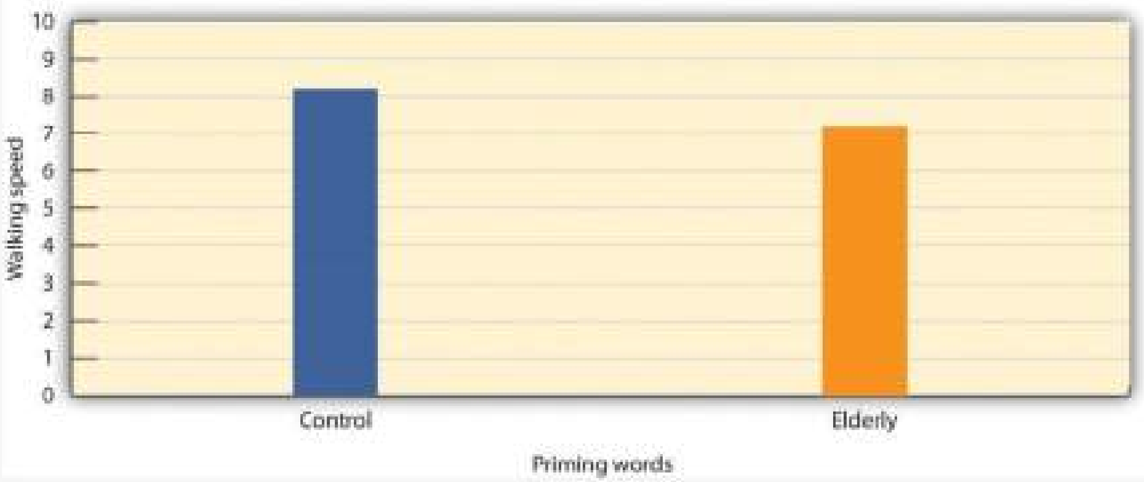
in Florida retired live people

bingo man the forgetful plays

The other half of the research participants also made sentences, but from words that had nothing to do with elderly stereotypes. The purpose of this task was to prime stereotypes of elderly people in memory for some of the participants but not for others.

The experimenters then assessed whether the priming of elderly stereotypes would have any effect on the students' behavior—and indeed it did. When the research participant had gathered all of his or her belongings, thinking that the experiment was over, the experimenter thanked him or her for participating and gave directions to the closest elevator. Then, without the participants knowing it, the experimenters recorded the amount of time that the participant spent walking from the doorway of the experimental room toward the elevator. As you can see in Figure 8.3 "Results From Bargh, Chen, and Burrows, 1996", participants who had made sentences using words related to elderly stereotypes took on the behaviors of the elderly—they walked significantly more slowly as they left the experimental room.

*Figure 8.3*Results From Bargh, Chen, and Burrows, 1996



Bargh, Chen, and Burrows (1996) found that priming words associated with the elderly made people walk more slowly.

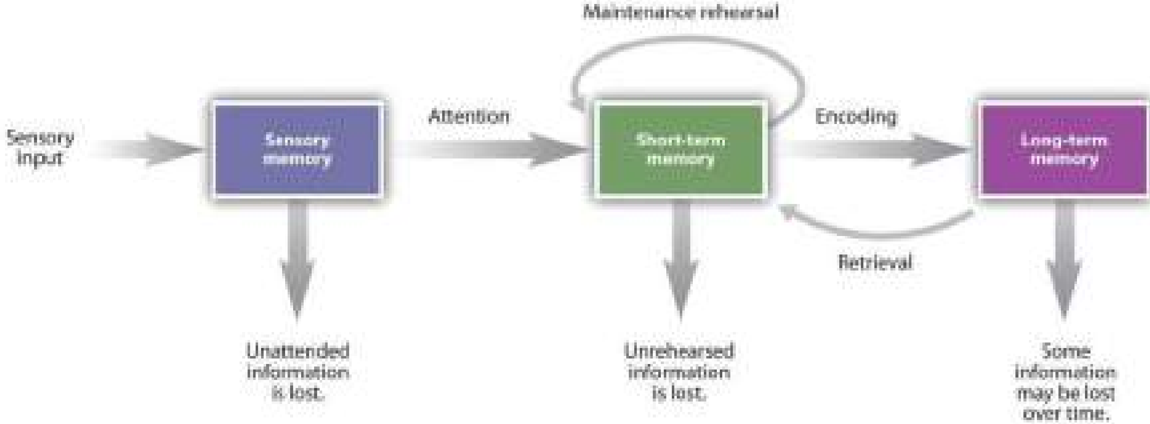
Source: Adapted from Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action. Journal of Personality & Social Psychology, 71, 230–244.

To determine if these priming effects occurred out of the awareness of the participants, Bargh and his colleagues asked still another group of students to complete the priming task and then to indicate whether they thought the words they had used to make the sentences had any relationship to each other, or could possibly have influenced their behavior in any way. These students had no awareness of the possibility that the words might have been related to the elderly or could have influenced their behavior.

Stages of Memory: Sensory, Short-Term, and Long-Term Memory

Another way of understanding memory is to think about it in terms of stages that describe the length of time that information remains available to us. According to this approach (see Figure 8.4 "Memory Duration"), information begins in *sensory memory*, moves to *short-term memory*, and eventually moves to *long-term memory*. But not all information makes it through all three stages; most of it is forgotten. Whether the information moves from shorter-duration memory into longer-duration memory or whether it is lost from memory entirely depends on how the information is attended to and processed.

Figure 8.4 Memory Duration



Memory can characterized in terms of stages—the length of time that information remains available to us.

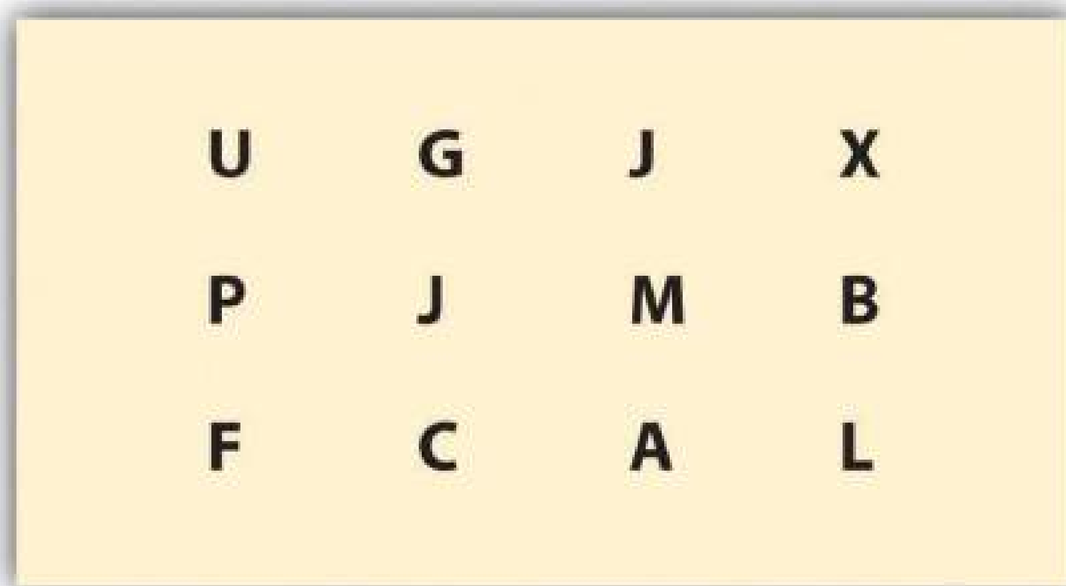
Source: Adapted from Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. Spence (Ed.), The psychology of learning and motivation (Vol. 2). Oxford, England: Academic Press.

Sensory Memory

Sensory memory refers to *the brief storage of sensory information*. Sensory memory is a memory buffer that lasts only very briefly and then, unless it is attended to and passed on for more processing, is forgotten. The purpose of sensory memory is to give the brain some time to process the incoming sensations, and to allow us to see the world as an unbroken stream of events rather than as individual pieces.

Visual sensory memory is known as iconic memory. Iconic memory was first studied by the psychologist George Sperling (1960).[6] In his research, Sperling showed participants a display of letters in rows, similar to that shown in Figure 8.5 "Measuring Iconic Memory". However, the display lasted only about 50 milliseconds (1/20 of a second). Then, Sperling gave his participants a recall test in which they were asked to name all the letters that they could remember. On average, the participants could remember only about one-quarter of the letters that they had seen.

Figure 8.5 Measuring Iconic Memory



Sperling (1960) showed his participants displays such as this one for only 1/20th of a second. He found that when he cued the participants to report one of the three rows of letters, they could do it, even if the cue was given shortly after the display had been removed. The research demonstrated the existence of iconic memory.

Source: Adapted from Sperling, G. (1960). The information available in brief visual presentation. Psychological Monographs, 74(11), 1–29.

Sperling reasoned that the participants had seen all the letters but could remember them only very briefly, making it impossible for them to report them all. To test this idea, in his next experiment he first showed the same letters, but then *after the display had been removed*, he signaled to the participants to report the letters from either the first, second, or third row. In this condition, the participants now reported almost all the letters in that row. This finding confirmed Sperling's hunch: Participants had access to all of the letters in their iconic memories, and if the task was short enough, they were able to report on the part of the display he asked them to. The "short enough" is the length of iconic memory, which turns out to be about 250 milliseconds (¼ of a second).

Auditory sensory memory is known as echoic memory. In contrast to iconic memories, which decay very rapidly, echoic memories can last as long as 4 seconds (Cowan, Lichty, & Grove, 1990).[7] This is convenient as it allows you—among other things—to remember the words that you said at the beginning of a long sentence when you get to the end of it, and to take notes on your psychology professor's most recent statement even after he or she has finished saying it.

In some people iconic memory seems to last longer, a phenomenon known as *eidetic imagery* (or "photographic memory") in which people can report details of an image over long periods of time. These people, who often suffer from psychological disorders such as autism, claim that they can "see" an image long after it has been presented, and can often report accurately on that image. There is also some evidence for eidetic memories in hearing; some people report that their echoic memories persist for unusually long periods of time. The composer Wolfgang Amadeus Mozart may have possessed eidetic memory for music, because even when he was very young and had not yet had a great deal of musical training, he could listen to long compositions and then play them back almost perfectly (Solomon, 1995).[8]

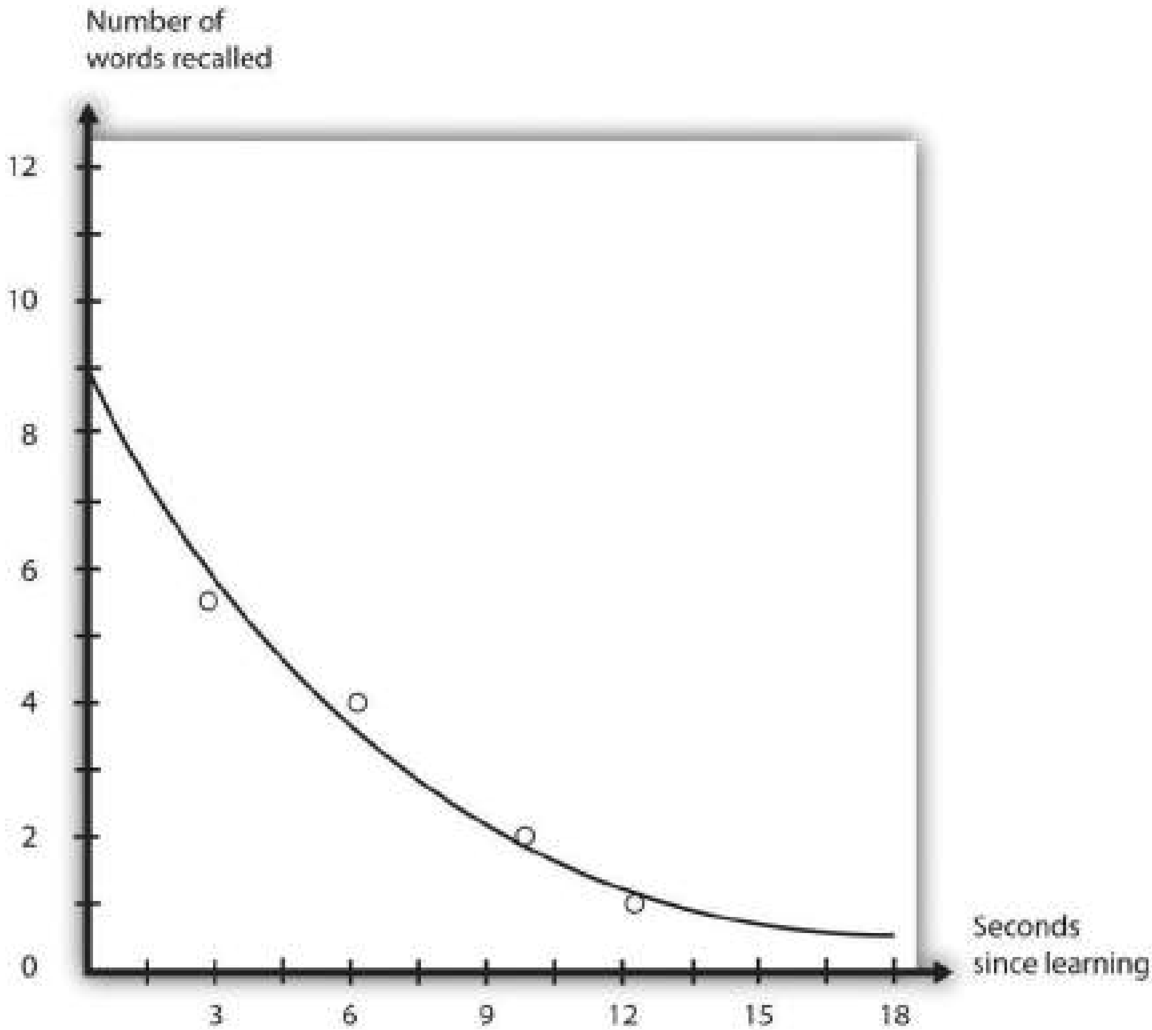
Short-Term Memory

Most of the information that gets into sensory memory is forgotten, but information that we turn our attention to, with the goal of remembering it, may pass into *short-term memory*. Short-term memory (STM) is *the place where small amounts of information can be temporarily kept for more than a few seconds but usually for less than one minute* (Baddeley, Vallar, & Shallice, 1990).[9] Information in short-term memory is not stored permanently but rather becomes available for us to process, and *the processes that we use to make sense of, modify, interpret, and store information in STM* are known as working memory.

Although it is called "memory," working memory is not a store of memory like STM but rather a set of memory procedures or operations.

Short-term memory is limited in both the length and the amount of information it can hold. Peterson and Peterson (1959)[10] found that when people were asked to remember a list of three-letter strings and then were immediately asked to perform a distracting task (counting backward by threes), the material was quickly forgotten (see Figure 8.6 "STM Decay"), such that by 18 seconds it was virtually gone.

Figure 8.6 STM Decay



Peterson and Peterson (1959) found that information that was not rehearsed decayed quickly from memory.

Source: Adapted from Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. Journal of Experimental Psychology, 58(3), 193–198.

One way to prevent the decay of information from short-term memory is to use working memory to rehearse it. Maintenance rehearsal is *the process of repeating information mentally or out loud with the goal of keeping it in memory*. We engage in maintenance rehearsal to keep a something that we want to remember (e.g., a person's name, e-mail address, or phone number) in mind long enough to write it down, use it, or potentially transfer it to long-term memory.

If we continue to rehearse information it will stay in STM until we stop rehearsing it, but there is also a capacity limit to STM. Try reading each of the following rows of numbers, one row at a time, at a rate of about one number each second. Then when you have finished each row, close your eyes and write down as many of the numbers as you can remember.

019

3586

10295

861059

1029384

75674834

657874104

6550423897

If you are like the average person, you will have found that on this test of working memory, known as a *digit span test*, you did pretty well up to about the fourth line, and then you started having trouble. I bet you missed some of the numbers in the last three rows, and did pretty poorly on the last one.

The digit span of most adults is between five and nine digits, with an average of about seven. The cognitive psychologist George Miller (1956)[11] referred to "seven plus or minus two" pieces of information as the "magic number" in short-term memory. But if we can only hold a maximum of about nine digits in short-term memory, then how can we remember larger amounts of information than this? For instance, how can we ever remember a 10-digit phone number long enough to dial it?

One way we are able to expand our ability to remember things in STM is by using a memory technique called *chunking*. Chunking is *the process of organizing information into smaller groupings (chunks), thereby increasing the number of items that can be held in STM*. For instance, try to remember this string of 12 letters:

XOFCBANNCVTM

You probably won't do that well because the number of letters is more than the magic number of seven.

Now try again with this one:

MTVCNNABCFOX

Would it help you if I pointed out that the material in this string could be chunked into four sets of three letters each? I think it would, because then rather than remembering 12 letters, you would only have to remember the names of four television stations. In this case, chunking changes the number of items you have to remember from 12 to only four.

[1] Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. Spence (Ed.), *The psychology of learning and motivation* (Vol. 2). Oxford, England: Academic Press.

[2] Haist, F., Shimamura, A. P., & Squire, L. R. (1992). On the relationship between recall and recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*(4), 691–702.

[3] Bridgeman, B., & Morgan, R. (1996). Success in college for students with discrepancies between performance on multiple-choice and essay tests. *Journal of Educational Psychology, 88*(2), 333–340.

[4] Nelson, T. O. (1985). Ebbinghaus's contribution to the measurement of retention: Savings during relearning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*(3), 472–478.

[5] Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action. *Journal of Personality & Social Psychology, 71*, 230–244.

[6] Sperling, G. (1960). The information available in brief visual presentation. *Psychological Monographs, 74*(11), 1–29.

[7] Cowan, N., Lichty, W., & Grove, T. R. (1990). Properties of memory for unattended spoken syllables. *Journal of Experimental*

Psychology: Learning, Memory, and Cognition, 16(2), 258–268.

[8] Solomon, M. (1995). *Mozart: A life*. New York, NY: Harper Perennial.

[9] Baddeley, A. D., Vallar, G., & Shallice, T. (1990). The development of the concept of working memory: Implications and contributions of neuropsychology. In G. Vallar & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory* (pp. 54–73). New York, NY: Cambridge University Press.

[10] Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items.*Journal of Experimental Psychology, 58*(3), 193–198.

[11] Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81–97.

Although it is useful to hold information in sensory and short-term memory, we also rely on our long-term memory (LTM). We want to remember the name of the new boy in the class, the name of the movie we saw last week, and the material for our upcoming psychology test. Psychological research has produced a great deal of knowledge about long-term memory, and this research can be useful as you try to learn and remember new material (see Table 8.2 "Helpful Memory Techniques Based on Psychological Research"). In this section we will consider this question in terms of the types of processing that we do on the information we want to remember. To be successful, the information that we want to remember must be *encoded* and *stored*, and then *retrieved*.

Table 8.2 Helpful Memory Techniques Based on Psychological Research

Technique	Description	Useful example
Use elaborative encoding.	Material is better remembered if it is processed more fully.	Think, for instance, "Proactive interference is like retroactive interference but it occurs in a forward manner."
Make use of the self-reference effect.	Material is better remembered if it is linked to thoughts about the self.	Think, for instance, "I remember a time when I knew the answer to an exam question but couldn't quite get it to come to mind. This was an example of the tip-of-the-tongue phenomenon."
Be aware of the forgetting curve.	Information that we have learned drops off rapidly with time.	Review the material that you have already studied right before the exam to increase the likelihood it will remain in memory.

Make use of the spacing effect.	Information is learned better when it is studied in shorter periods spaced over time.	Study a little bit every day; do not cram at the last minute.
Rely on overlearning.	We can continue to learn even after we think we know the information perfectly.	Keep studying, even if you think you already have it down.
Use context-dependent retrieval.	We have better retrieval when it occurs in the same situation in which we learned the material.	If possible, study under conditions similar to the conditions in which you will take the exam.
Use state-dependent retrieval.	We have better retrieval when we are in the same psychological state as we were when we learned the material.	Many possibilities, but don't study under the influence of drugs or alcohol, unless you plan to use them on the day of the exam (which is not recommended).

Encoding and Storage: How Our Perceptions Become Memories

Encoding is *the process by which we place the things that we experience into memory*. Unless information is encoded, it cannot be remembered. I'm sure you've been to a party where you've been introduced to someone and then—maybe only seconds later—you realize that you do not remember the person's name. Of course it's not really surprising that you can't remember the name, because you probably were distracted and you never encoded the name to begin with.

Not everything we experience can or should be encoded. We tend to encode things that we need to remember and not bother to encode things that are irrelevant. Look at Figure 8.8 "Pennies in Different Styles", which shows different images of U.S. pennies. Can you tell which one is the real one? Nickerson and Adams (1979) [1] found that very few of the U.S. participants they tested could identify the right one. We see pennies a lot, but we don't bother to encode their features.

Figure 8.8 Pennies in Different Styles

Can you identify the "real" penny? We tend to have poor memory for things that don't matter, even if we see them frequently.

One way to improve our memory is to use better encoding strategies. Some ways of studying are more effective than others. Research has found that we are better able to remember information if we encode it in a meaningful way. When we engage in elaborative encoding we *process new information in ways that make it more relevant or meaningful* (Craik & Lockhart, 1972; Harris & Qualls, 2000).[2]

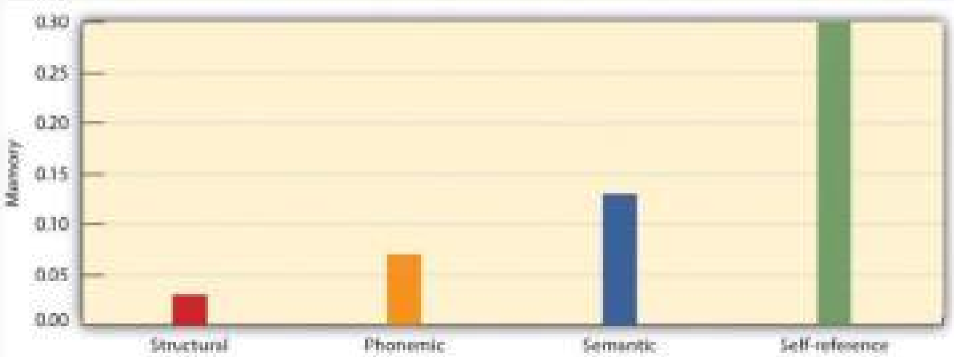
Imagine that you are trying to remember the characteristics of the different schools of psychology we discussed in Chapter 1 "Introducing Psychology". Rather than simply trying to remember the schools and their characteristics, you might try to relate the information to things you already know. For instance, you might try to remember the fundamentals of the cognitive school of psychology by linking the characteristics to the computer model. The cognitive school focuses on how information is input, processed, and retrieved, and you might think about how computers do pretty much the same thing. You might also try to organize the information into meaningful units. For instance, you might link the cognitive school to structuralism because both were concerned with mental processes. You also might try to use visual cues to help you remember the information. You might look at the image of Freud and imagine what he looked like as a child. That image might help you remember that childhood experiences were an important part of Freudian theory. Each person has his or her unique way of elaborating on information; the important thing is to try to develop unique and meaningful associations among the materials.

Research Focus: Elaboration and Memory

In an important study showing the effectiveness of elaborative encoding, Rogers, Kuiper, and Kirker (1977) [3] studied how people recalled information that they had learned under different processing conditions. All the participants were presented with the same list of 40 adjectives to learn, but through the use of random assignment, the participants were given one of four different sets of instructions about how to process the adjectives. Participants assigned to the structural task condition were asked to judge whether the word was printed in uppercase or lowercase letters. Participants in the phonemic task condition were asked whether or not the word rhymed with another given word. In the semantic task condition, the participants were asked if the word was a synonym of another word. And in the self-reference task condition, participants were asked to indicate whether or not the given adjective was or was not true of themselves. After completing the specified task, each participant was asked to recall as many adjectives as he or she could remember.

Rogers and his colleagues hypothesized that different types of processing would have different effects on memory. As you can see in Figure 8.9 "Self-Reference Effect Results", the students in the self-reference task condition recalled significantly more adjectives than did students in any other condition. This finding, known as the self-reference effect, is powerful evidence that the self-concept helps us organize and remember information. The next time you are studying for an exam, you might try relating the material to your own experiences. The self-reference effect suggests that doing so will help you better remember the information (Symons & Johnson, 1997).[4]

Figure 8.9 Self-Reference Effect Results



Participants recalled the same words significantly better when they were processed in relation to the self than when they were processed in other ways.

Source: Adapted from Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. Journal of Personality & Social Psychology, 35(9), 677–688.

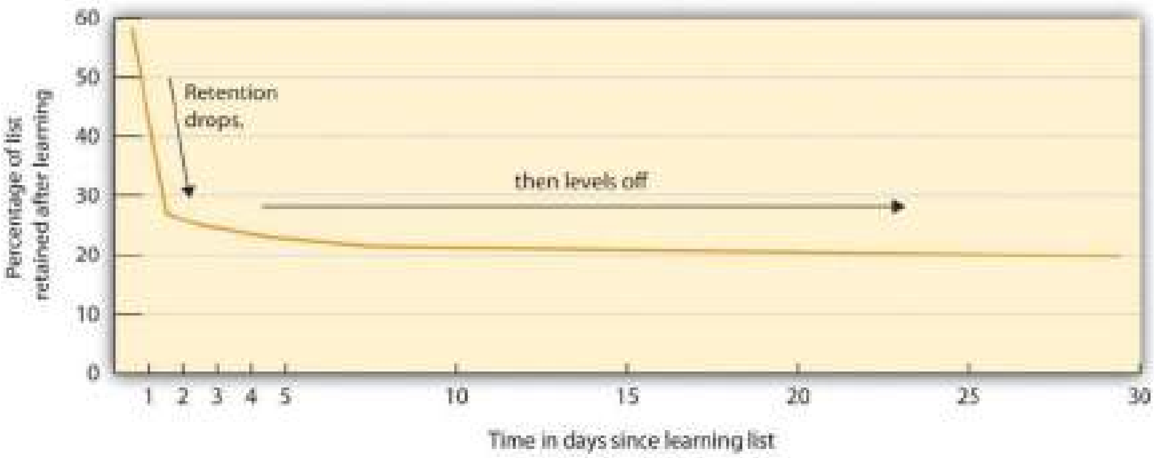
Using the Contributions of Hermann Ebbinghaus to Improve Your Memory

Hermann Ebbinghaus (1850–1909) was a pioneer of the study of memory. In this section we consider three of his most important findings, each of which can help you improve your memory. In his research, in which he was the only research participant, Ebbinghaus practiced memorizing lists of nonsense syllables, such as the following:

DIF, LAJ, LEQ, MUV, WYC, DAL, SEN, KEP, NUD

You can imagine that because the material that he was trying to learn was not at all meaningful, it was not easy to do. Ebbinghaus plotted how many of the syllables he could remember against the time that had elapsed since he had studied them. He discovered an important principle of memory: Memory decays rapidly at first, but the amount of decay levels off with time (Figure 8.10 "Ebbinghaus Forgetting Curve"). Although Ebbinghaus looked at forgetting after days had elapsed, the same effect occurs on longer and shorter time scales. Bahrick (1984)[5] found that students who took a Spanish language course forgot about one half of the vocabulary that they had learned within three years, but that after that time their memory remained pretty much constant. Forgetting also drops off quickly on a shorter time frame. This suggests that you should try to review the material that you have already studied right before you take an exam; that way, you will be more likely to remember the material during the exam.

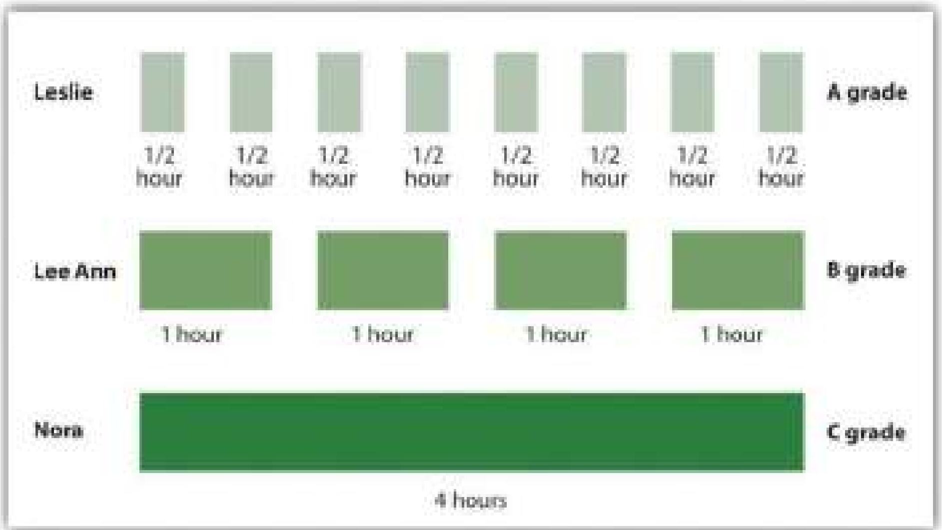
Figure 8.10 Ebbinghaus Forgetting Curve



Hermann Ebbinghaus found that memory for information drops off rapidly at first but then levels off after time.

Ebbinghaus also discovered another important principle of learning, known as the *spacing effect*. The spacing effect refers to *the fact that learning is better when the same amount of study is spread out over periods of time than it is when it occurs closer together or at the same time*. This means that even if you have only a limited amount of time to study, you'll learn more if you study continually throughout the semester (a little bit every day is best) than if you wait to cram at the last minute before your exam (Figure 8.11 "Effects of Massed Versus Distributed Practice on Learning"). Another good strategy is to study and then wait as long as you can before you forget the material. Then review the information and again wait as long as you can before you forget it. (This probably will be a longer period of time than the first time.) Repeat and repeat again. The spacing effect is usually considered in terms of the difference between *distributed practice* (practice that is spread out over time) and *massed practice* (practice that comes in one block), with the former approach producing better memory.

Figure 8.11 Effects of Massed Versus Distributed Practice on Learning



The spacing effect refers to the fact that memory is better when it is distributedrather than massed. Leslie, Lee Ann, and Nora all studied for four hours total, but the students who spread out their learning into smaller study sessions did better on the exam.

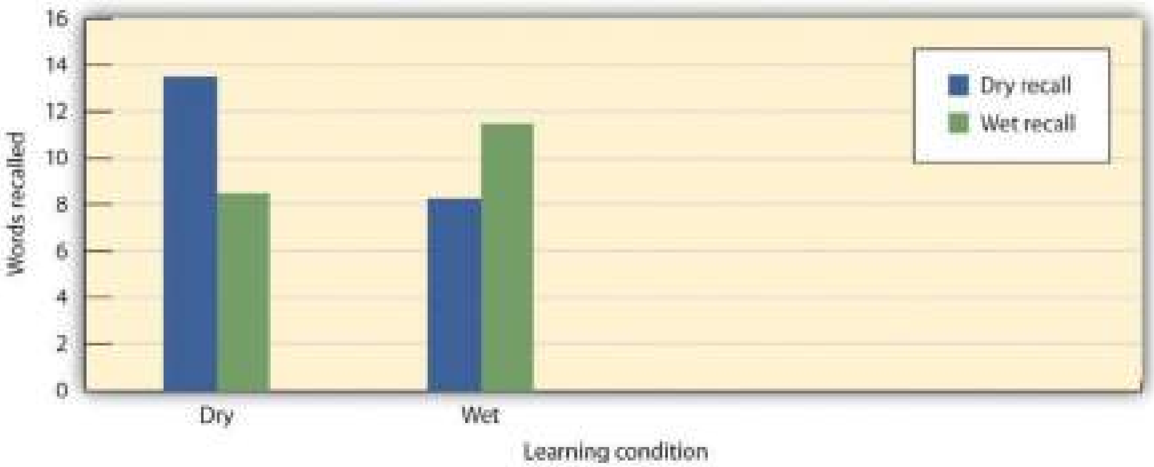
Ebbinghaus also considered the role of *overlearning*—that is, continuing to practice and study even when we think that we have mastered the material. Ebbinghaus and other researchers have found that overlearning helps encoding (Driskell, Willis, & Copper, 1992). [6] Students frequently think that they have already mastered the material but then discover when they get to the exam that they have not. The point is clear: Try to keep studying and reviewing, even if you think you already know all the material.

Retrieval

Even when information has been adequately encoded and stored, it does not do us any good if we cannot retrieve it. Retrieval refers to *the process of reactivating information that has been stored in memory*.

We are more likely to be able to retrieve items from memory when conditions at retrieval are similar to the conditions under which we encoded them. Context-dependent learning refers to *an increase in retrieval when the external situation in which information is learned matches the* *situation in which it is remembered*. Godden and Baddeley (1975) [7] conducted a study to test this idea using scuba divers. They asked the divers to learn a list of words either when they were on land or when they were underwater. Then they tested the divers on their memory, either in the same or the opposite situation. As you can see in Figure 8.12 "Results From Godden and Baddeley, 1975", the divers' memory was better when they were tested in the same context in which they had learned the words than when they were tested in the other context.

Figure 8.12 Results From Godden and Baddeley, 1975



Godden and Baddeley (1975) tested the memory of scuba divers to learn and retrieve information in different contexts and found strong evidence for context-dependent learning.

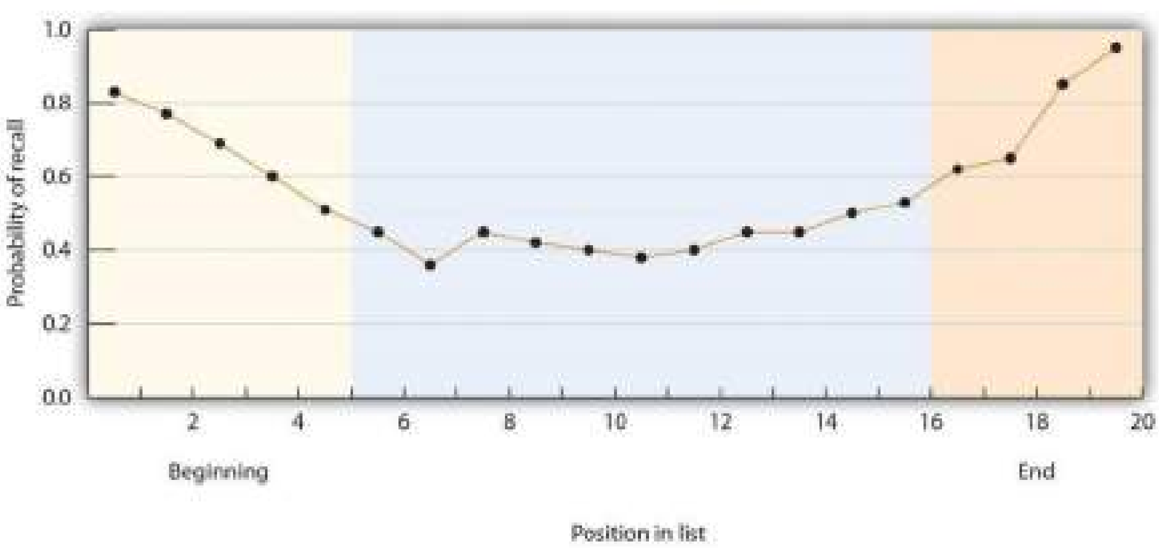
Source: Adapted from Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: On land and underwater.British Journal of Psychology, 66(3), 325–331.

You can see that context-dependent learning might also be important in improving your memory. For instance, you might want to try to study for an exam in a situation that is similar to the one in which you are going to take the exam.

Whereas context-dependent learning refers to a match in the external situation between learning and remembering, state-dependent learning refers to *superior retrieval of memories when the individual is in the same physiological or psychological state as during encoding*. Research has found, for instance, that animals that learn a maze while under the influence of one drug tend to remember their learning better when they are tested under the influence of the same drug than when they are tested without the drug (Jackson, Koek, & Colpaert, 1992). [8] And research with humans finds that bilinguals remember better when tested in the same language in which they learned the material (Marian & Kaushanskaya, 2007). [9] Mood states may also produce state-dependent learning. People who learn information when they are in a bad (rather than a good) mood find it easier to recall these memories when they are tested while they are in a bad mood, and vice versa. It is easier to recall unpleasant memories than pleasant ones when we're sad, and easier to recall pleasant memories than unpleasant ones when we're happy (Bower, 1981; Eich, 2008). [10]

Variations in the ability to retrieve information are also seen in the *serial position curve*. When we give people a list of words one at a time (e.g., on flashcards) and then ask them to recall them, the results look something like those in Figure 8.13 "The Serial Position Curve". People are able to retrieve more words that were presented to them at the beginning and the end of the list than they are words that were presented in the middle of the list. This pattern, known as the serial position curve, is caused by two retrieval phenomenon: The primacy effect refers to *a tendency to better remember stimuli that are presented early in a list*. The recency effect refers to *the tendency to better remember stimuli that are presented later in a list*.

Figure 8.13 The Serial Position Curve



The serial position curve is the result of both primacy effects and recency effects.

There are a number of explanations for primacy and recency effects, but one of them is in terms of the effects of rehearsal on short-term and long-term memory (Baddeley, Eysenck, & Anderson, 2009). [11] Because we can keep the last words that we learned in the presented list in short-term memory by rehearsing them before the memory test begins, they are relatively easily remembered. So the recency effect can be explained in terms of maintenance rehearsal in short-term memory. And the primacy effect may also be due to rehearsal—when we hear the first word in the list we start to rehearse it, making it more likely that it will be moved from short-term to long-term memory. And the same is true for the other words that come early in the list. But for the words in the middle of the list, this rehearsal becomes much harder, making them less likely to be moved to LTM.

In some cases our existing memories influence our new learning. This may occur either in a backward way or a forward way. Retroactive interference occurs when *learning something new impairs our ability to retrieve information that was learned earlier*. For example, if you have learned to program in one computer language, and then you learn to program in another similar one, you may start to make mistakes programming the first language that you never would have made before you learned the new one. In this case the new memories work backward (retroactively) to influence retrieval from memory that is already in place.

In contrast to retroactive interference, *proactive interference* works in a forward direction. Proactive interference occurs when *earlier learning impairs our ability to encode information that we try to learn later*. For example, if we have learned French as a second language, this knowledge may make it more difficult, at least in some respects, to learn a third language (say Spanish), which involves similar but not identical vocabulary.

The Biology of Memory

Just as information is stored on digital media such as DVDs and flash drives, the information in LTM must be stored in the brain. The ability to maintain information in LTM involves a gradual strengthening of the connections among the neurons in the brain. When pathways in these neural networks are frequently and repeatedly fired, the synapses become more efficient in communicating with each other, and these changes create memory. This process, known as long-term potentiation (LTP), refers to *the strengthening of the synaptic connections between neurons as result of frequent stimulation* (Lynch, 2002). [12] Drugs that block LTP reduce learning, whereas drugs that enhance LTP increase learning (Lynch et al., 1991). [13] Because the new patterns of activation in the synapses take time to develop, LTP happens gradually. The period of time in which LTP occurs and in which memories are stored is known as the period of *consolidation*.

Memory is not confined to the cortex; it occurs through sophisticated interactions between new and old brain structures (Figure 8.17 "Schematic Image of Brain With Hippocampus, Amygdala, and Cerebellum Highlighted"). One of the most important brain regions in explicit memory is the hippocampus, which serves as a preprocessor and elaborator of information (Squire, 1992). [14] The hippocampus helps us encode information about spatial relationships, the context in which events were experienced, and the associations among memories (Eichenbaum, 1999). [15] The hippocampus also serves in part as a switching point that holds the memory for a short time and then directs the information to other parts of the brain, such as the cortex, to actually do the rehearsing, elaboration, and long-term storage (Jonides, Lacey, & Nee, 2005). [16] Without the hippocampus, which might be described as the brain's "librarian," our explicit memories would be inefficient and disorganized.

While the hippocampus is handling explicit memory, the *cerebellum* and the *amygdala* are concentrating on implicit and emotional memories, respectively. Research shows that the cerebellum is more active when we are learning associations and in priming tasks, and animals and humans with damage to the cerebellum have more difficulty in classical conditioning studies (Krupa, Thompson, & Thompson, 1993; Woodruff-Pak, Goldenberg, Downey-Lamb, Boyko, & Lemieux, 2000). [17] The storage of many of our most important emotional memories, and particularly those related to fear, is initiated and controlled by the amygdala (Sigurdsson, Doyère, Cain, & LeDoux, 2007). [18]

Evidence for the role of different brain structures in different types of memories comes in part from case studies of patients who suffer from amnesia, *a memory disorder that involves the inability to remember information*. As with memory interference effects, amnesia can work in either a forward or a backward direction, affecting retrieval or encoding. For people who suffer damage to the brain, for instance, as a result of a stroke or other trauma, the amnesia may work backward. The outcome is retrograde amnesia, *a memory disorder that produces an inability to retrieve events that occurred before a given time*. Demonstrating the fact that LTP takes time (the process of consolidation), retrograde amnesia is usually more severe for memories that occurred just prior to the trauma than it is for older memories, and events that occurred just before the event that caused memory loss may never be recovered because they were never completely encoded.

Organisms with damage to the hippocampus develop a type of amnesia that works in a forward direction to affect encoding, known as *anterograde amnesia*. Anterograde amnesia is *the inability to transfer information from short-term into long-term memory*, making it impossible to form new memories. One well-known case study was a man named Henry Gustav Molaison (before he died in 2008, he was referred to only as H. M.) who had parts of his hippocampus removed to reduce severe seizures (Corkin, Amaral, González, Johnson, & Hyman, 1997). [19] Following the operation, Molaison developed virtually complete anterograde amnesia. Although he could remember most of what had happened before the operation, and particularly what had occurred early in his life, he could no longer create new memories. Molaison was said to have read the same magazines over and over again without any awareness of having seen them before.

Cases of anterograde amnesia also provide information about the brain structures involved in different types of memory (Bayley & Squire, 2005; Helmuth, 1999; Paller, 2004). [20] Although Molaison's explicit memory was compromised because his hippocampus was damaged, his implicit memory was not (because his cerebellum was intact). He could learn to trace shapes in a mirror, a task that requires procedural memory, but he never had any explicit recollection of having performed this task or of the people who administered the test to him.

Although some brain structures are particularly important in memory, this does not mean that all memories are stored in one place. The American psychologist Karl Lashley (1929) [21] attempted to determine where memories were stored in the brain by teaching rats how to run mazes, and then lesioning different brain structures to see if they were still able to complete the maze. This idea seemed straightforward, and Lashley expected to find that memory was stored in certain parts of the brain. But he discovered that no matter where he removed brain tissue, the rats retained at least some memory of the maze, leading him to conclude that memory isn't located in a single place in the brain, but rather is distributed around it.

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Memory (Encoding, Storage, Retrieval)

Kathleen B. McDermott & Henry L. Roediger

"Memory" is a single term that reflects a number of different abilities: holding information briefly while working with it (working memory), remembering episodes of one's life (episodic memory), and our general knowledge of facts of the world (semantic memory), among other types. Remembering episodes involves three processes: encoding information (learning it, by perceiving it and relating it to past knowledge), storing it (maintaining it over time), and then retrieving it (accessing the information when needed). Failures can occur at any stage, leading to forgetting or to having false memories. The key to improving one's memory is to improve processes of encoding and to use techniques that guarantee effective retrieval. Good encoding techniques include relating new information to what one already knows, forming mental images, and creating associations among information that needs to be remembered. The key to good retrieval is developing effective cues that will lead the rememberer back to the encoded information. Classic mnemonic systems, known since the time of the ancient Greeks and still used by some today, can greatly improve one's memory abilities.

Learning Objectives

- Define and note differences between the following forms of memory: working memory, episodic memory, semantic memory, collective memory.
- Describe the three stages in the process of learning and remembering.
- Describe strategies that can be used to enhance the original learning or encoding of information.
- Describe strategies that can improve the process of retrieval.
- Describe why the classic mnemonic device, the method of loci, works so well.

Introduction

In 2013, Simon Reinhard sat in front of 60 people in a room at Washington University, where he memorized an increasingly long series of digits. On the first round, a computer generated 10 random digits—6 1 9 4 8 5 6 3 7 1—on a screen for 10 seconds. After the series disappeared, Simon typed them into his computer. His recollection was perfect. In the next phase, 20 digits appeared on the screen for 20 seconds. Again, Simon got them all correct. No one in the audience (mostly professors, graduate students, and undergraduate students) could recall the 20 digits perfectly. Then came 30 digits, studied for 30 seconds; once again, Simon didn't misplace even a single digit. For a final trial, 50 digits appeared on the screen for 50 seconds, and again, Simon got them all right. In fact, Simon would have been happy to keep going. His record in this task—called "forward digit span"—is 240 digits!

In some ways memory is like file drawers where you store mental information. Memory is also a series of processes: how does that information get filed to begin with and how does it get retrieved when needed? [Photo: Jason Carpenter]

When most of us witness a performance like that of Simon Reinhard, we think one of two things: First, maybe he's cheating somehow. (No, he is not.) Second, Simon must have abilities more advanced than the rest of humankind. After all, psychologists established many years ago that the normal memory span for adults is about 7 digits, with some of us able to recall a few more and others a few less (Miller, 1956). That is why the first phone numbers were limited to 7 digits—psychologists determined that many errors occurred (costing the phone company money) when the number was increased to even 8 digits. But in normal testing, no one gets 50 digits correct in a row, much less 240. So, does Simon Reinhard simply have a photographic memory? He does not. Instead, Simon has taught himself simple strategies for remembering that have greatly increased his capacity for remembering virtually any type of material—digits, words, faces and names, poetry, historical dates, and so on. Twelve years earlier, before he started training his memory abilities, he had a digit span of 7, just like most of us. Simon has been training his abilities for about 10 years as of this writing, and has risen to be in the top two of "memory athletes." In 2012, he came in second place in the World Memory Championships (composed of 11 tasks), held in London. He currently ranks second in the world, behind another German competitor, Johannes Mallow. In this module, we reveal what psychologists and others have learned about memory, and we also explain the general principles by which you can improve your own memory for factual material.

Varieties of Memory

To be a good chess player you have to learn to increase working memory so you can plan ahead for several offensive moves while simultaneously anticipating - through use of memory - how the other player could counter each of your planned moves. [Photo: D-Stanley]

For most of us, remembering digits relies on *short-term memory*, or *working memory*—the ability to hold information in our minds for a brief time and work with it (e.g., multiplying 24 x 17 without using paper would rely on working memory). Another type of memory is episodic memory—the ability to remember the episodes of our lives. If you were given the task of recalling everything you did 2 days ago, that would be a test of episodic memory; you would be required to mentally travel through the day in your mind and note the main events. Semantic memory is our storehouse of more-or-less permanent knowledge, such as the meanings of words in a language (e.g., the meaning of "parasol") and the huge collection of facts about the world (e.g., there are 196 countries in the world, and 206 bones in your body). *Collective memory* refers to the kind of memory that people in a group share (whether family, community, schoolmates, or citizens of a state or a country). For example, residents of small towns often strongly identify with those towns, remembering the local customs and historical events in a unique way. That is, the community's collective memory passes stories and recollections between neighbors and to future generations, forming a memory system unto itself.

Psychologists continue to debate the classification of types of memory, as well as which types rely on others (Tulving, 2007), but for this module we will focus on episodic memory. Episodic memory is usually what people think of when they hear the word "memory." For example, when people say that an older relative is "losing her memory" due to Alzheimer's disease, the type of memory-loss they are referring to is the inability to recall events, or episodic memory. (Semantic memory is actually preserved in early-stage Alzheimer's disease.) Although remembering specific events that have happened over the course of one's entire life (e.g., your experiences in sixth grade) can be referred to as autobiographical memory, we will focus primarily on the episodic memories of more recent events.

Three Stages of the Learning/Memory Process

Psychologists distinguish between three necessary stages in the learning and memory process: encoding, storage, and retrieval (Melton, 1963). Encoding is defined as the initial learning of information; storage refers to maintaining information over time; retrieval is the ability to access information when you need it. If you meet someone for the first time at a party, you need to encode her name (Lyn Goff) while you associate her name with her face. Then you need to maintain the information over time. If you see her a week later, you need to recognize her face and have it serve as a cue to retrieve her name. Any successful act of remembering requires that all three stages be intact. However, two types of errors can also occur. Forgetting is one type: you see the person you met at the party and you cannot recall her name. The other error is misremembering (false recall or false recognition): you see someone who looks like Lyn Goff and call the person by that name (false recognition of the face). Or, you might see the real Lyn Goff, recognize her face, but then call her by the name of another woman you met at the party (misrecall of her name).

Whenever forgetting or misremembering occurs, we can ask, at which stage in the learning/memory process was there a failure?—though it is often difficult to answer this question with precision. One reason for this inaccuracy is that the three stages are not as discrete as our description implies. Rather, all three stages depend on one another. How we encode information determines how it will be stored and what cues will be effective when we try to retrieve it. And too, the act of retrieval itself also changes the way information is subsequently remembered, usually aiding later recall of the retrieved information. The central point for now is that the three stages—encoding, storage, and retrieval—affect one another, and are inextricably bound together.

Encoding

Encoding refers to the initial experience of perceiving and learning information. Psychologists often study recall by having participants study a list of pictures or words. Encoding in these situations is fairly straightforward. However, "real life" encoding is much more challenging. When you walk across campus, for example, you encounter countless sights and sounds—friends passing by, people playing Frisbee, music in the air. The physical and mental environments are much too rich for you to encode all the happenings around you or the internal thoughts you have in response to them. So, an important first principle of encoding is that it is selective: we attend to some events in our environment and we ignore others. A second point about encoding is that it is prolific; we are always encoding the events of our lives—attending to the world, trying to understand it. Normally this presents no problem, as our days are filled with routine occurrences, so we don't need to pay attention to everything. But if something does happen that seems strange—during your daily walk across campus, you see a giraffe—then we pay close attention and try to understand why we are seeing what we are seeing.

Right after your typical walk across campus (one without the appearance of a giraffe), you would be able to remember the events reasonably well if you were asked. You could say whom you bumped into, what song was playing from a radio, and so on. However, suppose someone asked you to recall the same walk a month later. You wouldn't stand a chance. You would likely be able to recount the basics of a typical walk across campus, but not the precise details of that particular walk. Yet, if you had seen a giraffe during that walk, the event would have been fixed in your mind for a long time, probably for the rest of your life. You would tell your friends about it, and, on later occasions when you saw a giraffe, you might be reminded of the day you saw one on campus. Psychologists have long pinpointed distinctiveness—having an event stand out as quite different from a background of similar events—as a key to remembering events (Hunt, 2003).

A giraffe in the context of a zoo or its natural habitat may register as nothing more than ordinary, but put it in another setting - in the middle of a campus or a busy city - and its level of distinctiveness increases dramatically. Distinctiveness is a key attribute to remembering events. [Image: David Blackwell]

In addition, when vivid memories are tinged with strong emotional content, they often seem to leave a permanent mark on us. Public tragedies, such as terrorist attacks, often create vivid memories in those who witnessed them. But even those of us not directly involved in such events may have vivid memories of them, including memories of first hearing about them. For example, many people are able to recall their exact physical location when they first learned about the assassination or accidental death of a national figure. The term flashbulb memory was originally coined by Brown and

Kulik (1977) to describe this sort of vivid memory of finding out an important piece of news. The name refers to how some memories seem to be captured in the mind like a flash photograph; because of the distinctiveness and emotionality of the news, they seem to become permanently etched in the mind with exceptional clarity compared to other memories.

Take a moment and think back on your own life. Is there a particular memory that seems sharper than others? A memory where you can recall unusual details, like the colors of mundane things around you, or the exact positions of surrounding objects? Although people have great confidence in flashbulb memories like these, the truth is, our objective accuracy with them is far from perfect (Talarico & Rubin, 2003). That is, even though people may have great confidence in what they recall, their memories are not as accurate (e.g., what the actual colors were; where objects were truly placed) as they tend to imagine. Nonetheless, all other things being equal, distinctive and emotional events are well-remembered.

Details do not leap perfectly from the world into a person's mind. We might say that we went to a party and remember it, but what we remember is (at best) what we encoded. As noted above, the process of encoding is selective, and in complex situations, relatively few of many possible details are noticed and encoded. The process of encoding always involves recoding—that is, taking the information from the form it is delivered to us and then converting it in a way that we can make sense of it. For example, you might try to remember the colors of a rainbow by using the acronym ROY G BIV (red, orange, yellow, green, blue, indigo, violet). The process of recoding the colors into a name can help us to remember. However, recoding can also introduce errors—when we accidentally add information during encoding, then remember that *new* material as if it had been part of the actual experience (as discussed below).

Although it requires more effort, using images and associations can improve the process of recoding. [Image: Leo Reynolds]

Psychologists have studied many recoding strategies that can be used during study to improve retention. First, research advises that, as we study, we should think of the meaning of the events (Craik & Lockhart, 1972), and we should try to relate new events to information we already know. This helps us form associations that we can use to retrieve information later. Second, imagining events also makes them more memorable; creating vivid images out of information (even verbal information) can greatly improve later recall (Bower

& Reitman, 1972). Creating imagery is part of the technique Simon Reinhard uses to remember huge numbers of digits, but we can all use images to encode information more effectively. The basic concept behind good encoding strategies is to form distinctive memories (ones that stand out), and to form links or associations among memories to help later retrieval (Hunt & McDaniel, 1993). Using study strategies such as the ones described here is challenging, but the effort is well worth the benefits of enhanced learning and retention.

We emphasized earlier that encoding is selective: people cannot encode all information they are exposed to. However, recoding can add information that was not even seen or heard during the initial encoding phase. Several of the recoding processes, like forming associations between memories, can happen without our awareness. This is one reason people can sometimes remember events that did not actually happen—because during the process of recoding, details got added. One common way of inducing false memories in the laboratory employs a word-list technique (Deese, 1959; Roediger & McDermott, 1995). Participants hear lists of 15 words, like *door, glass, pane, shade, ledge, sill, house, open, curtain, frame, view, breeze, sash, screen,* and *shutter*. Later, participants are given a test in which they are shown a list of words and asked to pick out the ones they'd heard earlier. This second list contains some words from the first list (e.g., *door, pane, frame*) and some words not from the list (e.g., *arm, phone, bottle*). In this example, one of the words on the test is *window*, which—importantly—does not appear in the first list, but which is related to other words in that list. When subjects were tested, they were reasonably accurate with the studied words (*door*, etc.), recognizing them 72% of the time. However, when *window* was on the test, they falsely recognized it as having been on the list 84% of the time (Stadler, Roediger, & McDermott, 1999). The same thing happened with many other lists the authors used. This phenomenon is referred to as the DRM (for Deese-Roediger-McDermott) effect. One explanation for such results is that, while students listened to items in the list, the words triggered the students to think about *window*, even though *window* was never presented. In this way, people seem to encode events that are not actually part of their experience.

Because humans are creative, we are always going beyond the information we are given: we automatically make associations and infer from them what is happening. But, as with the word association mix-up above, sometimes we make false memories from our inferences—remembering the inferences themselves as if they were actual experiences. To illustrate this, Brewer (1977) gave people sentences to remember that were designed to elicit *pragmatic inferences*. Inferences, in general, refer to instances when something is not explicitly stated, but we are still able to guess the undisclosed intention. For example, if your friend told you that she didn't want to go out to eat, you may infer that she doesn't have the money to go out, or that she's too tired. With *pragmatic* inferences, there is usually *one* particular inference you're likely to make. Consider the statement Brewer (1977) gave her participants: "The karate champion hit the cinder block." After hearing or seeing this sentence, participants who were given a memory test tended to remember the statement as having been, "The karate champion *broke* the cinder block." This remembered statement is not necessarily a *logical* inference (i. e., it is perfectly reasonable that a karate champion could hit a cinder block without breaking it). Nevertheless, the *pragmatic* conclusion from hearing such a sentence is that the block was likely broken. The participants remembered this inference they made while hearing the sentence in place of the actual words that were in the sentence (see also McDermott & Chan, 2006).

Encoding—the initial registration of information—is essential in the learning and memory process. Unless an event is encoded in some fashion, it will not be successfully remembered later. However, just because an event is encoded (even if it is encoded well), there's no guarantee that it will be remembered later.

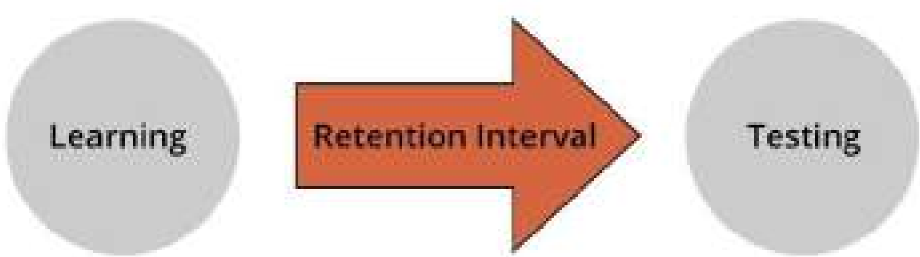
Storage

Memory traces, or engrams, are NOT perfectly preserved recordings of past experiences. The traces are combined with current knowledge to reconstruct what we think happened in the past. [Photo: INDEED]

Every experience we have changes our brains. That may seem like a bold, even strange, claim at first, but it's true. We encode each of our experiences within the structures of the nervous system, making new impressions in the process—and each of those impressions involves changes in the brain. Psychologists (and neurobiologists) say that experiences leave memory traces, or engrams (the two terms are synonyms). Memories have to be stored somewhere in the brain, so in order to do so, the brain biochemically alters itself and its neural tissue. Just like you might write yourself a note to remind you of something, the brain "writes" a memory trace, changing its own physical composition to do so. The basic idea is that events (occurrences in our environment) create engrams through a process of consolidation: the neural changes that occur after learning to create the memory trace of an experience. Although neurobiologists are concerned with exactly what neural processes change when memories are created, for psychologists, the term *memory trace* simply refers to the physical change in the nervous system (whatever that may be, exactly) that represents our experience.

Although the concept of engram or memory trace is extremely useful, we shouldn't take the term too literally. It is important to understand that memory traces are not perfect little packets of information that lie dormant in the brain, waiting to be called forward to give an accurate report of past experience. Memory traces are not like video or audio recordings, capturing experience with great accuracy; as discussed earlier, we often have errors in our memory, which would not exist if memory traces were perfect packets of information. Thus, it is wrong to think that remembering involves simply "reading out" a faithful record of past experience. Rather, when we remember past events, we reconstruct them with the aid of our memory traces—but also with our current belief of what happened. For example, if you were trying to recall for the police who started a fight at a bar, you may not have a memory trace of who pushed whom first. However, let's say you remember that one of the guys held the door open for you. When thinking back to the start of the fight, this knowledge (of how one guy was friendly to you) may unconsciously influence your memory of what happened in favor of the nice guy. Thus, memory is a construction of what you actually recall and what you believe happened. In a phrase, remembering is reconstructive (we reconstruct our past with the aid of memory traces) not reproductive (a perfect reproduction or recreation of the past).

Psychologists refer to the time between learning and testing as the retention interval. Memories can consolidate during that time, aiding retention. However, experiences can also occur that undermine the memory. For example, think of what you had for lunch yesterday —a pretty easy task. However, if you had to recall what you had for lunch 17 days ago, you may well fail (assuming you don't eat the same thing every day). The 16 lunches you've had since that one have created retroactive interference. Retroactive interference refers to new activities (i.e., the subsequent lunches) during the retention interval (i.e., the time between the lunch 17 days ago and now) that interfere with retrieving the specific, older memory (i.e., the lunch details from 17 days ago). But just as newer things can interfere with remembering older things, so can the opposite happen. *Proactive interference* is when past memories interfere with the encoding of new ones. For example, if you have ever studied a second language, often times the grammar and vocabulary of your native language will pop into your head, impairing your fluency in the foreign language.



Retroactive interference is one of the main causes of forgetting (McGeoch, 1932). In the module *Eyewitness Testimony and Memory Biases* (**http://noba.to/uy49tm37**), Elizabeth Loftus describes her fascinating work on eyewitness memory, in which she shows how memory for an event can be changed via misinformation supplied during the retention interval. For example, if you witnessed a car crash but subsequently heard people describing it from their own perspective, this new information may interfere with or disrupt your own personal recollection of the crash. In fact, you may even come to remember the event happening exactly as the others described it! This misinformation effect in eyewitness memory represents a type of retroactive interference that can occur during the retention interval (see Loftus [2005] for a review). Of course, if correct information is given during the retention interval, the witness's memory will usually be improved.

Although interference may arise between the occurrence of an event and the attempt to recall it, *the effect itself is always expressed when we retrieve memories*, the topic to which we turn next.

Retrieval

Endel Tulving argued that "the key process in memory is retrieval" (1991, p. 91). Why should retrieval be given more prominence than encoding or storage? For one thing, if information were encoded and stored but could not be retrieved, it would be useless. As discussed previously in this module, we encode and store thousands of events—conversations, sights and sounds—every day, creating memory traces. However, we later access only a tiny portion of what we've taken in. Most of our memories will never be used—in the sense of being brought back to mind, consciously. This fact seems so obvious that we rarely reflect on it. All those events that happened to you in the fourth grade that seemed so important then? Now, many years later, you would struggle to remember even a few. You may wonder if the traces of those memories still exist in some latent form. Unfortunately, with currently available methods, it is impossible to know.

Psychologists distinguish information that is available in memory from that which is accessible (Tulving & Pearlstone, 1966). *Available* information is the information that is stored in memory—but precisely how much and what types are stored cannot be known. That is, all we can know is what information we can retrieve—*accessible* information. The assumption is that accessible information represents only a tiny slice of the information available in our brains. Most of us have had the experience of trying to remember some fact or event, giving up, and then—all of a sudden!—it comes to us at a later time, even after we've stopped trying to remember it. Similarly, we all know the experience of failing to recall a fact, but then, if we are given several choices (as in a multiple-choice test), we are easily able to recognize it.

We can't know the entirety of what is in our memory, but only that portion we can actually retrieve. Something that cannot be retrieved now and which is seemingly gone from memory may, with different cues applied, reemerge. [Photo: sean drellinger]

What factors determine what information can be retrieved from memory? One critical factor is the type of hints, or *cues*, in the environment. You may hear a song on the radio that suddenly evokes memories of an earlier time in your life, even if you were not trying to remember it when the song came on. Nevertheless, the song is closely associated with that time, so it brings the experience to mind.

The general principle that underlies the effectiveness of retrieval cues is the encoding specificity principle (Tulving & Thomson, 1973): when people encode information, they do so in specific ways. For example, take the song on the radio: perhaps you heard it while you were at a terrific party, having a great, philosophical conversation with a friend. Thus, the song became part of that whole complex experience. Years later, even though you haven't thought about that party in ages, when you hear the song on the radio, the whole experience rushes back to you. In general, the encoding specificity principle states that, to the extent a retrieval cue (the song) matches or overlaps the memory trace of an experience (the party, the conversation), it will be effective in evoking the memory. A classic experiment on the encoding specificity principle had participants memorize a set of words in a unique setting. Later, the participants were tested on the word sets, either in the same location they learned the words or a different one. As a result of encoding specificity, the students who took the test in the same place they learned the words were actually able to recall more words (Godden & Baddeley, 1975) than the students who took the test in a new setting. In this instance, the physical context itself provided cues for retrieval. This is why it's good to study for midterms and finals in the same room you'll be taking them in.

One caution with this principle, though, is that, for the cue to work, it can't match too many other experiences (Nairne, 2002; Watkins, 1975). Consider a lab experiment. Suppose you study 100 items; 99 are words, and one is a picture—of a penguin, item 50 in the list. Afterwards, the cue "recall the picture" would evoke "penguin" perfectly. No one would miss it. However, if the *word* "penguin" were placed in the same spot among the other 99 words, its memorability would be exceptionally worse. This outcome shows the power of distinctiveness that we discussed in the section on encoding: one picture is perfectly recalled from among 99 words because it stands out. Now consider what would happen if the experiment were repeated, but there were 25 pictures distributed within the 100-item list. Although the picture of the penguin would still be there, the probability that the cue "recall the picture" (at item 50) would be useful for the penguin would drop correspondingly. Watkins (1975) referred to this outcome as demonstrating the **cue overload principle**. That is, to be effective, a retrieval cue cannot be overloaded with too many memories. For the cue "recall the picture" to be effective, it should only match one item in the target set (as in the one-picture, 99-word case).

To sum up how memory cues function: for a retrieval cue to be effective, a match must exist between the cue and the desired target memory; furthermore, to produce the best retrieval, the cue-target relationship should be distinctive. Next, we will see how the encoding specificity principle can work in practice.

Psychologists measure memory performance by using production tests (involving recall) or recognition tests (involving the selection of correct from incorrect information, e.g., a multiple-choice test). For example, with our list of 100 words, one group of people might be asked to recall the list in any order (a free recall test), while a different group might be asked to circle the 100 studied words out of a mix with another 100, unstudied words (a recognition test). In this situation, the recognition test would likely produce better performance from participants than the recall test.

We usually think of recognition tests as being quite easy, because the cue for retrieval is a copy of the actual event that was presented for study. After all, what could be a better cue than the exact target (memory) the person is trying to access? In most cases, this line of reasoning is true; nevertheless, recognition tests do not provide perfect indexes of what is stored in memory. That is, you can fail to recognize a target staring you right in the face, yet be able to recall it later with a different set of cues (Watkins & Tulving, 1975). For example, suppose you had the task of recognizing the surnames of famous authors. At first, you might think that being given the actual last name would always be the best cue. However, research has shown this not necessarily to be true (Muter, 1984). When given names such as Tolstoy, Shaw, Shakespeare, and Lee, subjects might well say that Tolstoy and Shakespeare are famous authors, whereas Shaw and Lee are not. But, when given a cued recall test using first names, people often recall items (produce them) that they had failed to recognize before. For example, in this instance, a cue like *George Bernard* _______ often leads to a recall of "Shaw," even though people initially failed to recognize *Shaw* as a famous author's name. Yet, when given the cue "William," people may not come up with Shakespeare, because William is a common name that matches many people (the cue overload principle at work). This strange fact—that recall can sometimes lead to better performance than recognition—can be explained by the encoding specificity principle. As a cue, *George Bernard* ________ matches the way the famous writer is stored in memory better than does his surname, Shaw, does (even though it is the target). Further, the match is quite distinctive with *George Bernard* _________, but the cue *William* ______________ is much more overloaded (Prince William, William Yeats, William Faulkner, will.i.am).

The phenomenon we have been describing is called the *recognition failure of recallable words*, which highlights the point that a cue will be most effective depending on how the information has been encoded (Tulving & Thomson, 1973). The point is, the cues that work best to evoke retrieval are those that recreate the event or name to be remembered, whereas sometimes even the target itself, such as *Shaw* in the above example, is not the best cue. Which cue will be most effective depends on how the information has been encoded.

Whenever we think about our past, we engage in the act of retrieval. We usually think that retrieval is an objective act because we tend to imagine that retrieving a memory is like pulling a book from a shelf, and after we are done with it, we return the book to the shelf just as it was. However, research shows this assumption to be false; far from being a static repository of data, the memory is constantly changing. In fact, every time we retrieve a memory, it is altered. For example, the act of retrieval itself (of a fact, concept, or event) makes the retrieved memory much more likely to be retrieved again, a phenomenon called the *testing effect* or the *retrieval practice effect* (Pyc & Rawson, 2009; Roediger & Karpicke, 2006). However, retrieving some information can actually cause us to forget other information related to it, a phenomenon called *retrieval-induced forgetting* (Anderson, Bjork, & Bjork, 1994). Thus the act of retrieval can be a double-edged sword—strengthening the memory just retrieved (usually by a large amount) but harming related information (though this effect is often relatively small).

As discussed earlier, retrieval of distant memories is reconstructive. We weave the concrete bits and pieces of events in with assumptions and preferences to form a coherent story (Bartlett, 1932). For example, if during your 10th birthday, your dog got to your cake before you did, you would likely tell that story for years afterward. Say, then, in later years you misremember where the dog actually found the cake, but repeat that error over and over during subsequent retellings of the story. Over time, that inaccuracy would become a basic fact of the event in your mind. Just as retrieval practice (repetition) enhances accurate memories, so will it strengthen errors or false memories (McDermott, 2006). Sometimes memories can even be manufactured just from hearing a vivid story. Consider the following episode, recounted by Jean Piaget, the famous developmental psychologist, from his childhood:

> One of my first memories would date, if it were true, from my second year. I can still see, most clearly, the following scene, in which I believed until I was about 15. I was sitting in my pram . . . when a man tried to kidnap me. I was held in by the strap fastened round

> me while my nurse bravely tried to stand between me and the thief. She received various scratches, and I can still vaguely see those on her face. . . . When I was about 15, my parents received a letter from my former nurse saying that she had been converted to the Salvation Army. She wanted to confess her past faults, and in particular to return the watch she had been given as a reward on this occasion. She had made up the whole story, faking the scratches. I therefore must have heard, as a child, this story, which my parents believed, and projected it into the past in the form of a visual memory. . . . Many real memories are doubtless of the same order. (Norman & Schacter, 1997, pp. 187–188)

Piaget's vivid account represents a case of a pure reconstructive memory. He heard the tale told repeatedly, and doubtless told it (and thought about it) himself. The repeated telling cemented the events as though they had really happened, just as we are all open to the possibility of having "many real memories ... of the same order." The fact that one can remember precise details (the location, the scratches) does not necessarily indicate that the memory is true, a point that has been confirmed in laboratory studies, too (e.g., Norman & Schacter, 1997).

Putting It All Together: Improving Your Memory

A central theme of this module has been the importance of the encoding and retrieval processes, and their interaction. To recap: to improve learning and memory, we need to encode information in conjunction with excellent cues that will bring back the remembered events when we need them. But how do we do this? Keep in mind the two critical principles we have discussed: to maximize retrieval, we should construct *meaningful* cues that remind us of the original experience, and those cues should be *distinctive* and *not associated with other memories*. These two conditions are critical in maximizing cue effectiveness (Nairne, 2002).

Some people employ tricks to help them improve their memories. [Photo: Flood]

So, how can these principles be adapted for use in many situations? Let's go back to how we started the module, with Simon Reinhard's ability to memorize huge numbers of digits. Although it was not obvious, he applied these same general memory principles, but in a more deliberate way. In fact, all mnemonic devices, or memory aids/tricks, rely on these fundamental principles. In a typical case, the person learns a set of cues and then applies these cues to learn and remember information. Consider the set of 20 items below that are easy to learn and remember (Bower & Reitman, 1972).

1. is a gun. 11 is penny-one, hot dog bun.
2. is a shoe. 12 is penny-two, airplane glue.
3. is a tree. 13 is penny-three, bumble bee.
4. is a door. 14 is penny-four, grocery store.
5. is knives. 15 is penny-five, big beehive.
6. is sticks. 16 is penny-six, magic tricks.
7. is oven. 17 is penny-seven, go to heaven.
8. is plate. 18 is penny-eight, golden gate.
9. is wine. 19 is penny-nine, ball of twine.
10. is hen. 20 is penny-ten, ballpoint pen.

It would probably take you less than 10 minutes to learn this list and practice recalling it several times (remember to use retrieval practice!). If you were to do so, you would have a set of peg words on which you could "hang" memories. In fact, this mnemonic device is called the *peg word technique*. If you then needed to remember some discrete items—say a grocery list, or points you wanted to make in a speech—this method would let you do so in a very precise yet flexible way. Suppose you had to remember bread, peanut butter, bananas, lettuce, and so on. The way to use the method is to form a vivid image of what you want to remember and imagine it interacting with your peg words (as many as you need). For example, for these items, you might imagine a large gun (the first peg word) shooting a loaf of bread, then a jar of peanut butter inside a shoe, then large bunches of bananas hanging from a tree, then a door slamming on a head of lettuce with leaves flying everywhere. The idea is to provide good, distinctive cues (the weirder the better!) for the information you need to remember while you are learning it. If you do this, then retrieving it later is relatively easy. You know your cues perfectly (one is gun, etc.), so you simply go through your cue word list and "look" in your mind's eye at the image stored there (bread, in this case).

This peg word method may sound strange at first, but it works quite well, even with little training (Roediger, 1980). One word of warning, though, is that the items to be remembered need to be presented relatively slowly at first, until you have practice associating each with its cue word. People get faster with time. Another interesting aspect of this technique is that it's just as easy to recall the items in backwards order as forwards. This is because the peg words provide direct access to the memorized items, regardless of order.

How did Simon Reinhard remember those digits? Essentially he has a much more complex system based on these same principles. In his case, he uses "memory palaces" (elaborate scenes with discrete places) combined with huge sets of images for digits. For example, imagine mentally walking through the home where you grew up and identifying as many distinct areas and objects as possible. Simon has hundreds of such memory palaces that he uses. Next, for remembering digits, he has memorized a set of 10,000 images. Every four-digit number for him immediately brings forth a mental image. So, for example, 6187 might recall Michael Jackson. When Simon hears all the numbers coming at him, he places an image for every four digits into locations in his memory palace. He can do this at an incredibly rapid rate, faster than 4 digits per 4 seconds when they are flashed visually, as in the demonstration at the beginning of the module. As noted, his record is 240 digits, recalled in exact order. Simon also holds the world record in an event called "speed cards," which involves memorizing the precise order of a shuffled deck of cards. Simon was able to do this in 21.19 seconds! Again, he uses his memory palaces, and he encodes groups of cards as single images.

Many books exist on how to improve memory using mnemonic devices, but all involve forming distinctive encoding operations and then having an infallible set of memory cues. We should add that to develop and use these memory systems beyond the basic peg system outlined above takes a great amount of time and concentration. The World Memory Championships are held every year and the records keep improving. However, for most common purposes, just keep in mind that to remember well you need to encode information in a distinctive way and to have good cues for retrieval. You can adapt a system that will meet most any purpose.

Outside Resources

Book: Brown, P.C., Roediger, H. L. & McDaniel, M. A. (2014). Smarter, sooner, longer: Effective strategies for learning and remembering. Cambridge, MA: Harvard University Press.

Student Video 1: Eureka Foong's - The Misinformation Effect. This is a student-made video illustrating this phenomenon of altered memory. It was one of the winning entries in the 2014 Noba Student Video Award.
https://www.youtube.com/watch?v=iMPIWkFtd88

Student Video 2: Kara McCord's - Flashbulb Memories. This is a student-made video illustrating this phenomenon of autobiographical memory. It was one of the winning entries in the 2014 Noba Student Video Award.
https://www.youtube.com/watch?v=mPhW9bUI4F0

Student Video 3: Ang Rui Xia & Ong Jun Hao's - The Misinformation Effect. Another student-made video exploring the misinformation effect. Also an award winner from 2014.
https://www.youtube.com/watch?v=gsn9iKmOJLQ

Video: Simon Reinhard breaking the world record in speedcards.
http://vimeo.com/12516465

Discussion Questions

1. Mnemonists like Simon Reinhard develop mental "journeys," which enable them to use the method of loci. Develop your own journey, which contains 20 places, in order, that you know well. One example might be: the front walkway to your parents' apartment; their doorbell; the couch in their living room; etc. Be sure to use a set of places that you know well and that have a natural order to them (e.g., the walkway comes before the doorbell). Now you are more than halfway toward being able to memorize a set of 20 nouns, in order, rather quickly. As an optional second step, have a friend make a list of 20 such nouns and read them to you, slowly (e.g., one every 5 seconds). Use the method to attempt to remember the 20 items.
2. Recall a recent argument or misunderstanding you have had about memory (e.g., a debate over whether your girlfriend/boyfriend had agreed to something). In light of what you have just learned about memory, how do you think about it? Is it possible that the disagreement

can be understood by one of you making a pragmatic inference?

3. Think about what you've just learned in this module and about how you study for tests. On the basis of what you have just learned, is there something that you want to try that might help your study habits?

Vocabulary

Autobiographical memory
Memory for the events of one's life.

Consolidation
The process occurring after encoding that is believed to stabilize memory traces.

Cue overload principle
The principle stating that the more memories that are associated to a particular retrieval cue, the less effective the cue will be in prompting retrieval of any one memory.

Distinctiveness
The principle that unusual events (in a context of similar events) will be recalled and recognized better than uniform (nondistinctive) events.

Encoding
The initial experience of perceiving and learning events.

Encoding specificity principle
The hypothesis that a retrieval cue will be effective to the extent that information encoded from the cue overlaps or matches information in the engram or memory trace.

Engrams
A term indicating the change in the nervous system representing an event; also, memory trace.

Episodic memory
Memory for events in a particular time and place.

Flashbulb memory
Vivid personal memories of receiving the news of some momentous (and usually emotional) event.

Memory traces
A term indicating the change in the nervous system representing an event.

Misinformation effect
When erroneous information occurring after an event is remembered as having been part of

the original event.

Mnemonic devices
A strategy for remembering large amounts of information, usually involving imaging events occurring on a journey or with some other set of memorized cues.

Recoding
The ubiquitous process during learning of taking information in one form and converting it to another form, usually one more easily remembered.

Retrieval
The process of accessing stored information.

Retroactive interference
The phenomenon whereby events that occur after some particular event of interest will usually cause forgetting of the original event.

Semantic memory
The more or less permanent store of knowledge that people have.

Storage
The stage in the learning/memory process that bridges encoding and retrieval; the persistence of memory over time.

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Topic: Forgetting

B .A . Part I Psychology Subsidiary Paper I General Psychology

By

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Forgetting refers to failure to either recall or retain information into present consciousness. All experiences leave traces or after-effects (images) in memory parts of the brain. Failure to retain these traces from the parts of memory is called Forgetting.

Forgetting or disremembering is the apparent loss or modification of information already encoded and stored in an individual's short or long-term memory. It is a spontaneous or gradual process in which old memories are unable to be recalled from memory storage. Problems with remembering, learning and retaining new information are a few of the most common complaints of older adults.[1] Studies show that retention improves with increased rehearsal. This improvement occurs because rehearsal helps to transfer information into long-term memory[2] – practise makes perfect.

Forgetting curves (amount remembered as a function of time since an event was first experienced) have been extensively analyzed. The most recent evidence suggests that a power function provides the closest mathematical fit to the forgetting function.

There are various factors that come into play that leads to disappearance of information from the brain. Traces are known to become weaker with the passage of time, and could even fade away gradually. Interference of new experiences also causes disruption in memory, which causes forgetting. Past experiences do not always remain fresh. We even repress certain memories of unpleasant experiences voluntarily.

Failure to transfer information from working memory to long-term memory is one of the most frequent reasons for forgetting. Furthermore, our inability to recall information from long-term memory also leads to forgetting There is variety of theories that explains forgetting. Here are some of the major types and causes of forgetting.

Fading

Disuse of information causes memory traces to slowly eradicate with time, and this process is called Fading. Fading occurs rapidly from the Short-term memory. Information in *working memory* fades away, as new incoming information is stored in the *Short-Term Memory*.
This form of fading is preventable.

- By continuously focusing attention on the information
- Continuous Rehearsal
- Transfer of information to the Long-Term Memory

Information can even fade away from Long-Term Memory in time. What really happens is the fading of link, a way, to retrieve that information. This kind of fading is also preventable.

- By encoding information as meaningfully as possible
- Frequent Retrieval
- Actively restoring it
- Using effective memory search strategies

Interference

Interference is another major cause of forgetting. General understanding of the subject suggests that "Information gets confused with other information in our *Long-Term Memory.*"
Two types of Interference are:

- Retroactive Interference
- Proactive Interference

Retroactive Interference

A mix up of previously learned information with new and similar information is called Retroactive information.

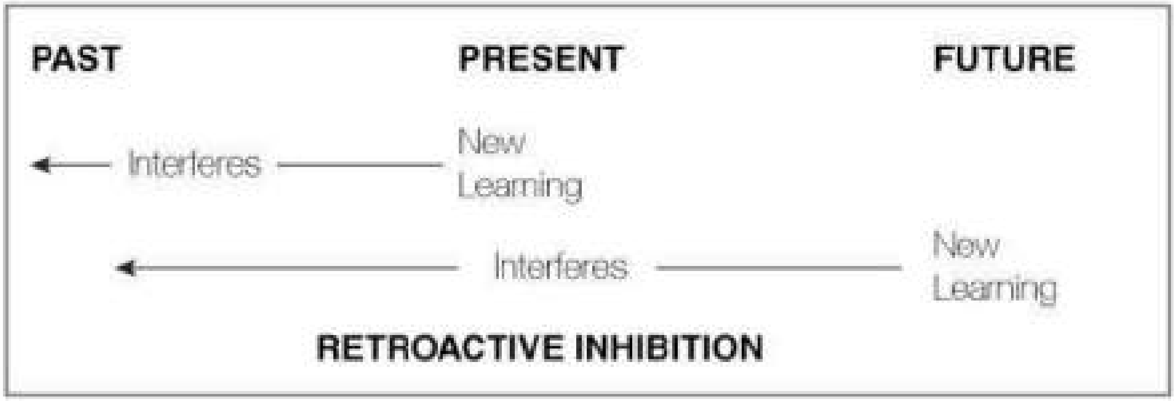
Example: A student studies and understands the events and causes of World-War I thoroughly. After few weeks, the student studies events and causes of World-War II. If the student then fails to remember the events and causes of First World-War, this would be an example of Retroactive Interference.

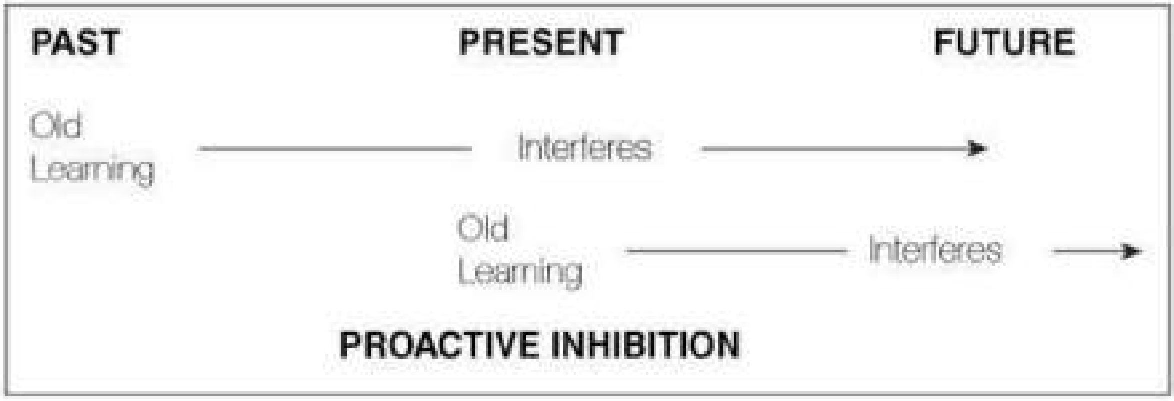
Proactive Interference

The phenomenon where the student fails to remember new information having mixed it with similar previous information is called Proactive Interference.

Example: Like the previous example, a student studies and understands the events and causes of World-War I in depth. After few weeks, the student studies events and causes of World-War II.

If the student then fails to remember the events and causes of Second World-War, this would be an example of Proactive Interference.





Motivated Forgetting

The process of purposefully blocking or repressing memory information is termed as motivated forgetting. The term is derived from Freudian Psychotherapy that refers to Repression. Basically, it means trying to avoid remembering or recalling any information deliberately.

Example: An abused child may not be able to recall the events in details having suppressed them.

Suppression or Repression of memory is not always a result of an emotional trauma. For instance, a student who hates her French teacher might not remember her French lessons. This is mainly because she has avoided contact with the subject matter.

Causes of Forgetting aren't limited to just these and there are various other factors that affect memory. Memory disorders like *Amnesia* also cause Forgetting. Two major types of Amnesia are:

- Psychological Amnesia: *Disturbances in the process of encoding, storage, and retrieval causes psychological amnesia.*
- Biological Amnesia: *Abnormal functioning of brain results in biological amnesia, which might be caused by any internal problem such as uneven blood flow, drugs, diseases, blow to the head, and other damages to brain.*

INTRODUCTION

Perception refers to interpretation of what we take in through our senses. The way we perceive our environment is what makes us different from other animals and different from each other. Perception depends on complex functions of the nervous system, but subjectively seems mostly effortless because this processing happens outside conscious awareness.

Since the rise of experimental psychology in the 19th Century, psychology's understanding of perception has progressed by combining a variety of techniques. Psychophysics quantitatively describes the relationships between the physical qualities of the sensory input and perception. Sensory neuroscience studies the brain mechanisms underlying perception. Perceptual systems can also be studied computationally, in terms of the information they process. Perceptual issues in philosophy include the extent to which sensory qualities such as sound, smell or color exist in objective reality rather than in the mind of the perceiver.

Although the senses were traditionally viewed as passive receptors, the study of illusions and ambiguous images has demonstrated that the brain's perceptual systems actively and pre-consciously attempt to make sense of their input. There is still active debate about the extent to which perception is an active process of hypothesis testing, analogous to science, or whether realistic sensory information is rich enough to make this process unnecessary.

The perceptual systems of the brain enable individuals to see the world around them as stable, even though the sensory information is typically incomplete and rapidly varying. Human and animal brains are structured in a modular way, with different areas processing different kinds of sensory information. Some of these modules take the form of sensory maps, mapping some aspect of the world across part of the brain's surface. These different modules are interconnected and influence each other. For instance, taste is strongly influenced by smell.

OVERVIEW

The following aspects of perception are covered by this study;

DEFINITION OF PERCEPTION

- ✓ Perception is the organization, identification, and interpretation of sensory information in order to represent and understand the environment
- ✓ Perception is the way we interpret the information we sense
- ✓ Perception can be defined as *the active process of selecting, organizing, and interpreting the information brought to the brain by the senses*

THE PERCEPTION PROCESS

The perceptual process is a sequence of steps that begins with stimuli in the environment and ends with our interpretation of those stimuli. This process is typically unconscious and happens hundreds of thousands of times a day. An unconscious process is simply one that happens without awareness or intention. When you open your eyes, you do not need to tell your brain to interpret the light falling onto your retinas from the object in front of you as "computer" because this has happened unconsciously. When you step out into a chilly night, your brain does not need to be told "cold" because the stimuli trigger the processes and categories automatically.

✓ SELECTION/IDENTIFICATION

The world around us is filled with an infinite number of stimuli that we might attend to, but our brains do not have the resources to pay attention to everything. Thus, the first step of perception is the (usually unconscious, but sometimes intentional) decision of what to attend to. Depending on the environment, and depending on us as individuals, we might focus on a familiar stimulus or something new. When we attend to one specific thing in our environment—whether it is a smell, a feeling, a sound, or something else entirely—it becomes the attended stimulus.

✓ ORGANIZATION

Once we have chosen to attend to a stimulus in the environment (consciously or unconsciously, though usually the latter), the choice sets off a series of reactions in our brain. This neural process starts with the activation of our sensory receptors (touch, taste, smell, sight, and hearing). The receptors transduce the input energy into neural activity, which is transmitted to our brains, where we construct a mental representation of the stimulus (or, in most cases, the multiple related stimuli) called a percept. An ambiguous stimulus may be translated into multiple percepts, experienced randomly, one at a time, in what is called "multistable perception."

✓ INTERPRETATION/DESCRIMINATION

After we have attended to a stimulus, and our brains have received and organized the information, we interpret it in a way that makes sense using our existing information about the world. Interpretation simply means that we take the information that we have sensed and organized and turn it into something that we can categorize. For instance, in the Rubin's Vase illusion mentioned earlier, some individuals will interpret the sensory information as "vase," while some will interpret it as "faces." This happens unconsciously thousands of times a day. By putting different stimuli into categories, we can better understand and react to the world around us.

TYPES OF PERCEPTION

✓ PERCEPTION OF SOUND

Hearing (or *audition*) is the ability to perceive sound by detecting vibrations. Frequencies capable of being heard by humans are called audio or *sonic*. The range is typically considered to be between 20 Hz and 20,000 Hz. Frequencies higher than audio are referred to as ultrasonic, while frequencies below audio are referred to as infrasonic. The auditory system includes the outer ears which collect and filter sound waves, the middle ear for transforming the sound pressure (impedance matching), and the inner ear which produces neural signals in response to the sound. By the ascending pathway these are led to the primary auditory cortex within the temporal lobe of the human brain, which is where the auditory information arrives in the cerebral cortex and is further processed there.

Sound does not usually come from a single source: in real situations, sounds from multiple sources and directions are superimposed as they arrive at the ears. Hearing involves the computationally complex task of separating out the sources of interest, often estimating their distance and direction as well as identifying them.

✓ PERCEPTION OF SPEECH

Speech perception is the process by which the sounds of language are heard, interpreted and understood. Research in speech perception seeks to understand how human listeners recognize speech sounds and use this information to understand spoken language. The sound of a word can vary widely according to words around it and the tempo of the speech, as well as the physical characteristics, accent and mood of the speaker. Listeners manage to perceive words across this wide range of different conditions. Another variation is that reverberation can make a large difference in sound between a word spoken from the far side of a room and the same word spoken up close. Experiments have shown that people automatically compensate for this effect when hearing speech.

The process of perceiving speech begins at the level of the sound within the auditory signal and the process of audition. After processing the initial auditory signal, speech sounds are further processed to extract acoustic cues and phonetic information. This speech information can then be used for higher-level language processes, such as word recognition. Speech perception is not necessarily uni-directional. That is, higher-level language processes connected with morphology, syntax, or semantics may interact with basic speech perception processes to aid in recognition of speech sounds. It may be the case that it is not necessary and maybe even not possible for a listener to recognize phonemes before recognizing higher units, like words for example. In one experiment, Richard M. Warren replaced one phoneme of a word with a cough-like sound. His subjects restored the missing speech sound perceptually without any difficulty and what is more, they were not able to identify accurately which phoneme had been disturbed.

✓ PERCEPTION OF TOUCH

Haptic perception is the process of recognizing objects through touch. It involves a combination of somatosensory perception of patterns on the skin surface (e.g., edges, curvature, and texture) and proprioception of hand position and conformation. People can rapidly and accurately identify three-dimensional objects by touch. This involves exploratory procedures, such as moving the fingers over the outer surface of the object or holding the entire object in the hand. Haptic perception relies on the forces experienced during touch.

Gibson defined the haptic system as "The sensibility of the individual to the world adjacent to his body by use of his body". Gibson and others emphasized the close link between haptic perception and body movement: haptic perception is active exploration. The concept of haptic perception is related to the concept ofextended physiological proprioception according to which, when using a tool such as a stick, perceptual experience is transparently transferred to the end of the tool.

✓ PERCEPTION OF TASTE

Taste (or, the more formal term, *gustation*) is the ability to perceive the flavor of substances including, but not limited to, food. Humans receive tastes through sensory organs called *taste buds*, or *gustatory calyculi*, concentrated on the upper surface of the tongue. The human tongue has 100 to 150 taste receptor cells on each of its roughly ten thousand taste buds. There are five primary tastes: sweetness, bitterness, sourness, saltiness, and umami. Other tastes can be mimicked by combining these basic tastes. The recognition and awareness of umami is a relatively recent development in Western cuisine. The basic tastes contribute only partially to the sensation and flavor of food in the mouth — other factors include smell, detected by the olfactory epithelium of the nose; texture, detected through a variety of mechanoreceptors, muscle nerves, etc.; and temperature, detected by thermoreceptors. All basic tastes are classified as either *appetitive* or *aversive*, depending upon whether the things they sense are harmful or beneficial.

✓ PERCEPTION OF THE OTHER SENSES

Other senses enable perception of body balance, acceleration, gravity, position of body parts, temperature, pain, time, and perception of internal senses such as suffocation, gag reflex, intestinal distension, fullness of rectum and urinary bladder, and sensations felt in the throat and lungs.

- ✓ **PERCEPTION OF THE SOCIAL WORLD**

Social perception is the part of perception that allows people to understand the individuals and groups of their social world, and thus an element of social cognition.

However, According to ***thescience.one***, the different types of perception were identified;

- ✓ **AMODAL PERCEPTION**

Amodal perception is one of the most recognizable types of perception in psychology. It is the observation and interpretation of things in terms of depth and motion. For instance, even if one sees only three points in a triangular object, he or she knows that the object is three-dimensional and that there are hidden points on the other side.

- ✓ **COLOR PERCEPTION**

Color perception, on the other hand, describes the way the visual senses, denoting the eyes, observe hues and contextualize them in the environment. For example, by interpreting blue as the color of depression, the eyes will tend to always attribute all things of this tinge to be melancholic.

- ✓ **SPEECH PERCEPTION**

The other types of perception in psychology include those that interpret verbal output. Speech perception, for one, helps in not only understanding one another, but deducing meaning from mere sounds. It also indicates the mechanical arrangement of the vocals when another person speaks which means that the listener interprets the speech through the phonetics such as syllables to create meaning.

- ✓ **HARMONIC PERCEPTION**

Harmonic perception, on the other hand, owes to the understanding that the ear usually perceives inter-related notes, as one, to create meaning in sounds. For instance, riffs in a guitar mixed with those of other instruments lead to interpretation of the music as a single output that is simple to listen to rather than one that actually consists of different notes.

- ✓ **RHYTHMIC PERCEPTION**

Rhythmic perception also follows the same theories in its interpretative methodology, whereby the ear gets into a groove by practically responding to it. For instance, one can easily listen to a beat while humming along to it or tapping along as it continues courtesy of its rhythmic harmony.

✓ DEPTH PERCEPTION

Depth perception also acts as one of the types of perception psychology. It relates to the way the human eye identifies and contextualizes things in space. For instance, though the naked eye cannot see the end of a tunnel, it interprets its possible depth through past experiences such as scientific measurements to know how deep the tunnel can be.

✓ FORM PERCEPTION

Finally, form perception indicates the contextualization of particular objects in a given environment, whereby the eyes sees them as primarily 2-D and at times as 3-D depending on the way of their placement. It is also the understanding of what characterizes the inner and outer core of an object. After seeing an orange, one immediately knows that it is round and has a rough texture on the skin that protects the soft interior.

THEORIES OF PERCEPTION

1. PERCEPTION AS DIRECT PERCEPTION

Cognitive theories of perception assume there is a poverty of stimulus. This (with reference to perception) is the claim that sensations are, by themselves, unable to provide a unique description of the world. Sensations require 'enriching', which is the role of the mental model. A different type of theory is the perceptual ecology approach of James J. Gibson. Gibson rejected the assumption of a poverty of stimulus by rejecting the notion that perception is based upon sensations – instead, he investigated what information is actually presented to the perceptual systems. His theory "assumes the existence of stable, unbounded, and permanent stimulus-information in the ambient optic array. And it supposes that the visual system can explore and detect this information. The theory is information-based, not sensation-based."

2. PERCEPTION-IN-ACTION

An ecological understanding of perception derived from Gibson's early work is that of "perception-in-action", the notion that perception is a requisite property of animate action; that without perception, action would be unguided, and without action, perception would serve no purpose. Animate actions require both perception and motion, and perception and movement can be described as "two sides of the same coin, the coin is action". Gibson works from the assumption that singular entities, which he calls "invariants", already exist in the real world and that all that the perception process does is to home in upon them. A view known as constructivism (held by such philosophers as Ernst von Glasersfeld) regards the continual adjustment of perception and action to the external input as precisely what constitutes the "entity", which is therefore far from being invariant.

Glasersfeld considers an "invariant" as a target to be homed in upon, and a pragmatic necessity to allow an initial measure of understanding to be established prior to the updating that a statement aims to achieve. The invariant does not and need not represent an actuality, and Glasersfeld describes it as extremely unlikely that what is desired or feared by an organism will never suffer change as time goes on. This social constructionist theory thus allows for a needful evolutionary adjustment.

A mathematical theory of perception-in-action has been devised and investigated in many forms of controlled movement, and has been described in many different species of organism using the General Tau Theory. According to this theory, tau information, or time-to-goal information is the fundamental 'percept' in perception.

3. EVOLUTIONARY PSYCHOLOGY (EP) AND PERCEPTION

Many philosophers, such as Jerry Fodor, write that the purpose of perception is knowledge, but evolutionary psychologists hold that its primary purpose is to guide action. For example, they say, depth perception seems to have evolved not to help us know the distances to other objects but rather to help us move around in space. Evolutionary psychologists say that animals from fiddler crabs to humans use eyesight for collision avoidance, suggesting that vision is basically for directing action, not providing knowledge.

Building and maintaining sense organs is metabolically expensive, so these organs evolve only when they improve an organism's fitness. More than half the brain is devoted to processing sensory information, and the brain itself consumes roughly one-fourth of one's metabolic resources, so the senses must provide exceptional benefits to fitness. Perception accurately mirrors the world; animals get useful, accurate information through their senses.

Scientists who study perception and sensation have long understood the human senses as adaptations. Depth perception consists of processing over half a dozen visual cues, each of which is based on a regularity of the physical world. Vision evolved to respond to the narrow range of electromagnetic energy that is plentiful and that does not pass through objects. Sound waves provide useful information about the sources of and distances to objects, with larger animals making and hearing lower-frequency sounds and smaller animals making and hearing higher-frequency sounds. Taste and smell respond to chemicals in the environment that were significant for fitness in the environment of evolutionary adaptedness. The sense of touch is actually many senses, including pressure, heat, cold, tickle, and pain. Pain, while unpleasant, is adaptive. An important adaptation for senses is range shifting, by which the organism becomes temporarily more or less sensitive to sensation. For example, one's eyes automatically adjust to dim or bright ambient light. Sensory abilities of different organisms often coevolve, as is the case with the hearing of echolocating bats and that of the moths that have evolved to respond to the sounds that the bats make.

FACTORS INFLUENCING THE PERCEPTION

The three important factors influencing the perception, i.e., (a) Characteristics of the Perceiver, (b) Characteristics of the Perceived, and (c) Characteristics of the Situation.

A. CHARACTERISTICS OF THE PERCEIVER:

When a person looks at a target and attempts to interpreter what he sees, his interpretation is greatly influenced by his personal characteristics which are discussed as follows:

1. Needs and Motives:

Our need pattern play an important part in how we perceive things. A need is a feeling of discomfort or tension when one things he is missing something or requires something. Therefore, unsatisfied needs or motives stimulate individuals and may exert a strong influence on their perception. When people are not able to satisfy their needs they are engaged in wishful thinking which is a way to satisfy their needs not in the real world but imaginary world. In such cases, people will perceive only those items which suit their wishful thinking. Motives also influence the perception of people. People who are devious are prone to see others as also devious.

2. Self Concept:

Self concept indicates how we perceive ourselves which then influences how we perceive others and the situation we are in. The more we understand ourselves, the more we are able to perceive others accurately. For example, secure people tend to see others as warm and friendly. Less secure people often find fault with others. Perceiving ourselves accurately and enhancing our-self concept are factors that enhance accurate perception.

3. Past Experience:

Our perceptions are often guided by our past experiences and what we expect to see. A person's past experiences mould the way he perceives the current situation. If a person has been betrayed by a couple of friends in the past, he would tend to distrust any new friendship that he might be in the process of developing.

4. Current Psychological State:

The psychological and emotional states of an individual are likely to influence how things are perceived. If a person is depressed, he is likely to perceive the same situation differently than if he is elated. Similarly, if a person is scared out of wits by seeing a snake in the garden, she is likely to perceive a rope under the bed as a snake.

5. Beliefs:

A person's beliefs influence his perception to a great extent. Thus, a fact is conceived not on what it is but what a person believes it to be. The individual normally censors stimulus inputs to avoid disturbance of his existing beliefs.

6. Expectations:

Expectations affect the perception of a person. Expectations are related with the state of anticipation of particular behaviour from a person. For example, a technical manager will expect that the non- technical people will be ignorant about the technical features of the product.

7. Situation:
Elements in the environment surrounding an individual like time, location, light, heat etc., influence his perception. The context in which a person sees the objects or events is very important.

8. Cultural Upbringing:
A person's ethics, values and his cultural upbringing also play an important role in his perception about others. It is difficult to perceive the personality of a person raised in another culture because our judgment is based upon our own values.

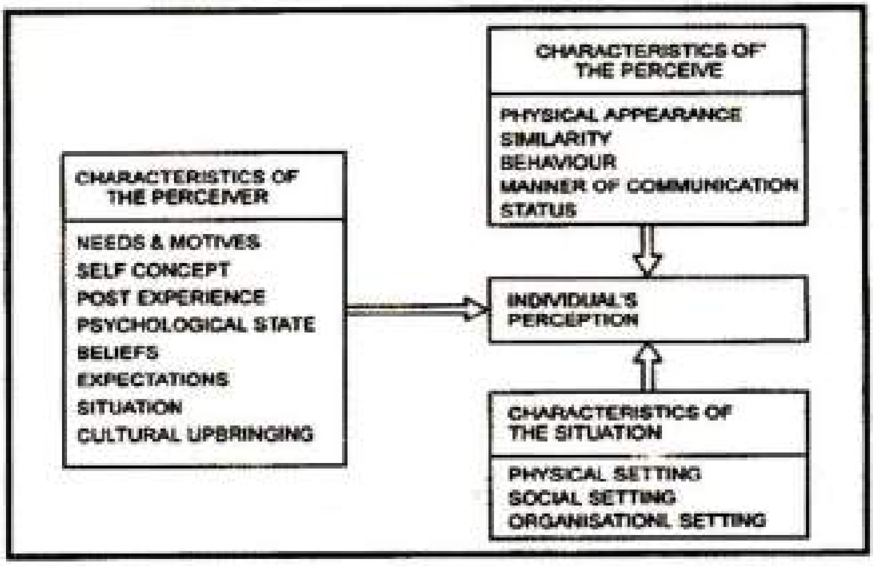
B. CHARACTERISTICS OF THE PERCEIVED:
Characteristics of the person who is being observed can affect what is perceived. Though, it may go against logic and objectivity, but it cannot be denied that our perceptions about others are influenced by their physical characteristics such as appearances, age, gender, manner of communication as well as personality traits and other forms of behaviour. For example, loud people are more likely to be noticed in a group than are quite ones. So too are extremely attractive or extremely ugly individuals.
Persons, objects or events that are similar to each other tend to be grouped together. People dressed in business suits are generally thought to be professionals, while employees dressed in ordinary work clothes are assumed to be lower level employees.
Manner of communication, both verbal and non-verbal, affect our perception about others. For example, the choice of words and precision of language can form impressions about the education and sophistication of the person. The tone of voice indicates the mood of the person. The depth of conversation and choice of topics provide clues of people's intelligence. The body language or expressive behaviour such as how a person sits and the movement of his eyes or a smile can indicate whether he is nervous or self confident.
The status or occupation of a person also influences the perception. We tend to behave in a more respectful way when we are introduced to the principal of a school in which our child is studying, judge of the high court or Supreme Court or a famous cricket player. Sometimes our perception of a person tends to be; biased, depending upon the description given to us by other persons. When we meet a person who is described to us as warm and friendly, we treat him differently as compared to meeting a person who is known to be cold & calculating.

C. CHARACTERISTICS OF THE SITUATION:
The context in which we see objects or events is very important. The surrounding environment and the elements present in it influence our perception while perceiving a particular situation or event, its physical, social and organisational setting can also influence the perception. For example, if you meet a person for the first time and he is with a person whom you respect and admire, you will create a favourable image about him in your mind as compared to a situation in which you see him with another person whom you intensely dislike. Of course, the initial impressions may change with the

passage of time, but the saying that "First impression is the last impression" is very valued.

SUMMARY

Perception is the way we interpret the information we sense
The perceptual process is a sequence of steps that begins with stimuli in the environment and ends with our interpretation of those stimuli; it involves the use of our special senses; **EYE, EAR, NOSE, SKIN, TONGUE** as well as other **SENSES** thus the following types of perception exists with respect to individual sense **SIGHT, SOUND, SMELL, TOUCH/PRESSURE, etc…**
Perception involves the ***selection/identification*** of stimuli; ***organizing*** such perceived stimuli and ***interpretation*** of stimuli.



The above figure shows the summary of the factors influencing perception.

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Scales of Measurement

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1 What is Measurement?

What it means to "measure" something has long been a topic of both scientific and philosophical debate. The concept of measurement is fundamental to the field of psychology because we need reliable measurements of psychological constructs in order to trust any statistical results pertaining to those constructs. Despite the importance of measurement, this topic is often glossed over in many psychological applications—researchers often begin by *assuming* that they have measured their construct of interest, without necessarily providing any concrete evidence that such measurements are reliable or valid. Of course, this is a serious problem for interpreting results of psychological studies because statistical methods cannot overcome issues pertaining to poor measurement. More specifically, most statistical methods abide by the "garbage in, garbage out" principle, so you should expect to obtain invalid results if your input variables are measured inadequately.

In this chapter, we will not cover all of the specifics regarding psychological measurement—entire books and courses have been devoted to this topic. Instead, I will provide a brief overview of the "Theory of Scales of Measurement" that was proposed by Stevens (1946). In this influential paper, Stevens defined measurement as "the assignment of numerals to objects or events according to rules" (p. 677), and this broad definition still seems to be embraced by many applied psychological studies. In his paper, Stevens presents four different scales (or levels) of measurement that can characterize different types of measures that are used in psychological and other social science studies. It should be noted that Steven's approach to measurement has been widely criticized by researchers who specialize in measurement and statistics (e.g., see Michell, 1986). However, it is important to understand Steven's ideas, which are an implicit part of applied psychology.

2 Scales of Measurement

2.1 Nominal Scale

According to Stevens (1946), "[t]he *nominal scale* represents the most unrestricted assignment of numerals" such that "[t]he numerals are used only as labels or type numbers, and words or letters would serve as well" (p. 678). In other words, nominal scales of measurement involve assigning numerals that are *not* meant to convey any quantitative meaning. For example, suppose that we record the variable Gender, and code the responses as 1 = Female, 2 = Male, and 3 = Other. This would be an example of a nominal scale of measurement, given that the numbers 1, 2, and 3 are simply used as labels for the levels of Gender. In statistical language, variables that are measured using a nominal scale are discrete categorical variables that have probability mass functions.

2.2 Ordinal Scale

According to Stevens (1946), "[t]he *ordinal scale* arises from the operation of rank-ordering" such that "any 'order-preserving' transformation will leave the scale form invariant" (p. 679). In other words, ordinal scales of measurement involve assigning numerals that are only meant to convey meaning regarding the order of objects or events. Stevens correctly notes that "most of the scales used widely and effectively by psychologists are ordinal scales" (p. 679); however, psychological researchers typically treat them otherwise. As an example of an ordinal scale, think of the positions in which runners cross the finish line for a race, i.e., first place, second place, third place, etc. These positions can be used to put the runners in order, but they cannot be used for anything beyond ordering the runners. For example, using only the order that the runners crossed the finish line, we cannot say anything about differences in the runners's times or speeds—aside from the fact that the runner in position i had a smaller time (or faster speed) than the runner in position $i + 1$. For variables with an ordinal scale of measurement, calculating difference scores, means, standard deviations, etcetera do not have any valid meaning. Instead, we should be focused on the quantiles of the distribution. In statistical language, variables that are measured using an ordinal scale are discrete (ordered) categorical variables that have probability mass functions.

2.3 Interval Scale

According to Stevens (1946), "[w]ith the *interval scale* we come to a form that is "quantitative" in the ordinary sense of the word. Almost all of the usual statistical measures are applicable here, unless they are the kinds that imply a knowledge of a 'true' zero point" (p. 679). In other words, interval scales are what we typically think of when we think of a quantitative measure, but such scales have a zero point that is "a matter of convention or convenience" (p. 679). The classic examples of interval scales of measurement are the Celsius and Fahrenheit scales that are used to measure temperature. Note that these scales have a linear relation to one another

$$°\text{Fahrenheit} = °\text{Celsius}\left(\frac{9}{5}\right) + 32$$

and both scales have an arbitrary zero point. Regarding the arbitrary zero point, note that zero does not indicate a complete absence of the property being measured (i.e., temperature) for either scale: 0°C is when water freezes and 0°F is when a brine freezes.[1] Despite using ordinal measures used to collect psychological data, most psychological researchers treat their collected data as if were interval scale. In statistical language, variables that are measured using an interval scale are continuous variables that have probability density functions.

2.4 Ratio Scale

According to Stevens (1946), "*ratio scales* are those most commonly encountered in physics and are possible only when there exist operations for determining all four relations: equality, rank-order, equality of intervals, and equality of ratios" (p. 679). Note that ratio scales are similar to interval scales, except that ratio scales have a true zero point. As an example of a ratio scale, consider the measurement of the length of an object. In this case, we can convert between units by multiplying by a constant, for example

$$\text{foot} = 12\text{inch}$$

and such scales have a true zero point: 0 inches indicates a complete absence of the property being measured (i.e., length). Ratio scales are (almost?) never encountered in psychology.

[1] For some history of the Fahrenheit scale, see `https://en.wikipedia.org/wiki/Fahrenheit`

Table 1: Reproduction of Table 1 from Stevens (1946).

Scale	Basic Empirical Operations	Mathematical Group Structure	Permissible Statistics (invariantive)
NOMINAL	Determination of equality	*Permutation group* $x' = f(x)$ $f(x)$ means any one-to-one substitution	Number of cases Mode Contingency correlation
ORDINAL	Determination of greater or less	*Isotonic group* $x' = f(x)$ $f(x)$ means any monotonic increasing function	Median Percentiles
INTERVAL	Determination of equality of intervals or differences	*General linear group* $x' = ax + b$	Mean Standard deviation Rank-order correlation Product-moment correlation
RATIO	Determination of equality of ratios	*Similarity group* $x' = ax$	Coefficient of variation

Note. According to Stevens (1946) "any numeral, x, on a scale can be replaced by another numeral, x', where x' is the function of x listed in this column" (p. 678).

2.5 Summary

Steven's scales of measurement are summarized in Table 1. The second column provides a simple description of what you can determine using each type of scale. The third column provides some details on how different units for a given scale must be related to one another. The fourth column describes what sort of analytic procedures are allowed for each scale of measurement. This fourth column is of particular importance for applications in psychology. As a reminder, most applied studies in psychology use ordinal measurements but apply methods that are only permissible for interval scale data. This is important because one could argue that the "reproducibility crisis" in psychology is related to the incongruence between psychological measurements and the methods applied to the measured data.

3 Reliability and Validity

3.1 Overview

Although not directly related to the scales of measurement proposed by Stevens (1946), the concepts of reliability and validity are essential to address whenever discussing the topic of measurement. In practice, it is important to understand the scale of measurement that is being used, as well as the quality of the measurements.

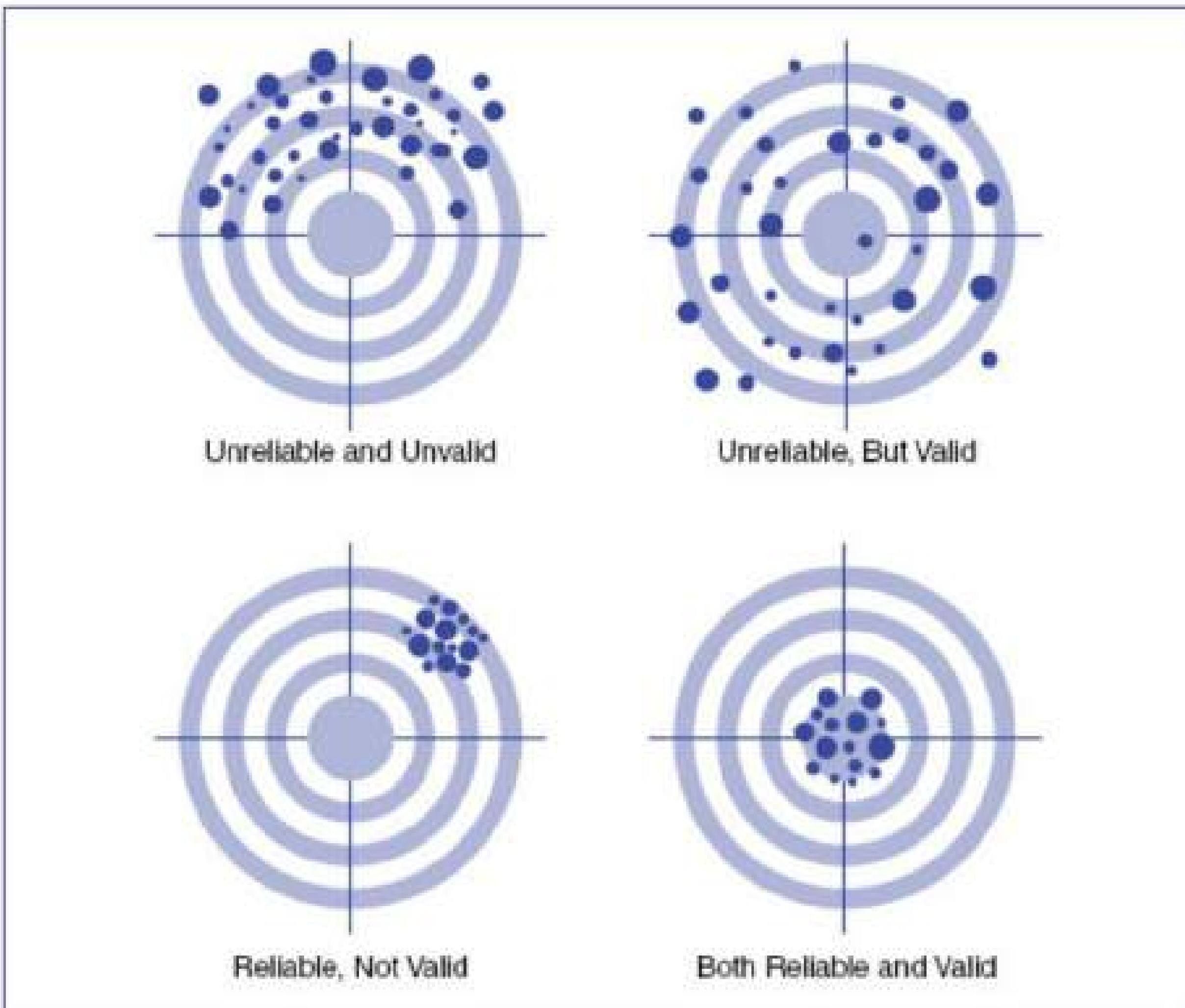

Figure 1: Visualization of reliability and validity from Ruel et al. (2016).

3.2 Reliability

There are many types of reliability that are discussed in psychological research, but all of the variants are centered around a common theme: a *reliable* measure is one that is "dependable, replicable, and consistent" (Ruel et al., 2016). In other words, a reliable measure is one that produces the same measurement results (up to the scale's precision) when measuring two objects that have the same amount of the property being measured. For example, if two individuals have the same weight, a reliable scale would return the same weight measurements up to the scale's measurement precision (e.g., 0.1 pounds).

Types of Measurement Reliability:

- *Test-retest reliability*: the correlation between two measurements of the same object measured at different times using the same scale.
- *Alternate form reliability*: the correlation between two measurements of the same object measured at the same time using different scales.
- *Internal consistency*: the pairwise correlations between the individual items that compose the measurement scale (item-wise congruence).
- *Split-test reliability*: the correlation between the scores on the first half and the second half of the measurement scale.
- *Inter-rater reliability*: the correlation between measurements as determined by two independent subjects (raters) measuring the same object.

3.3 Validity

There are many types of validity that are discussed in psychological research, but all of the variants are centered around a common theme: a *valid* measure is one that "operates the way [researchers] expect" (Ruel et al., 2016). In other words, a valid measure is one that measures what it is supposed to measure—without missing key properties or including unintended properties. For example, if an exam is supposed to measure statistical knowledge, then the exam would be a valid measurement if it comprehensively quantifies statistical knowledge without measuring extra unintended constructs (e.g., reading or language skills).

Types of Measurement Validity:

- *Face validity*: the measurement appears valid at face value.
- *Content validity*: the content of the measurement scale is complete, applicable, and representative of the measured construct.
- *Criterion-based validity*: the agreement between a scale's measurement and the measurement from a "gold standard" scale.
- *Concurrent validity*: the agreement between a scale's measurement and measurements of related (but distinct) constructs meaured from the same objects.
- *Predictive validity*: the ability of a measurement to predict related constructs.
- *Construct validity*: the degree to which a measurement scale is assessing the construct of interest, e.g., instead of some other construct.
- *Convergent validity*: the agreement between two measures in the same study that are intended to assess the same construct
- *Discriminant validity*: the lack of agreement between two measures in the same study that are intended to assess different constructs

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Chapter 5

Measurement

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Ordinal Scale

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Operational Definitions

An essential component of an operational definition is measurement. A simple and accurate definition of **measurement** is the assignment of numbers to a variable in which we are interested. These numbers will provide the raw material for our statistical analysis.

Measurement is so common and taken for granted that we seldom ask why we measure things or worry about the different forms that measurement may take. It is often not sufficient to describe a runner as "fast," a basketball player as "tall," a wrestler as "strong," or a baseball hitter as "good." If coaches recruited potential team members on the basis of these imprecise words, they would have difficulty holding down a job. Coaches want to know how fast the runner runs the 100-yard dash or the mile. They want to know exactly how tall the basketball player is, the strength of the wrestler, the batting average of the hitter. Measurement is a way of refining our ordinary observations so that we can assign numerical values to our observations. It allows us to go beyond simply describing the presence or absence of an event or thing to specifying how much, how long, or how intense it is. With measurement, our observations become more accurate and more reliable.

Precision is important in all areas of our lives, especially in the sciences and technologies, and we look for ways of increasing it. Here is an interesting classroom demonstration of the precision of numbers versus the precision of words Ask the class members to write down on a piece of paper what number the word "several" represents to them. Gather the responses and then plot them on the board. You will be surprised at the wide range of numbers represented by the word (it usually ranges from 2 to 7).

How often have you been in an argument with a friend, only to find out after much debate that you are using key words in different ways? The argument is one of *semantics* rather than of issues. You defined the word one way, and your friend defined it a different way. This experience is more common among laypersons than among scientists, but it still occurs. Before the merits of an issue or a position can be discussed, there must be agreement about the meaning of the important terms. The same is true in science. If we are to avoid confusion and misinterpretation, we must be able to communicate unambiguously the meaning of such terms as *intelligence, anxiety, altruism, hostility, love, alienation, aggression, guilt, reinforcement, frustration, memory*, and *information*. These terms have all been used scientifically, in very precise ways. Each of these terms could be given a dictionary definition, usually referred to as a literary or conceptual definition. But dictionary definitions are not sufficiently precise for many scientific terms because they are too general and often too ambiguous. When a word is to be used scientifically or technically, its precise meaning must be conveyed—it must be clear and unambiguous. We achieve this clarity of meaning by operationally defining the term. To state the operations for a term means to make the term observable by pointing to how it is measured. An **operational definition,** then, makes the concept observable by stating what the scientist does to measure it.

For example, *anxiety* could be defined in dictionary terms as "a state of being uneasy, apprehensive, or worried." An operational definition of the term could include observable measures such as sweating palms (observable as sweat gland activity), increased heart rate (observable with heartbeat recording), dilated pupils, and other observable physiological changes. It could also be a self-rating scale or a paper-and-pencil questionnaire. We could in each case specify the precise amounts of each measure necessary for our operational definition of anxiety.

As another example, consider the hypothesis that we proposed in the last chapter. We hypothesized that the effect of TV violence on older children's aggressive behavior at school will be less if the characters are not human. Although this appears to be a clear statement, more specific operational definitions would be necessary before any research could be undertaken to test the hypothesis. The researcher must make several decisions. What is violence on TV? Certainly, one character killing another character would be considered violence. What about a shove or push? What about a verbal assault? What about when Wile E. Coyote falls off the cliff and is hit in the head with a rock? What constitutes a character that is not human? We could probably agree that Wiley Coyote fits this category. What about a computer-animated person? How will aggressive behavior at school be defined? Of course, getting into a fight would be aggressive behavior. What about profanity directed toward another student or teacher? What about little Johnny chasing Mary on the playground? Notice that there are no correct answers to these questions. However, the researcher must decide what is going to be meant by each of the variables in a particular study and be able to communicate those operational definitions to those who will be consumers of the research findings.

Table 5.1 contains both dictionary definitions and operational definitions of some common terms. Note that in each case, the operational definition refers to events that are observable or events that can easily be made observable. Note further that the definition is very specific rather than general.

Table 5.1 Dictionary and Operational Definitions of Several Terms Commonly Used by Psychologists

For each concept, other operational definitions are possible.

TERM	DICTIONARY DEFINITION	OPERATIONAL DEFINITION
Punishment	Harsh or injurious treatment for an offense	Presentation of 3 milliamp shock for .5 second following certain (specified) behavior
Learning	Acquiring knowledge or skill	Change in behavior (specify kind of behavior) as a function of practice
Anxiety	State of being uneasy, apprehensive, or worried	Sweat gland activity (amount), heart rate (amount), physiological changes (specify), self-reported anxiety on a scale of 1 to 7
Intelligence	Ability to learn or understand from experience	Score on the Stanford–Binet Intelligence Test, score on the Wechsler Intelligence Scale for Children
Thirst	Distressful feeling caused by a desire or need for water	Eighteen hours (or other value) without access to water
Sleep	Recurring condition of rest, no conscious thought, eyes closed, etc.	Specific brain wave frequencies (EEG) for different sleep stages
Guilt	A painful feeling of self-reproach	Score on a personality inventory, self-reported guilt on a scale of 1 to 10

The feature that determines whether a particular definition is more useful than another is whether it allows us to discover meaningful laws about behavior. Some will, and some will not. Those definitions that are helpful to our understanding of behavior will be retained; those that do not will be discarded. The first step in the life of a concept is to define it in clearly unambiguous, observable terms. It then may or may not be useful. If the concept of intelligence were defined as "the distance between the ears," or "the circumference of the head," its meaning would be clear, but it is very doubtful that it would ever become useful.

Let's look at one additional point before leaving the topic of definitions. An operational definition, or any other kind of definition, is not an explanation. When definitions are unintentionally used as explanations, we label them as **tautological** or **circular reasoning.** Circular reasoning has little value. A definition doesn't explain behavior or provide you with information that will, in and of itself, help in understanding behavior. It is a necessary step in discovering lawful relations, but it is only one side of a two-sided law. To explain behavior, two independent (different) types of observation are necessary: one is observations that relate to the independent variable (variable manipulated by the experimenter or "cause"), and the second is observations that relate to the dependent variable (behavior of participant or "effect"). When the relationship between the independent and dependent variables is predictable, we say that we have a lawful relationship. A circular argument uses only one side of the relationship—only one of these observations. For example, suppose we observe two children fighting with each other (body contact with intent to harm). We may be tempted to say they are fighting because they are hostile children, because hostility leads to fighting. To this point, we have not explained anything. All we have is an operational definition of hostility as fighting behavior. Our argument would be a tautology (circular) if we said that the children are fighting because they are hostile and then said that we know that they are hostile because they are fighting. To avoid circularity and to explain the behavior, we would have to define hostility and fighting independently and show that the operations for defining hostility do in fact give rise to fighting.

Tautological reasoning occurs with a higher frequency than it should. For example, it is not uncommon to hear the statement "Individuals who commit suicide are mentally ill." To the question "How do you know they are mentally ill?" the response is often "Because they committed suicide." Another common tautology refers to musical ability. For example, it is said "Individuals who play the piano well do so because they have musical ability." To the question "How do you know they have musical ability?" the response is "Because they play the piano well." Another example is "Individuals drink excessively because they are alcoholics. We know that they are alcoholics because they drink excessively." We repeat, tautological arguments do not advance our knowledge. To avoid circularity in our last example, we would have to define what we mean by "drinks excessively" and then identify the factors that give rise to drinking excessively—for example, genetics, specific early experiences, or stressful events. We then would have an explanation for the drinking.

Numbers and Precision

As noted earlier, measurement scales are important because they allow us to transform or substitute precise numbers for imprecise words. We are restricted in what we can do with words but less so with numbers. Numbers permit us to perform certain activities and operations that words do not. In many instances, numbers permit us to add, multiply, divide, or subtract. They also permit the use of various statistical procedures. These statistics, in turn, result in greater precision and objectivity in describing behavior or other phenomena. At a minimum, we know that the numbers 1, 2, 3, 4, and so on, when applied to the frequency of occurrence of any event, mean that 4 instances are more than 3, which in turn are more than 2, and so on. Contrast numbers with words such as *frequently, often,* or *many times.* Does an event occurring *frequently* occur a greater or fewer number of times than an event occurring *often*? It may be true that a given individual uses the two terms *frequently* and *often* consistently across situations; another individual may also use the two terms consistently, but in reverse order. The result would be confusion.

The use of numbers rather than words increases our precision in communicating in other ways also. Finer distinctions (discriminations) can often be achieved with numbers if the distinctions can be made reliably. Instead of saying a certain behavior was either present or absent, or occurred with high, medium, or low frequency, numbers permit us to say, more precisely, how frequently the behavior occurred. Words are often too few in number to allow us to express finer distinctions.

Our number system is an abstract system of symbols that has little meaning in and of itself. It becomes meaningful when it becomes involved in measurement. As noted earlier, measurement is the process of assigning numbers to objects and events in accordance with a set of rules. To grasp the full impact of measurement, we need to understand the concept of a measurement scale. There are several different kinds of scales: nominal, ordinal, interval, and ratio. The distinction among scales becomes of particular importance when we conduct statistical analyses of data. Underlying statistical tests are various assumptions, including those relating to the scale of measurement. In other words, the scale of measurement for a variable can determine the most appropriate type of statistical analysis of the data.

Scales of Measurement

Nominal Scale

There has been some disagreement among experts whether a **nominal scale** should even be described as a scale. Most would agree that it should. The fact is that we do name things, and this naming permits us to do other things as a result. The word *nominal is* derived from the Latin word for *name.* With a nominal scale, numbers are assigned to objects or events simply for identification purposes. For example, participants in various sports have numbers on their jerseys that quickly allow spectators, referees, and commentators to identify them. This identification is the sole purpose of the numbers. Performing arithmetic operations on these numbers, such as addition, subtraction, multiplication, or division, would not make any sense. The numbers do not indicate more or less of any quantity. A baseball player with the number 7 on his back does not necessarily have more of something than a player identified by the number 1. Other examples include your social security number, your driver's license number, or your credit card number. Labeling or naming allows us to make qualitative distinctions or to categorize and then count the frequency of persons, objects, or things in each category. This activity can be very useful. For example, in any given voting year, we could label or name individuals as Democrat or Republican, Liberal or Conservative, and then count frequencies for the purpose of predicting voting outcomes. Other examples of nominal scales used for identifying and categorizing are male–female, violent show–nonviolent show, and punishment–reward. As you will see later, a chi-square statistic is appropriate for data derived from a categorical (nominal) scale.

Ordinal Scale

An **ordinal scale** allows us to rank-order events. Original numbers are assigned to the order, such as first, second, third, and so on. For example, we might determine that runners in a race finished in a particular order, and this order would provide us with useful information. We would know that the runner finishing first (assigned a value of 1) ran the distance faster than the runner finishing second (assigned a value of 2), that the second-place finisher ran faster than the third-place finisher (assigned a value of 3), and so on. However, we would not know how much faster the first runner was than the second-place runner, or the second compared with the third. The difference between the first- and second-place runners may have been a fraction of a second, or it could have been several seconds. Similarly, the difference between the second- and third-place runners could have been very small or very large. An ordinal scale does not convey precise quantitative information. With an ordinal scale, we know the rank order, but we do not have any idea of the distance or interval between the rankings. Some other examples of ordinal scales are grades such as "A," "B," "C," "D," and "F"; scores given in terms of high, medium, and low; birth order in terms of firstborn, second-born, or later-born; a list of examination scores from highest to lowest; a list of job candidates ranked from high to low; and a list of the ten best-dressed persons.

What about the common use of Likert-type scales in behavioral research? For example, a researcher may pose a question to a teacher as follows:

How aggressive has Johnny been in your classroom this week?

Not at all		Somewhat		Very
1	2	3	4	5

Although most psychological scales are probably ordinal, psychologists assume that many of the scales have equal intervals and act accordingly. In other words, the difference in level of aggression between a score of 1 and a score of 2 is about the same as the difference in level of aggression between a score of 2 and a score of 3, and so on. Many researchers believe that these scales do approximate equality of intervals reasonably well, and it is unlikely that this assumption will lead to serious difficulties in interpreting our findings.

Interval Scale

When we can specify both the order of events *and* the distance between events, we have an **interval scale.** The distance between any two intervals on this type of scale is equal throughout the scale. The central shortcoming of an interval scale is its lack of an absolute zero point—a location where the user can say that there is a complete absence of the variable being measured. This type of scale often has an arbitrary zero point, sometimes called an *anchor point.* An example may make clear the difference between an arbitrary zero point and an absolute zero point. Scores on intelligence tests are considered to be on an interval scale. With intelligence test scores, the anchor point is set at a mean IQ value of 100 with a standard deviation (SD) of 15. A score of 115 is just as far above the mean (one SD) as a score of 85 is below the mean (one SD). Because we have a relative zero point and not an absolute one, we cannot say that a person with an IQ of 120 is twice as intelligent as a person with an IQ of 60. It is simply not meaningful to do so. Some additional examples of interval scales are both the centigrade and Fahrenheit scales of temperature, altitude (zero is sea level rather than the center of the earth), and scores on a depression scale or an anxiety scale. Students often confuse historical time. Is the year 2000 twice as old as the year 1000? The answer is no. Why?

Ratio Scale

A **ratio scale** has a number of properties that the others do not. With ratio scales, we can identify rank order, equal intervals, *and* equal ratios—two times as much, one-half as much. Ratios can be determined because the zero point is absolute, a true anchor—the complete absence of a property. Zero weight or height means the complete absence of weight or height. A 100-pound person has one-half the weight of a 200-pound person and twice the weight of a 50-pound person. We can say these things because we know that the starting points for these dimensions or measures is 0. It is important to notice that it is not necessary for any research participant to obtain a score of 0, only that it exists on the scale. Obviously no research participant would receive a weight score of 0!

A ratio scale is common when the researcher is counting the number of events. For example, you might measure a child's aggressive behavior by counting the number of times that the child inflicts physical harm on another person during a one-week observation period. Clearly, 10 incidents would be twice as many as 5, and 0 incidents would represent the absence of the variable you are measuring. Frequency counts that represent the number of times that a particular event occurred are a common example of measurement on a ratio scale. But be careful not to confuse this use of *frequency* with the use of *frequency* as a summary statistic for data measured on a nominal scale (how many times observations fit a particular category).

Table 5.2 provides additional examples of each scale of measurement.

Table 5.2	Examples of Variables for Each Scale of Measurement
Nominal	Type of disorder (schizophrenia, depression, anxiety)
Label or category	Religious affiliation (none, Catholic, Protestant, Jewish, other)
	Region of the country (Northeast, Midwest, Southwest, etc.)
	Eye color (blue, brown, hazel, green)
	Flavor of ice cream (vanilla, chocolate, strawberry)
	Type of reinforcer (food, water, money, compliment)
Ordinal	College classification (freshman, sophomore, junior, senior)
Rank order	Grade on a test (A, B, C, D, F)
	National ranking of a sports team (1st, 2nd, 3rd, 4th, 5th, etc.)
	Reaction time (fastest, 2nd fastest, 3rd fastest, 4th fastest, etc.)
	Intensity of light (very bright, bright, dim, none)
	Age classification (child, teen, young adult, adult, older adult)
Interval	Difference between the mean test score and each student's score
Rank order	Score on the Beck Anxiety Scale (scores range from 0 to 44, but note that a score of 0 does not represent a complete absence of anxiety)
+	Score on a Likert-type scale (1, 2, 3, 4, 5, 6, 7)
Equal intervals	Temperature measured in degrees Celsius or degrees Fahrenheit
	Weight measured on a scale not calibrated to zero
Ratio	Number of college credits completed
Rank order	Number of correct answers on a test
+	Number of total points scored in a season by a sports team
Equal intervals	Reaction time measured in milliseconds
+	Intensity of light measured in lumens
Absolute zero	A person's age measured in years

Determining the scale of measurement for a variable is often a challenging task for students learning about behavioral research. One technique that you may find useful is to remember three questions and use the decision tree shown in Figure 5.1.

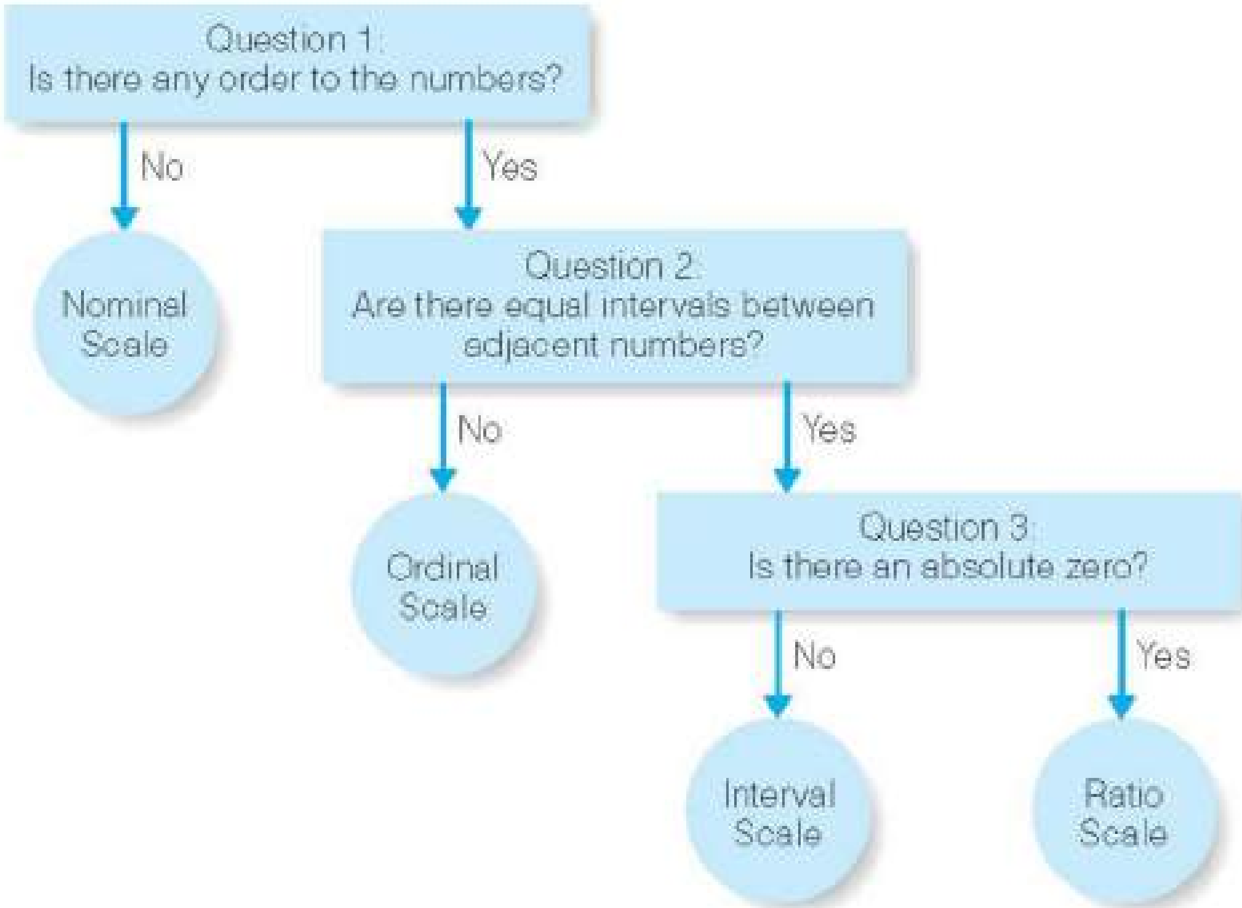

Figure 5.1 Decision tree to determine the appropriate scale of measurement.

Validity of Measurement

Two important concepts relate to the measuring instruments that we use: validity and reliability. In a general sense, **validity** refers to whether the measuring instrument does what it is intended to do, and **reliability** refers to how consistently it does so. It is critical that our measurements of variables be both valid and reliable. If they are not, then we cannot be sure of what we are measuring.

The validity and reliability of a test are established by evidence. Does the SAT (Scholastic Aptitude Test) measure students' ability to do academic work (question of validity), and if so, how consistently does it do so (question of reliability)? Do those students scoring high on the SAT perform predictably better in college than those scoring low (validity)? If a student took the SAT today and then again six months from today, would the score on the two performances be similar (reliability)? We should note that a test may be highly reliable, but if it does not relate to our behavior of interest (validity), it is useless for predicting that behavior. The length of the big toe can be measured with a high degree of consistency, but it is unlikely to be a valid predictor of academic success. We can measure many things very reliably, but unless they enter into meaningful behavioral relationships (lawful relationships), they are not useful. Thus, we can achieve reliability without having validity. However, the reverse is not possible. In order to be valid, a measure must be reliable.

Let us look at five types of validity that are commonly distinguished: content validity, face validity, concurrent validity, predictive validity, and construct validity (see Figure 5.2). Content validity and face validity relate to tests of current knowledge and skills, whereas predictive validity relates to future performance on a job or task. Concurrent validity assesses similarity to other current measures, and construct validity deals with evaluating theoretical terms.

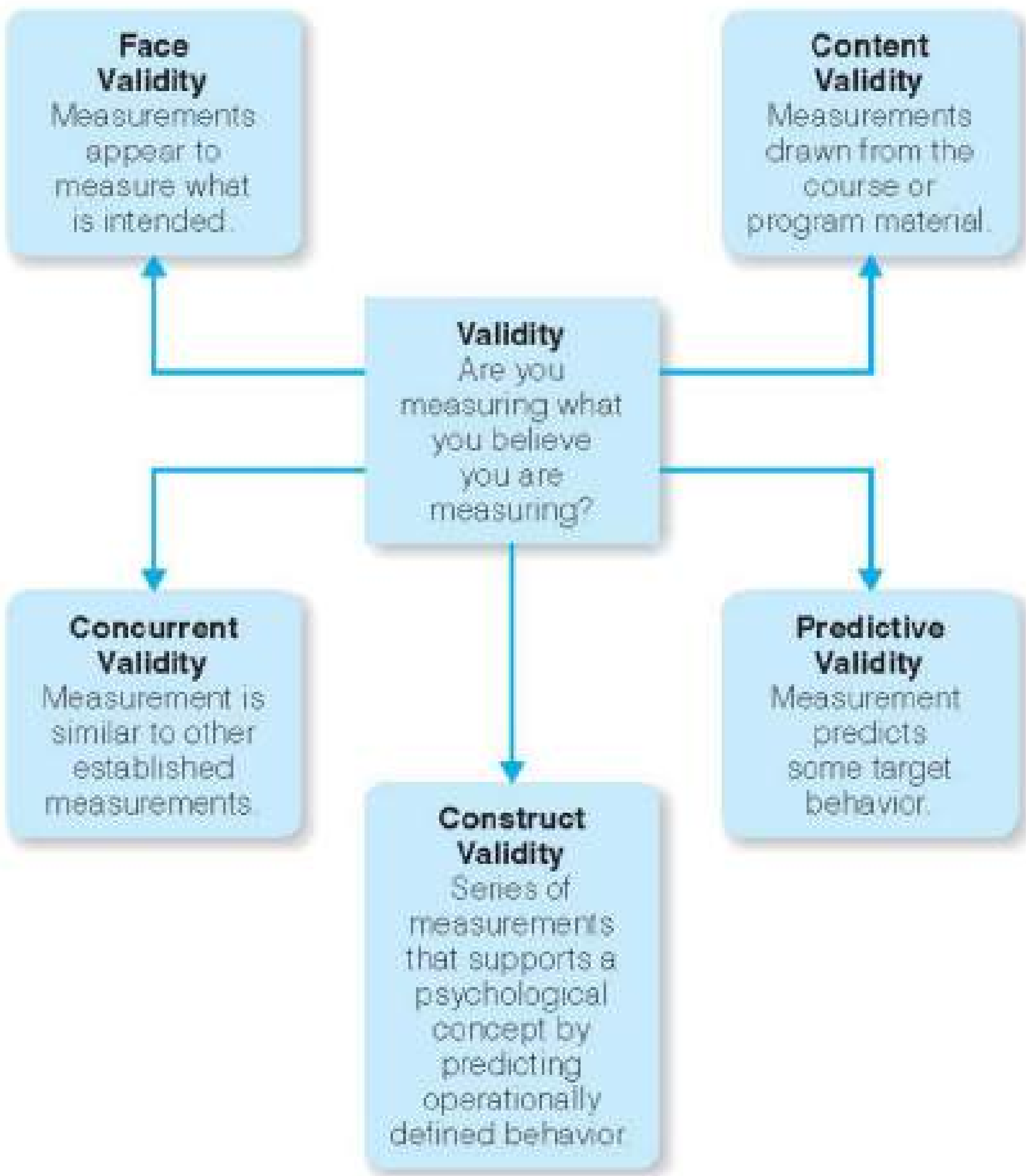

Figure 5.2 Ways to assess validity.

Content Validity

With **content validity,** we are interested in assessing current performance rather than predicting future performance. A test is constructed to measure whether participants in a program have mastered the contents of the program. Course examinations—whether midterm, finals, or some other kind—deal with content validity. Developers of social programs that require training of personnel are concerned about the effectiveness of the training. Thus, they frequently rely on content validity. *Content validity is achieved by constructing a test drawn directly from material in a program or course.* There can be disagreements regarding the representativeness of the test materials. For example, students taking an exam sometimes complain that it did not cover the material they were required to read. If this were true, the exam would be low in content validity. Although not always possible, we could assure representativeness by constructing a complete list of the content for the program or course and then selecting test items randomly from the material. Thus, content validity is based on prior considerations about what content will be included.

Face Validity

Face validity is similar to content validity, but it is determined *after* the test is constructed. We ask ourselves whether or not the test appears, on the face of it, to measure what we intend it to measure. If the test is known to have content validity, face validity can be assumed. However, it does not work in reverse direction; that is, face validity does not ensure content validity. The face validity of an exam in research methods would be high if the questions appeared to deal with research methods. However, without actual knowledge of the course materials, there would be no assurance that the questions were representative of the actual course material.

Concurrent Validity

Often, we measure psychological constructs for which there is a long history of investigation. Such constructs include intelligence, aggression, fear, attention, depression, anxiety, and many others. One way to assess the validity of our instrument is to determine whether it has **concurrent validity**—that is, whether it provides measurements that are similar to those provided by other instruments, previously established as valid, designed to measure the same construct. If our new measure of aggression results in scores that are the same as or similar to those found with a traditional measure of aggression, then we can be reasonably confident that we are measuring the same construct. For example, if the authors developed a new Lammers–Badia Depression Scale, we would want individuals to complete our instrument and also to complete an established instrument such as the Beck Depression Inventory (BDI). If our scale in fact measures depression, then individuals who score high (depressed) on our scale ought to score high on the BDI as well.

Predictive Validity

Predictive validity, also called criterion validity, is often used in program evaluation studies and is very suitable for applied research. Essentially, a test is constructed and developed for the purpose of predicting some form of behavior. For example, score on the SAT (the predictor) is moderately correlated with academic performance in college (the criterion). Knowing this relationship and an individual's score gives us a better idea of how a student will perform in college than we would have in the absence of this information. The higher the correlation between the criterion and the predictor, the greater the predictive validity. Indeed, if the correlation is perfect (1.00), the prediction is also perfect. However, most of the time correlations are only modest, somewhere between .30 and .60. Nevertheless, they are considered useful. It is very difficult to construct a good predictor measure; it is also very difficult to obtain a good criterion measure.

Construct Validity

Construct validity is one of the most important and also the most difficult to understand. We can only touch upon it here. Construct validity is especially important for the construction of theories. Researchers create theoretical constructs to better understand, explain, and predict behavior. Many hypotheses that are tested in research are derived from constructs, or theories of behavior. The construct or theory predicts how people should behave under certain conditions. The degree to which the results support the theory is a measure of construct validity. Examples of some constructs are frustration, aggression, motivation, learning, fear, hopelessness, creativity, and intelligence. Constructs are created by describing the procedures for measuring them. If the instrument for measuring them assists us in understanding and predicting behavior, they are considered valid. If they do not serve these purposes, their validity is rejected. Notice how constructs are related to the notion of operational definitions discussed at the beginning of this chapter. Constructs are general terms that can be operationally defined in different ways. For example, the construct of aggression could be operationally defined as the number of behaviors that lead to physical harm, or it could be defined as the number of physical and verbal threats. Thus, a construct attempts to summarize or explain a set of operational definitions.

Construct validity asks whether a particular measure actually measures the construct that it is intended to measure. Establishing construct validity involves several steps. Generally, the researcher or theorist designs a test and specifies what it is intended to measure. The test is then tied to, or related to, the relevant theory. Then predictions are made that relate behavior to the test scores. Finally, data are gathered to ascertain whether the predictions are confirmed.

Let's consider two related examples of psychological constructs and how construct validity was assessed. In the late 1960s, Martin Seligman conducted a series of studies with dogs that led him to develop the psychological construct of learned helplessness. He observed that dogs that had been exposed to situations in which they could not avoid an unpleasant event would, in later situations, not even attempt to remove or avoid an unpleasant event even when it was possible (Seligman & Maier, 1967). This finding led to the hypothesis (theory) that early lack of control over environmental events can be debilitating, both cognitively and physiologically. That is, when individuals are subjected to aversive environmental events over which they have no control, the result is learned helplessness, which will be reflected in impaired learning, reduced levels of motivation, poor performance, and physiological deterioration. An extensive series of studies in other animal species (including humans) since the late 1960s supports the notion that the construct of learned helplessness (predictor) does lead to behavioral evidences of impaired learning, motivation, and so on (criterion). This correlation between the predictor and the criterion provides evidence of construct validity. In more recent years, Seligman has developed the related construct of learned optimism (Seligman, 1998) and the Seligman Attributional Style Questionnaire (SASQ) to measure optimism. The construct validity of learned optimism has been demonstrated in numerous studies (reported to be over 500) that show a relationship between optimism scores on the SASQ (predictor) and measures of success, performance, motivation, and physical well-being (criterion variables). Again, such research evidence supports the notion that the psychological construct of optimism is useful in understanding, explaining, and predicting behavior.

What we are suggesting through these examples is that constructs reflect basic behavioral processes. If learned helplessness and learned optimism exist, then certain behaviors should follow. If our expectations are confirmed a number of times in a variety of settings, our construct is useful—that is, valid. Usually, many studies are necessary to demonstrate construct validity. With time and continued research, both the construct and the theory usually undergo a series of modifications and become more refined.

Before turning to the issue of reliability, take a look at the box "Thinking Critically About Everyday Information" and review several concepts presented thus far in the chapter.

Thinking Critically About Everyday Information: Understanding Sleep Apnea

What follows is an article that appeared in the *New York Times* newspaper.

> John Holman of St. Paul is a very busy man, and he was not accustomed to having to "let things go" because he was too tired to do them. But tired he was, tired driving to and from work, tired during the day at the warehouse company he runs, too tired some days to play his beloved game of tennis after work, and really tired in the evening—in bed by 8:30 to arise at 6.
>
> But Mr. Holman, an average-size 67-year-old, did nothing about his fatigue until his wife, Marna, threatened to move out of their bedroom because his snoring was keeping her awake. It was she who suggested that he might have sleep apnea. With it, breathing stops, often for a minute or longer, sometimes hundreds of times a night and resumes each time with a loud snort or snore. So at his wife's urging, Mr. Holman spent a night in the sleep laboratory at Abbott Northwestern Hospital in Minneapolis. Her suspicions were confirmed. Mr. Holman now sleeps with a device that assists his breathing, and both he and his wife, who feared he would fall asleep while driving and kill himself or someone else, are feeling a lot better.
>
> The National Institutes of Health estimates that as many as 18 million Americans, 6 percent of the nation, have sleep apnea. After the proliferation of sleep centers around the country and greater awareness of the condition, the diagnosis of sleep apnea increased twelvefold from 1990 to 1998.
>
> Still, experts estimate that fewer than 10 percent of people who have it are aware of it. As a result, they risk their health and their lives and possibly the lives of others.

Sleep apnea is a disorder that occurs only in sleep and more in REM (rapid eye movement) sleep than in the other stages of sleep. When this disorder is present, the individual stops breathing during sleep for 10 seconds or longer but can breathe normally when awake. Cessation of breathing may occur hundreds of times during the night, with no memory of it in the morning. To determine whether the disorder is present requires the individual to spend a night at a sleep disorders clinic where brain waves (EEG) and respiratory activity can be monitored using a polygraph machine. The EEG pattern reveals when the individual is asleep, how long it takes the person to fall asleep, and the various sleep stages that he or she passes through during the night. Measurement of respiration reveals how frequently an individual has stopped breathing and for how long. Respiration is measured in two ways during the night. One is with sensors near the nose and mouth to measure airflow. The second way is with a respiratory belt attached to diaphragm/chest to measure breathing effort. People with sleep apnea wake up very tired in the morning and are very sleepy all day long. They frequently fall asleep while driving, watching television, reading, or sitting in a meeting. As mentioned, they are unaware that they have sleep apnea, even though they may have awakened hundreds of times during the night. The most prominent symptoms are daytime sleepiness, mood changes, and irritability. If the condition is left untreated, other health problems emerge.

Effective treatments for sleep apnea are available. Any effective treatment would have to address the symptoms noted. One way that sleepiness is measured is with a self-rating scale. Similar rating scales are used for mood changes and irritability. Consider the following questions:

- Is sleep apnea a quantitative or qualitative event?
- What kind of measurement scale would be involved in measuring severity of sleep apnea?
- What measurement scale would be involved if sleepiness, irritability, and mood were each rated on a self-report scale from 1 to 10 (1 = not at all sleepy, 10 = extremely sleepy)?
- In addition to a self-report assessment of sleepiness, can you think of another way to operationally define sleepiness that would be less subjective (perhaps on a ratio scale)?
- How might you show concurrent validity for the psychological construct of sleepiness?

- How might you show predictive validity for the psychological construct of sleepiness?

SOURCE: Jane E. Brody, "Sleep Apnea: A Noisy but Often Invisible Threat," *New York Times*, 17 September 2002, p. F7.

Reliability of Measurement

A measuring instrument is reliable if measurements recorded at different times give similar results. Obviously, we would not want to use a measuring instrument if it did not give similar results under similar circumstances. Consistency is imperative if we are to obtain useful data. As we have previously noted, reliability is a necessary but not a sufficient condition for validity. Information regarding test reliability should be available for every test or measure. This information should specify the extent of the reliability, including the type of reliability and the conditions under which it was obtained. Reliability estimates are expressed in terms of a correlation coefficient and, therefore, are not all-or-none scores. As we noted, correlations can vary from –1.0 to 1.0, but most reliability coefficients remain in the 0.0 to 1.0 range.

The upper limits of a test of reliability are established by the similarity of items in terms of what they have in common (interitem correlation) and the number of items on the test. As long as the test items provide independent measures of the same construct, the larger the number of items on a test, the more reliable the test will be. This notion is reflected in the way many sports championships are determined (as in baseball, basketball, and hockey), using a series of several games rather than just one. On any given day, a weaker team may defeat a stronger team, but it is unlikely that a weaker team will consistently beat a stronger team. Similarly, witness the Olympic decathlon. It is a contest in which an athlete must take part in ten events. Consider another example. A course in psychology at the end of the term may have available 1,000 questions that could be used on the final exam. The final exam will be constructed by sampling these items. A sample of only 5 items would be too few for reliability purposes. As we added items, our reliability would increase rapidly, but beyond a certain point, reached rather quickly, adding more items would add very little to our reliability. Thus, a 50-item test would be considerably more reliable than a 5-item test.

For those interested in pursuing this notion further, an estimate of reliability that considers both interitem correlation and the number of items on a test is referred to as the *coefficient alpha* or the *Kuder–Richardson Method*. Among other things, this method will allow you to determine the number of items needed to achieve a given value of reliability.

Next, we discuss three specific methods to assess reliability (see Figure 5.3).

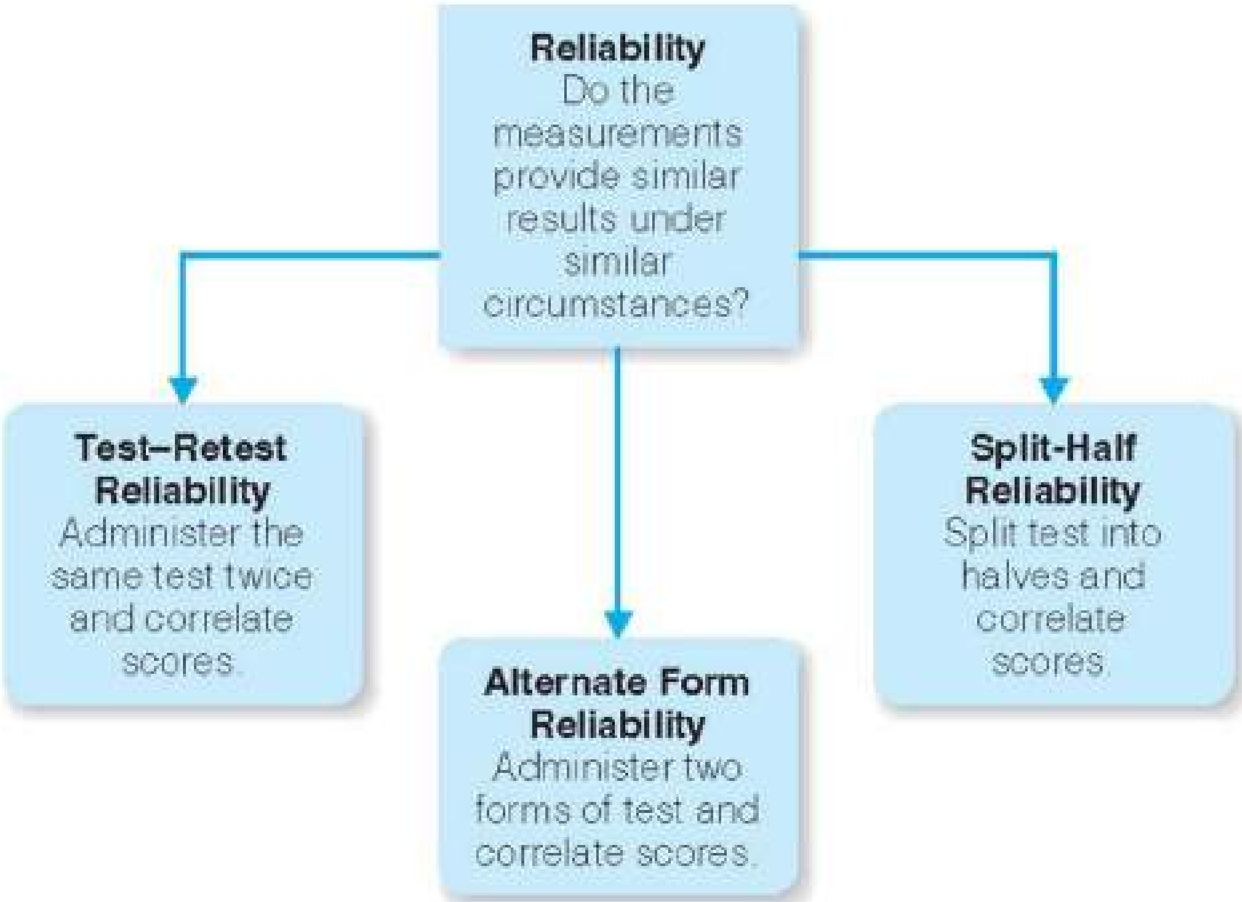

Figure 5.3 Ways to assess reliability.

Test–Retest Reliability

One obvious way to determine the reliability of a test is to administer the same test twice to the same individual. To establish **test–retest reliability,** we administer the identical test a second time, usually after a week or two has gone by. We then calculate a correlation coefficient for the first and second test scores. The time interval between the tests must be specified because retest correlations decrease as the time interval between tests increases. Some problems with this procedure relate to possible practice effects. Also, if the interval between the tests is very short, the individual may be able to remember previous answers given the first time, and the scores between the two sets of test scores would not be independent.

Take a look at the scores shown in Table 5.3. These scores represent a test–retest assessment for two different tests. Although high test–retest reliability ($r = 0.98$) suggests that both instruments are relatively free of measurement error, care should be taken in interpreting this coefficient. It is evident in Table 5.3 that high reliability does not mean that an individual's first and second scores are nearly the same; this may or may not be the case. Glancing over the pairs of scores for Test A, you do get the impression that the individuals scored similarly on both test administrations. However, glancing over the pairs of scores for Test B, you can see that the similarity in scores is much less and that, overall, the scores on the second administration are higher. Because test–retest reliability is derived through a correlational analysis, the strength of the relationship depends upon the similarity in rank order on the first and second test distributions—that is, whether the individual was first, second, third, and so on, on the two distributions of test scores. In this regard, test–retest reliability is a relative measure. It is possible to have high test–retest reliability and yet have different absolute scores on the first and second testing. Although this situation is unusual, the occurrence of some significant event between the two test administrations could cause a shift in scores.

Table 5.3 Test–Retest Reliability Coefficients for Two Different Tests

	Test A		Test B	
Test Taker	1st Administration	2nd Administration	1st Administration	2nd Administration
Ryan	76	78	76	87
Beth	84	83	84	92
Brandi	85	85	85	94
Chandler	67	64	67	73
John	86	89	86	98
Mary	92	91	92	100
Casey	71	75	71	84
Nina	58	55	58	64
Amy	63	60	63	69
	$r = 0.98$		$r = 0.98$	

We also want to comment on low test–retest reliability. Low reliability does not always suggest a faulty measuring instrument. If a significant event occurs between the two test administrations for some of the test takers but not all, then low test–retest reliability may result. For example, a therapy or training program for a reading disability may take place between the first and second testing periods. If those with the greatest disability showed the greatest improvement, then this would lower test–retest reliability. However, if no deliberate effort to change the condition of individuals was made and only a short period of time intervened between the first and second tests, then low test–retest reliability is most likely due to a faulty measuring instrument.

Alternate Form Reliability

Some of the difficulties with the test–retest procedure can be avoided by using **alternate form reliability.** With this method, an individual is tested on one form of the test (Form A) and then again on a comparable second form (Form B). Again, a correlation coefficient is computed between the scores on Forms A and B. The period of time between the two tests is usually a week or two, although this time varies considerably. Usually, the two forms contain the same number of items and cover similar content. Alternate form reliability is used more frequently than test–retest reliability because it has fewer associated problems, including a substantial reduction in practice effects.

Split-Half Reliability

Only a single test session is involved when using the method of **split-half reliability.** Two scores for each individual are obtained by splitting the test into comparable halves. This is usually achieved by assigning odd-numbered items to one form and even-numbered items to the other (odd–even split). Generally, this method is not preferred over others because the scores on the two halves are not independent. To illustrate, if a test taker is "spaced out" while taking the test, both scores will be depressed. With a sufficient number of instances of this sort, a spuriously high correlation will result, and the reliability will appear to be higher than it really is.

Factors That Affect Reliability

A number of factors can lower the reliability of a test. Within a testing period, individuals may become upset or ill, or they may misread the question, make a clerical error when recording an answer, or guess at the answer. Between testing sessions, an individual may change, there may be differences between the two tests (alternate form), or scoring criteria may change. It is also important to remember that reliability is measured using correlation coefficients. One factor than can reduce correlations is a restricted range of scores on one or both variables. A restricted range of scores can result from a testing instrument that does not allow a variety of possible scores or from testing samples of individuals who all score very similarly on the instrument (either very high or very low). For example, you would not want to assess the reliability of a depression scale by using a sample of suicidal individuals!

Experimental procedures are available to address these factors that affect reliability. In addition to selecting an appropriate sample of research participants, researchers can reduce measurement error and improve reliability by writing the items carefully. They should follow a standardized procedure for giving the test so that testing conditions are very similar. They should state instructions clearly so that they are easily understood. Finally, they should use objective scoring procedures to avoid error due to subjectivity and changing criteria. We should also restate that longer tests (given the same interitem correlation) are more reliable than shorter tests. Obviously, when new tests are being constructed, considerable "pilot testing" (preliminary selection of items, testing, revising) is necessary before a useful instrument can be developed.

Acceptable reliability levels depend on what the test is used for. For basic research purposes, reliabilities of approximately .70 are not uncommon, but correlations of .80 or higher are considered desirable. To obtain higher estimates of reliability requires considerable effort in selecting items, standardizing the procedure, and administering and scoring the test. For applied problems dealing with social issues such as placement in a retraining program or a special class, or for awards, measurement error must be minimized. Under these and similar circumstances, reliability coefficients less than .90 are usually not acceptable.

We should note that this discussion has focused on the reliability of testing instruments. Often in behavioral research, human observers record behavior, and their observations provide the data for analysis. The reliability of researcher observations is also an important issue and involves the degree to which multiple observers record the same observations. This notion of interobserver agreement (interrater reliability) will be discussed in the next chapter, along with other issues of observation.

Case Analysis

Universities continually examine ways to increase the academic success of their students. One factor may be the level of emphasis on academics in the student's life. Thus, you believe that students who experience an out-of-class living environment that emphasizes academics will be more successful in college. Your university has several housing options for incoming freshmen. You work with the housing office to assign some freshmen to live in off-campus apartments, some freshmen to live in on-campus residence halls, and some freshmen to live in on-campus residence halls called residential colleges. These residential colleges emphasize academics by having faculty live in the residence hall, by holding classes in the residence hall, by creating a peer tutoring system in the residence hall, and by creating a program of activities that revolve around academics. At the end of their freshman year, you assess the students' study skills and grade point average. You assess study skills by asking the students 63 true/false questions related to actions and attitudes toward studying. The study habits score is the number of questions answered positively.

Critical Thinking Questions

1. Identify your independent variable(s).

2. Identify your dependent variable(s).
3. What is your hypothesis?
4. What is your operational definition of academic emphasis?
5. What is your operational definition of success in college?
6. Your independent variable is measured on what scale of measurement?
7. Study skills are measured on what scale of measurement?
8. What criterion could be measured to support the predictive validity of the study habits instrument?
9. How would you test the reliability of the study habits instrument?

General Summary

Many of the concepts that we study in psychology are subject to different interpretations. Therefore, the researcher must provide operational definitions that define the variables in specific and measurable terms. For the purpose of analysis, the observations that are made must be assigned numerical values. These numbers that result from the measurement process possess particular characteristics defined by the scale of measurement. Numbers on a nominal scale are simply labels with no greater-than or less-than qualities. Numbers on an ordinal scale indicate greater than and less than, but do not tell us how much greater or less. Numbers on an interval scale have equal intervals between adjacent numbers, but the scale has no absolute zero. A ratio scale has order, equal intervals, and an absolute zero.

Quality research involves measurements that are valid and reliable. Validity refers to confidence that you are measuring what you intended to measure, and reliability refers to consistency in your measurements. Validity is composed of content validity, face validity, concurrent validity, predictive validity, and construct validity. Reliability can be assessed with test–retest, alternative forms, and split-half methods. Although all of these concepts may seem a bit tedious, the good researcher knows that attention to them is directly related to confidence that the results will indeed answer the research question.

Now that we understand some of the issues regarding the measurement of variables, the next chapter will focus on the methods we use to collect such data.

Detailed Summary

1. Measurement is a way of refining our observations so that we can assign numerical values to them. Measurement requires precise definitions of psychological variables such as intelligence, anxiety, altruism, hostility, love, alienation, aggression, guilt, reinforcement, frustration, and memory.
2. Operational definitions provide precision by defining psychological variables in terms of specific operations. For example, hunger could be defined as the number of calories consumed. Operational

definitions are useful when they allow us to discover lawful relationships among variables. Operational definitions, by themselves, are not explanations. Using definitions as explanations results in inappropriate tautological reasoning.

3. The conversion of observations to numbers permits the use of mathematical operations to better describe and analyze observations. The numbers that represent observations exist on one of four scales of measurement: nominal, ordinal, interval, or ratio. The scale of measurement is important because it determines the types of mathematical operations and statistical analyses that are appropriate.
4. On a nominal scale of measurement, numbers simply represent labels and have no quantitative meaning (for example, religious affiliation). On an ordinal scale of measurement, numbers represent rank order but without equal intervals between adjacent numbers (for example, letter grade on a test). An interval scale has equal intervals between adjacent numbers but no absolute zero (for example, score on a Likert-type scale). A ratio scale of measurement has equal intervals and an absolute zero (for example, number of correct test questions).
5. Validity refers to whether the instrument measures what it is intended to measure. Validity can be assessed in different ways.
6. Content validity is the degree to which measurement items are drawn from the content of the course or program to be evaluated. Face validity is the degree to which measurement items appear (on the face of it) to accurately represent the content to be evaluated. Concurrent validity is the degree to which measurements correlate with measurements from an established (validated) instrument. Predictive validity is the degree to which measurements predict some target behavior. Construct validity is the degree to which measurements support a psychological concept that helps to explain and predict behavior.
7. In order for measurements to be valid, they must be reliable; that is, they should provide similar results under similar circumstances.
8. Test–retest reliability is the degree to which measurements are similar when the same instrument is administered a second time. Alternate form reliability is the degree to which measurements are similar when a comparable version of the instrument is administered. Split-half reliability is the degree to which measurements are similar when different halves of the same instrument are compared.
9. Factors that can lower the reliability of a test include a restricted range of scores, feeling ill, misreading questions, making clerical errors, guessing at answers, changes in the test takers, differences between two tests (alternate form), or changes in scoring criteria.

Key Terms

alternate form reliability

concurrent validity

construct validity

content validity

face validity

interval scale

measurement

nominal scale

operational definition

ordinal scale

predictive validity

ratio scale

reliability

split-half reliability

tautological (circular) reasoning

test–retest reliability

validity

Review Questions / Exercises

1. Provide an operational definition for each of the following variables: hunger, reaction time, academic success, college year (such as freshman or sophomore), fear, and type of automobile.
2. For each of the variables in question 1, describe the types of numbers that would be used to measure these variables, and identify the appropriate scale of measurement.
3. Search a library database for a study that addresses the validity of an instrument or construct. Describe which methods were used to assess validity.
4. Search a library database for a study that addresses the reliability of an instrument. Describe which methods were used to assess reliability.
5. In your own words, describe why validity and reliability of measurement are important in behavioral research.

Piaget's Theory of Cognitive Development

Citation: Huitt, W., & Hummel, J. (2003). Piaget's theory of cognitive development. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved [date] from http://chiron.valdosta.edu/whuitt/col/cogsys/piaget.html.

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Jean Piaget (1896-1980) was one of the most influential researchers in the area of developmental psychology during the 20th century. Piaget originally trained in the areas of biology and philosophy and considered himself a "genetic epistemologist." He was mainly interested in the biological influences on "how we come to know." He believed that what distinguishes human beings from other animals is our ability to do "abstract symbolic reasoning." Piaget's views are often compared with those of Lev Vygotsky (1896-1934), who looked more to social interaction as the primary source of cognition and behavior. This is somewhat similar to the distinctions made between Freud and Erikson in terms of the development of personality. The writings of Piaget (e.g., 1972, 1990; see Piaget, Gruber, & Voneche) and Vygotsky (e.g. Vygotsky, 1986; Vygotsky & Vygotsky, 1980), along with the work of John Dewey (e.g., Dewey, 1997a, 1997b), Jerome Bruner (e.g., 1966, 1974) and Ulrick Neisser (1967) form the basis of the constructivist theory of learning and instruction.

While working in Binet's IQ test lab in Paris, Piaget became interested in how children think. He noticed that young children's answers were qualitatively different than older children which suggested to him that the younger ones were not dumber (a quantitative position since as they got older and had more experiences they would get smarter) but, instead, answered the questions differently than their older peers because they thought differently.

There are two major aspects to his theory: the process of coming to know and the stages we move through as we gradually acquire this ability.

Process of Cognitive Development. As a biologist, Piaget was interested in how an organism adapts to its environment (Piaget described as intelligence.) Behavior (adaptation to the environment) is controlled through mental organizations called schemes that the individual uses to represent the world and designate action. This adaptation is driven by a biological drive to obtain balance between schemes and the environment (equilibration).

Piaget hypothesized that infants are born with schemes operating at birth that he called "reflexes." In other animals, these reflexes control behavior throughout life. However, in human beings as the infant uses these reflexes to adapt to the environment, these reflexes are quickly replaced with constructed schemes.

Piaget described two processes used by the individual in its attempt to adapt: assimilation and accomodation. Both of these processes are used thoughout life as the person increasingly adapts to the environment in a more complex manner.

Assimilation is the process of using or transforming the environment so that it can be placed in preexisting cognitive structures. Accomodation is the process of changing cognitive structures in order to accept something from the environment. Both processes are used simultaneously and alternately throughout life. An example of assimilation would be when an infant uses a sucking schema that was developed by sucking on a small bottle when attempting to suck on a larger bottle. An example of accomodation would be when the child needs to modify a sucking schema developed by sucking on a pacifier to one that would be successful for sucking on a bottle.

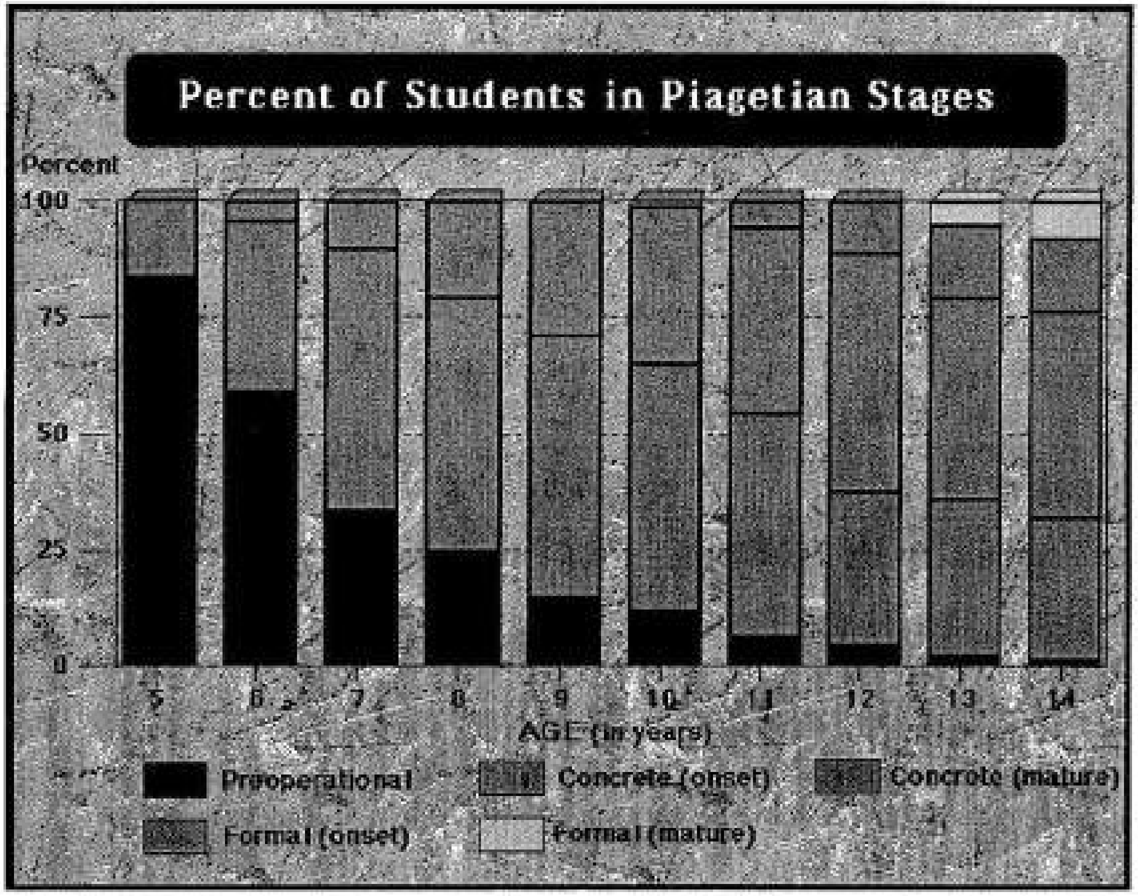
As schemes become increasingly more complex (i.e., responsible for more complex behaviors) they are termed structures. As one's structures become more complex, they are organized in a hierarchical manner (i.e., from general to specific).

Stages of Cognitive Development. Piaget identified four stages in cognitive development:

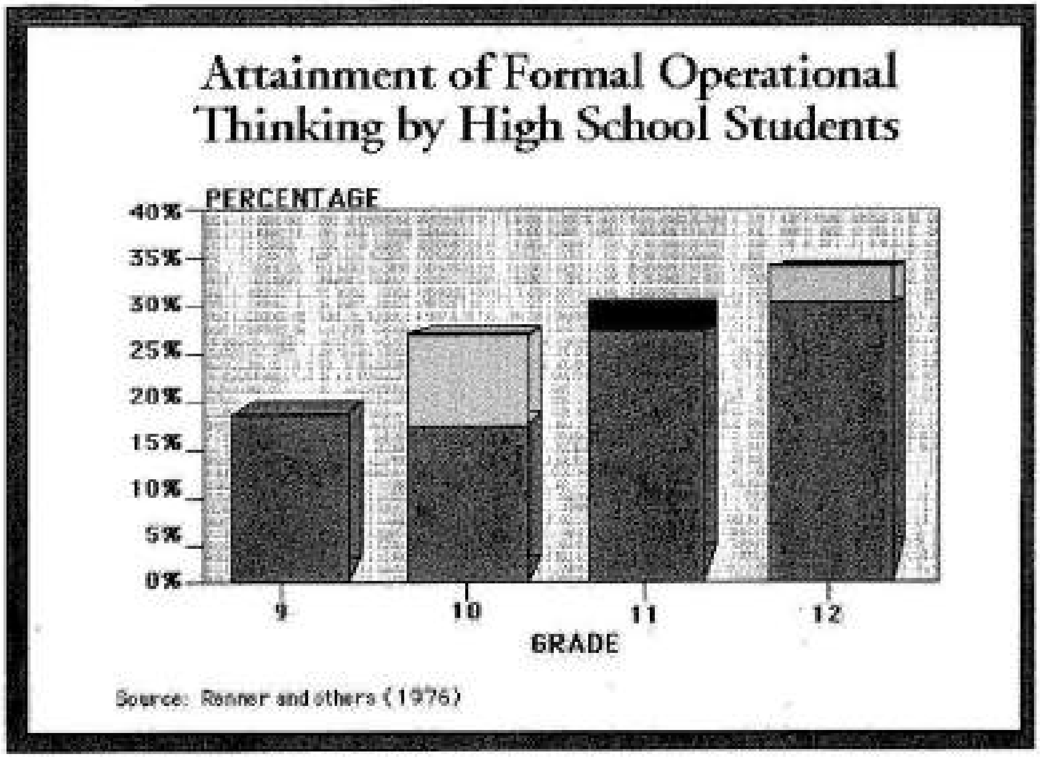
1. **Sensorimotor stage** (Infancy). In this period (which has 6 stages), intelligence is demonstrated through motor activity without the use of symbols. Knowledge of the world is limited (but developing) because its based on physical interactions / experiences. Children acquire object permanence at about 7 months of age (memory). Physical development (mobility) allows the child to begin developing new intellectual abilities. Some symbollic (language) abilities are developed at the end of this stage.
2. **Pre-operational stage** (Toddler and Early Childhood). In this period (which has two substages), intelligence is demonstrated through the use of symbols, language use matures, and memory and imagination are developed, but thinking is done in a nonlogical, nonreversable manner. Egocentric thinking predominates
3. **Concrete operational stage** (Elementary and early adolescence). In this stage (characterized by 7 types of conservation: number, length, liquid, mass, weight, area, volume), intelligence is demonstarted through logical and systematic manipulation of symbols related to concrete objects. Operational thinking develops (mental actions that are reversible). Egocentric thought diminishes.
4. **Formal operational stage** (Adolescence and adulthood). In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts. Early in the period there is a return to egocentric thought. Only 35% of high school graduates in industrialized countries obtain formal operations; many people do not think formally during adulthood.

Many pre-school and primary programs are modeled on Piaget's theory, which, as stated previously, provides part of the foundation for constructivist learning. Discovery learning and supporting the developing interests of the child are two primary instructional techniques. It is recommended that parents and teachers challenge the child's abilities, but NOT present material or information that is too far beyond the child's level. It is also recommended that teachers use a wide variety of concrete experiences to help the child learn (e.g., use of manipulatives, working in groups to get experience seeing from another's perspective, field trips, etc).

Piaget's research methods were based primarily on case studies [they were descriptive]. While some of his ideas have been supported through more correlational and experimental methodologies, others have not. For example, Piaget believed that biological development drives the movement from one cognitive stage to the next. Data from cross-sectional studies of children in a variety of western cultures seem to support this assertion for the stages of sensorimotor, preoperational, and concrete operations.



However, data from similar cross-sectional studies of adolescents do not support the assertion that all individuals will automatically move to the next cognitive stage as they biologically mature. Data from adult populations provides essentially the same result: Between 30 to 35% of adults attain the cognitive development stage of formal operations (Kuhn, Langer, Kohlberg & Haan, 1977). For formal operations, it appears that maturation establishes the basis, but a special environment is required for most adolescents and adults to attain this stage.



There are a number of specific examples of how to use Piagetian theory in teaching/learning process.

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INTELLIGENCE: NATURE &THEORIES

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Intelligence

- Intelligence is cognition comprising sensory, perceptual associative and relational knowledge. It is sum total of all cognitive processes including coding of information, planning, attention and arousal.

Prior to Binet in 1895 intelligence was a philosophical concept and could not be estimated. Binet was interested to studying the way individual differ from each other and suggested testing for differences in their intelligence. Test should be appropriate to their background and occupation.

The aim of the Binet was to determine qualitatively the mental ability at which a child functions rather than to give to child a number such as mental age.

- Intelligence Quotient was devised by William Stern in 1912
- Binet said the I.Q. could not reduce to sensory, motor or perceptual process as Cattle and Galton rather Binet stressed a core of intelligence consist of more complex process as memory, imagery, comprehension and judgment.

Binet's complex set of qualities includes

- The appreciation of a problem and the direction of the mind towards its execution.
- The capacity for making the necessary adaptation to reach on a definite end.
- The power of self criticism: Judge well, understand well, & reason well, attention and adaptation.

Definition of Intelligence:

Binet and Simon (1905):

The essence of intelligence is to judge well, to comprehend well, and to reason well.

Definition

American Psychologist M.L.Terman (1921)

"A person is intelligent in proportion as he is able to carry on abstract thinking.

Definition

Wechsler :

Intelligence is a global capacity of an individual to think rationally, to act purposefully and to cope effectively with the environment.

Definition

Anstey (1966)

"Capacity to utilize past experiences to solve new problems."

Gardner's theory of multiple intelligence:

Gardner's theory is based on the idea that the mind is not a holistic entity, but instead consists of distinct, independent modules.

Gardner (1985) has described seven different types of intelligence

Linguistic intelligence

used when reading, writing or comprehending speech

Musical intelligence

used in musical appreciation, composition and performance

Mathematical-logical intelligence

used in arithmetic, numerical calculation and logical reasoning

Spatial intelligence

used in arranging objects spatially, as well as in visual art and finding one's way around

Bodily-kinesthetic intelligence

used in sport, dancing or simple everyday movement and dexterity

Interpersonal intelligence

used in relating to others, interpreting social signals and predicting social outcomes

Intrapersonal intelligence

used in understanding and predicting one's own behaviour, and in identifying aspects of the self and one's own personality

Factors affecting intelligence

- Intelligence is an ill-defined, difficult to quantify concept. Accordingly, the IQ tests used to measure intelligence provide only approximations of the posited 'real' intelligence.
- In addition, a number of theoretically unrelated properties are known to correlate with IQ such as race, gender etc., but since correlation does not imply causation the true relationship between these factors is uncertain.

Factors affecting IQ

- Factors affecting IQ may be divided into biological and environmental.

Biological

- Evidence suggests that genetic variation has a significant impact on IQ, accounting for three fourths in adults. Despite the high heritability of IQ, few genes have been found to have a substantial effect on IQ, suggesting that IQ is the product of interaction between multiple genes.

Environmental

- Evidence suggests that family environmental factors may have an effect upon childhood IQ, accounting for up to a quarter of the variance. On the other hand, by late adolescence this correlation disappears, such that adoptive siblings are no more similar in IQ than strangers.
- Moreover, adoption studies indicate that, by adulthood, adoptive siblings are no more similar in IQ than strangers, while twins and full siblings show an IQ correlation.

- Consequently, in the context of the nature versus nature debate, the "nature" component appears to be much more important than the "nurture" component in explaining IQ variance in the general population.

Theories of Intelligence

Psychologists have attempted to understand the structure of intelligence for which they have formulated theories. Among the important theories of intelligence, we shall study three of them.

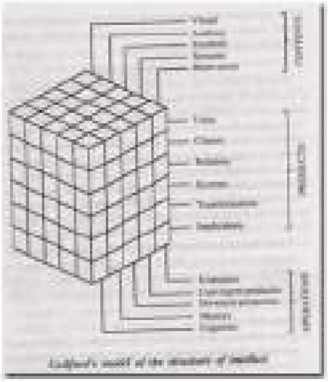
- Spearman's Two-Factor Theory
- Guilford's Theory of Structure of Intellect (S. I Model)
- Thurston's Group Factor Theory

2. Guildford's Structure of Intelligence (SI Model)

J.P. Guilford developed a model of intelligence (1966) using factor analysis. He outlines topography of the structure of intellect, providing an integrated rationale for describing the many dimension of intellectual performance. He suggests that there are three basic parameters along which any intellectual activity takes place. These are:

1. Operations – the act of thinking
2. Contents – the terms in which we think, and
3. Products – the ideas we come up with.

Guilford identified 5 operations, 5 contents and 6 products. Thus the maximum number of factors in terms of the different possible combination s of these dimensions will be 5x5x6 = 150.



1. **Operations:** It consists of five major groups of intellectual abilities.

- **Cognition:** It refers to discovery, rediscovery or recognition.
- **Memory:** Simply remembering what was once known.
- **Convergent Thinking:** This type of thinking, by reasoning, results in useful solution to problems.
- **Divergent Thinking:** This is thinking in different directions, seeking and searching some variety and novelty.
- **Evaluation:** It is reaching decisions or making judgments about information

2. **Content:** A Second way of classifying the intellectual factor is according to the kind of material or content involved. It involves five factors:

- **Visual Content:** It is concrete material which is perceived through our senses, i.e. size, form, colour, etc.
- **Auditory Content:** It consists of language, speech, sounds, music and words
- **Symbolic Content:** It is composed of letters, digits, and other conventional signs.
- **Semantic Content:** It is in the forms of verbal meanings or ideas which we get from others.
- **Behavioural Content:** It means social behaviour in society.

3. **Products:** When a certain operation is applied to certain kind of content as many as six kinds of products may be involved.

- **Units:** Understanding the meaning of words, visual, auditory and symbolic units.
- **Classes:** It means classification of words and ideas.
- **Relations:** It implies discovering relations of words and ideas.
- **Systems:** The ability to structure objects in space and to structure symbolic elements and to formulate problems.
- **Transformation:** The ability to look into the future lines of development or to suggest changes in the existing situations.
- **Implications:** The ability to utilize present information for future ends.

Educational Implication and relevance of SI Model:

1. This theory about the idea that the brain of a child is like a computer, who acquires, stores and uses information.
2. It provides knowledge about the specific ability of the students to guide them in the right direction.
3. SI Model is useful in finding out the reasons of the unsatisfactory performance of the students in spite of their adequate intelligence.
4. This model points out that for understanding higher mental processes like thinking some drastic modifications could be needed in our curriculum or method of instruction.
5. This model has explored 150 intellectual abilities and this enables us to find out whether we are paying sufficient attention to each one of them or not and if not how to improve.
6. This model guides us to device enrichment programmes for the gifted children.

7. It stresses that learning of specific skills should be our focus of attention.

8. SI Model is very useful in constructing tests of various types for different age groups.

9. This concept of Guildford will prove useful in our future research in the areas of learning, memory, problem-solving etc.

10. This model discovered many abilities which were not known before.

11. It is very useful for vocational training.

Conclusion: Guildford's theory of Intelligence seems to be the most comprehensive theory as it attempts to take into considerations all possible aspects of intellectual activity.

3. Thurston's Group Factor Theory

Louis Thurston came out with the group factor theory (1937) saying that Intelligence is a cluster of abilities. These mental operations then constitute a group. A second group of mental operations has its own unifying Primary factor; a third group has a third Primary factor and so on. Each of them has its own primary factor. Each of these primary factors is said to be relatively independent of others. He pointed out that there were **Seven Primary Mental Abilities** and later on added two more. They are:

- **Verbal comprehension Factor.** This factor involves a person's ability to understand verbal material. It is measured by tests such as vocabulary and reading comprehension.

- **Verbal fluency Factor.** This ability is involved in rapidly producing words, sentences, and other verbal material. It is measured by tests such as one that requires the examinee to produce as many words as possible beginning with a particular letter in a short amount of time.
- **Numerical Factor.** This ability is involved in rapid arithmetic computation and in solving simple arithmetic word problems.
- **Perceptual speed Factor.** This ability is involved in proofreading and in rapid recognition of letters and numbers. It is measured by tests such as those requiring the crossing out of As in a long string of letters or in tests requiring recognition of which of several pictures at the right is identical to the picture at the left.
- **Inductive reasoning Factor.** This ability requires generalization—reasoning from the specific to the general. It is measured by tests, such as letter series, number series, and word classifications, in which the examinee must indicate which of several words does not belong with the others.

- **Spatial visualization Factor.** This ability is involved in visualizing shapes, rotations of objects, and how pieces of a puzzle fit together. An example of a test would be the presentation of a geometric form followed by several other geometric forms. Each of the forms that follows the first is either the same rotated by some rigid transformation or the mirror image of the first form in rotation. The examinee has to indicate which of the forms at the right is a rotated version of the form at the left, rather than a mirror image.
- **Memory Factor.** It means the ability to recall and associate previously learned items effectively or memorize quickly.

Later on other factors were added on like **Deductive Reasoning** (P) – Ability to use the generalized results correctly and **Problem solving ability factor** (PS) -Ability to solve problem independently

Educational Significance and Implications

- Thurston contributed greatly to the measurement of attitudes. In psychology, the 'Thurston scale' developed in 1928 was the first formal techniques for measuring of attitudes.
- Thurston's theory of intelligence was a major influence on later theories of multiple intelligences, such as those of Guilford, Gardner, and Sternberg.
- Thurston has been noted for developing a comparative judgment scaling technique. The rank scale can be used to rank all possible feelings related to an issue and to categorize people expressing an opinion based on the rank of that opinion. It is used today mainly in basic research.
- Thurston held that if the individual wants to perform any particular activity, one or more of these factors or abilities are involved. Some of them are more important than others.

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Chapter Seven

HOWARD GARDNER'S MULTIPLE INTELLIGENCES THEORY AND HIS IDEAS ON PROMOTING CREATIVITY

HANI MORGAN

ABSTRACT: This book chapter highlights Howard Gardner's contributions to the areas of education and creativity. It includes an introductory section on his background and accomplishments. The chapter focuses on his theory of multiple intelligences, Gardner's best-known theory, and provides details on how he got the idea for this theory. It offers an explanation of this theory and the implications it has for educators. His theory of human intelligence contradicts the view that there is one type of intelligence that could be measured by standardized tests. Gardner first described seven intelligences and later added an eighth. The chapter also focuses on Gardner's ideas on creativity and offers information on how teachers can implement the kind of teaching that promotes creativity.

Introduction

The theory of multiple intelligences has influenced educators from all over the world, encouraging them to envision more effective ways of teaching. This theory was developed over 30 years ago by Howard Gardner, a world-renowned psychologist. In 1983, Gardner transformed the field of education when he published *Frames of Mind: The Theory of Multiple Intelligences*. In this book, he described a new way of thinking about human intelligence, challenging the traditional view that there is one kind of intelligence standardized tests can measure (Strauss, 2013).

Howard Gardner's Early Years

Howard Gardner was born in 1943 in Scranton, Pennsylvania. He was very successful in school. As an early reader and writer, he produced a newspaper when he was in second grade and enjoyed writing it and watching the pages come out of the printer. His parents allowed him to make his own decisions and trusted him (Mineo, 2018). Although he was described as a gifted pianist, he found the responsibilities associated with formal piano instruction burdensome (Gordon, 2005). He even quit after one of his teachers told him he had to practice three hours every day (Mineo, 2018). But he never lost his love of music. In fact, his passion for music played a role in the beliefs he developed about multiple intelligences (Gordon, 2005).

His parents were German Jews who came to America to escape the Holocaust. They arrived in New York City with little money and later hid the horrors of the Holocaust from their son, fearing that becoming aware of these atrocities would harm him. They also did not tell him about how his 8-year-old brother tragically died in a sleigh-riding accident before he was born. When he found out by looking through clippings, Gardner became annoyed because he had not been told about this tragedy, but recently mentioned that he later understood how difficult it must have been for his parents to talk about it (Mineo, 2018).

The death of one of their sons led Gardner's parents to be protective. When he was a child, they took measures to prevent him from participating in sports. It was not until he was in his twenties that he rode a bicycle. Although he was not antisocial, the activities he participated in were predominantly solitary and included reading, writing, and playing the piano. Although he was social with his close friends, he was not gregarious. His parents were eventually warned not to shelter him in excess. And at age seven, he attended camp away from home where he participated in competitive sports. At first, he did not enjoy camp and lacked talent in sports, but after going year after year, he became more enthusiastic (Gardner, 2020).

Career at Harvard University

Gardner completed his professional training at Harvard University, where he focused on research involving gifted children and brain-damaged adults. During his early career, he developed into a prolific writer. And after he published *Frames of Mind*, his theory of multiple intelligences became popular all over the world (Gordon, 2005).

He first came to Harvard in 1961 and thought about majoring in history. However, after taking history classes during his freshman year, Gardner's aversion of the way historians wrote led him to lose interest in pursuing history as a major. Instead, he majored in Social Relations after being influenced by a teacher who noticed Gardner's interest in psychology and sociology and recommended Social Relations as a major. Although Social Relations —a mix of psychology, anthropology, and sociology—was not viewed as a prestigious major, it interested him (Mineo, 2018).

Several factors led him to write *Frames of Mind*. One of these was Gardner's fondness of writing. He has always enjoyed writing and had written three books by the time he started his postdoctoral work in 1971. He published his fourth book, *The Shattered Mind,* in 1975. This book focused on how different forms of brain damage affect people and how different parts of the brain regulate different cognitive functions. After completing this book, he thought about writing a book on how different human faculties are connected to the brain. In 1976, he wrote an outline for this new book, which was eventually titled *Frames of Mind* (Gardner, 2011a).

Several experiences enhanced Gardner's interest in cognitive function. One of these was his work at the Boston Veterans Administration Hospital. After completing his doctorate in Developmental Psychology, he got a fellowship at this hospital, allowing him to observe patients with brain damage. While working there, he continued to work at Project Zero, where he held a position that started shortly after he began his graduate studies. Project Zero was founded in 1967 at the Harvard Graduate School of Education and has focused on exploring learning through the arts. Today, Project Zero also focuses on inquiry through diverse disciplinary perspectives to explore various topics including intelligence, creativity, and ethics (Harvard Graduate School of Education, 2016).

His work at Project Zero concentrated on the development of children's artistic thinking. For a certain period, Gardner would be working in the morning with patients with brain damage and in the afternoon with children at Project Zero. These experiences shaped Gardner's concept of multiple intelligences because he noticed how some patients at the hospital were very musical but were not able to use language well. And he observed a similar pattern when working with kids (Mineo, 2018).

Multiple Intelligences

In addition to his previous interest in and work on cognitive abilities, Gardner's participation in a research project funded by the Bernard van Leer Foundation contributed to the writing of *Frames of Mind*. This project focused on conducting research on human potential. Its principal investigators assigned him to write a book documenting what was known about the connection between human cognition and the biological and behavioral sciences. It was this research that ultimately led to the theory of multiple intelligences (Gardner, 2011b).

The grant from the van Leer Foundation allowed Gardner to synthesize the work he did on brain damage with what he had learned about cognitive development. His studies on cognitive development explored seven ways in which children mastered symbol use and included their singing, drawing, and storytelling abilities. With his colleagues, he used literature from various fields, including psychology and anthropology, to determine the best taxonomy of intellectual capacities (Gardner, 2011b).

Calling the different abilities he identified "intelligences" created controversy, but popularized Gardner's work. He mentioned that had he used another word, he would not have been known all over the world. His theory was not accepted by many psychologists because they generally have different ideas about studying intelligence. For example, his views on intelligence are at odds with those of psychologists like Richard Herrnstein, who believed that IQ is inherited to a great extent (Mineo, 2018). In fact, Gardner was critical of a book Herrnstein co-authored entitled *The Bell Curve,* arguing that the book encourages readers to be sympathetic to the IQ elite and does not provide ideas about how to educate those who do not excel on IQ tests (Gardner, 2001).

According to Gardner, an intelligence involves a person's ability to solve a problem or do something considered valuable in one or more cultures. In the early 1980s, he identified seven intelligences and about a decade later added an eighth (Checkley, 1997). Table 1 (overleaf) shows the eight intelligences he identified.

Gardner mentioned that the linguistic intelligence appears to be the one most widely shared by humans across the world because without linguistic skills in semantics, phonology, syntax, and pragmatics, people would have difficulty functioning with efficacy in the world. In contrast, the abilities of gymnasts, mathematicians, musicians, and visual artists are often perceived as remote and even mysterious by the average person (Gardner, 2011b).

Table 1

Intelligence	*Description of Intelligence*
Linguistic	People with strong linguistic skills can use their native language, and sometimes other languages, to understand people and express their thoughts. Examples of professionals with above average intelligence levels in this area include writers and orators.
Logical-mathematical	Scientists are examples of people strong in the logical-mathematical intelligence because they can manipulate numbers the way mathematicians do. They tend to have above average logical-mathematical skills also because of their knowledge of causal systems.
Spatial	Spatial intelligence involves the skills people have to represent the spatial world. Spatially intelligent people tend to become painters, sculptors, and architects. Spatial intelligence is used more often in certain sciences like anatomy and topology.
Bodily-kinesthetic	This intelligence relates to the ability to use whole or certain body parts to create something, solve a problem, or display skills involving bodily movement at an event. Examples of professionals strong in this intelligence include athletes and dancers.
Musical	People with enhanced musical intelligence have a heightened ability to hear, recognize, and remember patterns. They think in music and cannot get it out of their minds. In *Frames of Mind*, Gardner indicated that musical intelligence emerges earlier than other intelligences.
Interpersonal	The interpersonal intelligence involves one's ability to understand others. People strong in this intelligence can detect other people's moods, intentions, and desires. This intelligence is especially important for individuals who deal frequently with people like teachers, clinicians, and salespeople.

Intrapersonal	An enhanced understanding of oneself is a characteristic of someone strong in the intrapersonal intelligence. A developed intrapersonal intelligence enables people to anticipate how they would react to experiences and how to choose the experiences that can be beneficial. It also helps people be aware of the difficulties they might encounter.
Naturalist	The naturalist intelligence was added to the original seven. It relates to an individual's ability to differentiate among living things. People strong in this intelligence are good at classifying plants, minerals, and animals as well as rocks and grass.

Note. The information in this table is adapted from (Checkley, 1997).

Criticisms of Multiple Intelligences Theory

Although MI theory has received tremendous attention, it has been criticized. In *Frames of Mind*, Gardner mentioned that two books were published with critiques of his theory: *Howard Gardner Under Fire* and *MI at 25*. Gardner has responded to criticisms of his theory. In 2006, for instance, he co-authored an article mentioning that Lynn Waterhouse had misunderstood his theory. One of the problems Gardner and Moran (2006) discussed regarding Waterhouse's idea of MI theory was her belief that it is not grounded in empirical findings. Gardner and Moran responded to this critique, insisting that the origins of MI theory are entirely based on empirical conclusions and that Waterhouse was using a naïve perspective of science when making this claim.

In *Frames of Mind*, Gardner summarized some of the common criticisms of his theory and offered his responses. One of the objections critics mention involves using the word "intelligence." For instance, critics say that "talent" would be a more appropriate word to describe the ability of a gifted dancer. Gardner's response is that in accepting a narrow definition of intelligence, people would likely regard the abilities that fall outside of this definition as less valuable.

Another criticism of MI theory involves the connections between different faculties. Some scholars believe that since there are correlations between tests of ability, there is a level of general intelligence that people have. However, Gardner has expressed skepticism about these correlations, arguing that almost all tests focus primarily on logical and linguistic faculties. He mentioned that people strong in the logical and linguistic intelligences are likely to perform well on tests that focus on musical and spatial abilities. But those with weak logical and linguistic skills will likely perform poorly even if they have the skills these tests are allegedly measuring. According to Gardner, the extent to which various intelligences are correlated is unknown (Gardner, 2011b).

Other criticisms focus on the similarities between the intelligences and the lists some researchers have published about the different styles people might display, such as learning styles, personality styles, working styles, etc. Although there may be similarities, there are differences between these styles and Gardner's intelligences. Intelligences are content specific, but researchers tend to believe that styles remain the same across content. For instance, people can be viewed as emotive or analytic regardless of the content to which they are exposed. In contrast, Gardner identified his intelligences according to the content in the world, such as numerical and spatial content. A child may be engaged with one type of content but be inattentive with another type. Therefore, considering styles and intelligences to be synonymous is problematic (Gardner, 2011b).

Implications of the Multiple Intelligences for Educators

In a 1997 interview, Gardner described the implications of his theory of multiple intelligences for how schools might provide instruction. At the start of the interview, he emphasized that the primary role of schools is to promote the learning of content and to develop the skills students will need and use after they graduate. However, whatever students learn in school will likely be forgotten unless they take an active role. To be active requires them to ask questions, participate in hands-on activities, and recreate and transform information as needed. Unfortunately, exams do not necessarily measure the extent to which students are involved in active learning. Students can do well on an exam by memorizing information, which they will likely forget after a few years. In contrast, students who make a prediction, conduct an experiment, analyze the data, and see the results develop skills and knowledge likely to last for a much longer period (Edutopia, 2009).

Regrettably, American schools have too often failed to encourage the environment needed for students to take the active role that will develop the skills and knowledge they will need after they graduate. One reason for this trend involves the overuse of standardized tests to evaluate schools and teachers. At the start of the 21st century, for example, schools began to rely more on these tests to evaluate teachers and schools, leading many teachers to use a style of teaching that focuses on memorization (Morgan, 2016). In December of 2015, the passing of the Every Student Succeeds Act (ESSA) ended the high-stakes consequences previously attached to students' standardized test scores. However, ESSA requires students in grades 3 to 8 to be assessed through standardized tests every year (Wang, 2019).

ESSA is a policy that is more harmonious with Gardner's views on the type of learning that benefits students because it encourages teachers to meet the needs of students by implementing innovative methods, such as differentiated instruction. Under No Child Left Behind (NCLB), the policy ESSA replaced, schools did not have this option, and schools that continuously failed to meet their state's annual achievement targets faced the possibility of being shut down (Klein, 2015). The pressure teachers were under led many of them to teach to the test, using the kind of teaching that Gardner mentioned should be avoided.

While ESSA will likely reduce the type of teaching based on memorization that NCLB encouraged, some states have continued to use test scores to hold teachers accountable (Close, Amrein-Beardsley, & Collins, 2019). This trend is unfortunate because some systems of education do not use standardized tests to evaluate teachers to avoid the problems associated with this practice. For example, Finland's education system has received tremendous attention because its approach to education differs greatly from the methods many other nations implement and does not involve the use of standardized tests to evaluate teachers. Although standardized tests are used in Finland, they are implemented *only* for curricular decisions and university admission (Morgan, 2018).

Since students vary greatly in the intelligences Gardner identified, teachers need to differentiate instruction to be effective for *all* their students. If they teach to develop several intelligences as they neglect others, they end up discriminating against the students who are strong in the intelligences they neglect but weak in those teachers choose to develop. It may seem impossible to adjust instruction according to the differences in intelligence levels among students in a given class. For example, how can a teacher achieve this goal in a class containing a student with a very hands-on way of learning, a learner with strong visual intelligence, and a pupil with highly developed linguistic skills? Gardner addressed this question, mentioning that the teacher can provide resources, materials, and software that present content in ways for each child to use her or his intelligences productively (Edutopia, 2009).

One of the problems of using standardized tests to assess students is that such tests usually do not measure many of the intelligences Gardner identified including the interpersonal, intrapersonal, musical, and bodily kinesthetic. Instead, these tests focus only on two: the linguistic and mathematical intelligences (Morgan, 2016). And when teachers are evaluated in part on how well their students perform on standardized tests, they often feel pressure to develop the intelligences these tests measure and ignore the others. Although ESSA reduced the use of standardized tests, it maintained many of the testing mandates the No Child Left Behind Act required (Blad, 2021).

In addition to the importance of having students do well on standardized tests, schools may avoid implementing instruction according to multiple intelligences (MI) theory based on the false belief that uniform instruction is fair. It may seem fair to assess all students in the same way and provide instruction uniformly because everyone is receiving the same treatment. However, this approach to instruction is based on the assumption that all students learn in a similar way. But according to MI theory, students weak in one intelligence will not learn as well if teachers deliver instruction only through the intelligence students may be weak in. For example, a child with weak verbal skills will likely perform less well than one with strong verbal skills if a teacher uses an instruction style that focuses primarily on learning through words and language. But if the child with weak verbal skills has strong spatial skills and if the teacher uses plenty of pictures, images, photos, and drawing activities, this child will have a much better chance of making academic gains.

According to Gardner (1999), teachers may ignore certain intelligences and focus primarily on providing instruction through language and logic for several reasons. First, they may be unaware that different students have different types of minds. Second, they may have a set of students who vary greatly in the intelligences they are strong in and may feel incapable of accommodating each student. Third, they may be convinced that although students are different, they need to learn to be more alike to become members of a community. Teachers who ignore the intelligences students are strong in as they acknowledge the intelligences students are weak in are not only providing instruction unfairly but making certain students feel stupid (Gardner, 1999).

In a recent interview, Gardner expressed the importance of using students' strong areas when introducing them to topics in the traditional curriculum. Teachers who avoid proceeding this way as they focus primarily on pupils' weak areas increase the chances for students to develop low self-esteem (Hunter, 2021). It is crucial to allow students to develop the areas in which they are talented. In his recent interview, Gardner used physics to show how providing instruction through the intelligences commonly ignored may be achieved by teaching this subject using a method other than one focusing on a textbook. For example, students could understand physics topics through their bodily intelligence (Hunter, 2021).

Personalized Learning

Since uniform instruction is detrimental, one alternative for improving the teaching environment is to implement personalized instruction. This type of instruction involves a type of teaching that matches the different kinds of minds students have. Teachers who use this approach must first gain awareness of the types of minds their students possess by learning about students' interests, anxieties, goals, and strengths without stereotyping them (Gardner, 1999).

James Keefe (2007), a former high school principal, mentioned that personalized learning develops the entire range of human talents but that schooling is rarely personalized. This trend can contribute to catastrophic results. It can also lead the most creative people to be miserable in formal schools. For example, people like Charles Darwin, Sir Isaac Newton, Louis Pasteur, Orville Wright, Albert Einstein, and Marlon Brando failed to thrive in their schools (Keefe, 2007).

Personalized learning involves tailoring students' learning experiences according to their individual needs, skills, and interests. It allows students to follow an optimal learning path based on various types of instructional methods, which include group projects, instructional software, and individual and small-group time with teachers. This approach differs from the traditional way of teaching, which emphasizes leading the whole class to learn a common lesson (Childress & Benson, 2014).

Schools and teachers can personalize instruction in many ways. And there is no one optimal way to achieve this goal. Different views also exist about personalized learning. For some educators, it means adding a personal touch when dealing with students. For others, it involves modifying instruction based on their needs. The differences in ideas about personalizing instruction have led to confusion. Many educators know little about this approach or think that it is too difficult to implement. And others perceive it as a fad that will disappear like other ones that come and go quickly (Keefe, 2007).

These views are unfortunate because when implemented well, personalized learning can help students make strong academic gains. For instance, after providing support to teachers on differentiating instruction, the Summit Public Schools in California experienced impressive success in enhancing students' academic progress. Six of Summit's charter schools improved their reputation as institutions that prepare students well for college, although they served a considerable number of pupils from low-income families (Childress & Benson, 2014).

After analyzing data on the students who went to college, Summit administrators discovered that many pupils were not ready for college-level math. This problem led to a need to explore ways to enhance math preparation. Summit teachers then personalized learning by developing a blended math model with Khan Academy (Childress & Benson, 2014). Blended learning consists of a combination of different models of teaching and modes of delivery (Gonzales & Vodicka, 2012). This approach combines face-to-face and online instruction to customize learning for each student and makes content more accessible. When implemented well, it usually involves student choice or agency in their own learning (Pierce, 2017).

Fortunately, approaches based on personalized learning have increased considerably in recent years. ESSA is partly responsible for this trend because it authorizes Congress to provide funding for professional development. Districts can use this funding for supporting teachers to integrate technology into the curriculum to personalize instruction and implement blended learning (Center for Digital Education, 2017). It was recently estimated that at least three-fourths of U.S. school districts have used some form of blended learning (Pierce, 2017).

One of the ways teachers can implement blended learning is by converting their classrooms into "flipped classrooms." This approach to teaching personalizes instruction to a certain extent because it permits students more chances to learn at their own pace. Students learn at a level that matches their abilities because they receive instruction through a video at home rather than through a face-to-face setting. When teachers provide instruction through a traditional approach, they usually deliver content too slowly for some students and too quickly for others. However, when students have access to the content on a video they view at home, they can view difficult material over and over and spend little time on content they easily understand. When lecturing, teachers typically have little information on which content students understand, because they normally get this feedback after reviewing students' homework. In contrast, in a flipped classroom, students do much of their "homework" at school, allowing the teacher to provide more guidance to students who have difficulty, while offering more challenging work for those who find it easy (Morgan, 2014a).

Blended learning can be implemented in a variety of ways. But regardless of how teachers use this approach, it requires more time to plan. The planning involves preparing the variety of activities that will match students' abilities and appeal to their learning preferences. Although teachers may be intimidated by having to design different lessons based on students' needs, the progress students typically make is usually worth the extra effort teachers put forth (Pierce, 2017).

To plan well for personalizing or differentiating instruction, teachers need to have a strong understanding of the theories behind this approach to learning. As previously mentioned, Howard Gardner's theory of multiple intelligences is crucial for understanding how to provide instruction based on the different minds people have. Another critical theory for knowing how to personalize instruction is Lev Vygotsky's zone of proximal development.

Lev Vygotsky's Zone of Proximal Development

Gardner's theory of MI is similar in some ways to Lev Vygotsky's zone of proximal development. Indeed, differentiated instruction has been described as an approach to teaching based on both Gardner's MI theory and Lev Vygotsky's zone of proximal development (Morgan, 2014b). These two theories are alike in that they have similar implications in regard to teaching according to a level that matches students' abilities. As previously mentioned, Gardner indicated in one of his books that if teachers continuously teach students according to the intelligences they are weak in, students will feel stupid. Vygotsky's theory also suggested that if there is a mismatch between teachers' instructional methods and the skills of their students, negative outcomes will likely occur (Morgan, 2014b).

According to Lev Vygotsky, the zone of proximal development involves the level at which a learner can achieve a task with the guidance from a more capable peer or an adult (Vygotsky, 1978). According to this theory, teachers need to teach students having difficulty understanding a concept in a way that will allow them to comprehend the concept and proceed at their own pace. One way to fulfill this goal is by providing instruction through the intelligences students may be strong in for the purpose of developing their weak intelligences. For example, as noted earlier, children with weak verbal skills but strong spatial skills will much more likely improve their verbal skills if their teachers use plenty of pictures, images, photos, and drawing activities. But if teachers insist that their students can learn as well as those with more advanced verbal skills without such visual aids, those with weak verbal skills will likely feel frustrated.

Research on the chemicals the brain releases when students learn supports the idea that teachers need to instruct students according to students' abilities. If students are frustrated or bored because the instruction their teachers provide is too difficult or easy, their brains will likely release too much or too little of the chemicals needed for learning. As a result, they may experience a sense of withdrawal or behave inappropriately (Morgan, 2014b).

Teaching according to a level that matches students' abilities does not necessarily mean relying on the intelligences not commonly used during classroom instruction. Students can be taught according to the zone of proximal development simply by adjusting instruction so that it is neither too challenging nor too simple. However, in many cases, when teachers provide instruction through a wide variety of intelligences rather than a few, they make content easier for students who would otherwise have difficulty understanding it (Morgan, 2014b).

When teaching math, for example, teachers can make content easier to learn by allowing students to use manipulatives, which are physical objects such as pens. Such an approach creates opportunities for students to interact physically with objects to learn new content (Carbonneau, Marley, & Selig, 2013). By using this method, teachers permit students to learn in part through their bodily-kinesthetic intelligence. The use of manipulatives also encourages students to connect concrete experiences to abstract concepts and usually makes math fun to learn (Tichenor, 2008).

Ideas on Enhancing Creativity

Personalizing instruction is not the only topic Gardner discussed regarding how the education of students might be improved. He also covered topics involving creativity and provided examples of how certain people developed their creative potential using each of the intelligences he identified. These people are important to study because they shared certain qualities allowing them to be creative. Educators, therefore, might attempt to promote the development of these qualities to enhance student creativity. Gardner also offered his ideas about what educators might do to promote creativity.

Before exploring some of the individuals he identified as exemplars in the area of creativity and his views on the approach most likely to promote creativity, it is important to explore his understanding of creativity. Gardner indicated that creativity occurs when someone produces something new that first seems odd but becomes accepted by people who have knowledge about it. The decisive test involves whether the domain the invention is associated with becomes changed as a result of the invention (Schreuder, 1997).

Another important aspect involving creativity is that it differs from intelligence. In fact, psychologists often perceive people with creative potential as those who think divergently. However, intelligent people are often perceived as those who think in a narrower way. Rather than generate a large number of possible answers, intelligent people tend to be thought of as those who can figure out the right one. Although creativity is correlated with intelligence, people can be highly intelligent with unimpressive creativity skills or be much more creative than intelligent (Gardner, 2011c).

Individuals with Extraordinary Creative Skills

Gardner (1995) chose examples of people who had extraordinary skills in each of his intelligences. These people included T. S. Eliot (linguistic), Sigmund Freud (intrapersonal), Pablo Picasso (spatial), Albert Einstein (logical-mathematical), Igor Stravinsky (musical), Mahatma Gandhi (interpersonal), and Martha Graham (bodily-kinesthetic). In thinking about the creativity of these individuals, he considered the interaction of three constituents:

1. The individuals themselves with their styles and needs.
2. The area of knowledge in which each person specialized.
3. The collection of people who offered awards and training and who made judgments regarding the products the individuals produced.

He noted that it makes no sense to think that creativity emerges by thinking about the individual without considering the field and the domain: "the possibility of creativity emerges only when an individual carries out work within a domain and the field ultimately comes to value that work" (Gardner, 1995, p. 35).

In exploring the lives of the seven individuals, Gardner noticed some similarities in their personalities and in the way they lived their lives. One similarity was that they tended to reject standard practices and desired to try new things. For instance, Einstein rejected the paradigms of the physics of his time (Gardner, 2011c). These creative people also needed cognitive and affective support. Those who provided them with affective support loved them and assured them they were not crazy. And those providing cognitive support realized they were in the process of making an important discovery (Gardner, 1995).

Gardner found that these individuals had above average ability in more than one intelligence. For instance, Einstein had outstanding logical-mathematical skills as well as excellent spatial skills. And Freud not only had notable personal skills but also had excellent linguistic skills. These extraordinarily creative people were also difficult, demanding people at some point of their lives. Although it might be misleading to describe some of them as workaholics during their youth, all of them became so absorbed in their work to a degree that nothing else was more important. Gardner indicated that great creators are responsible for a number of breakthroughs during their lives and that it takes about 10 years for them to achieve each one (Gardner, 1995).

There were also differences among these people. For example, the breakthroughs they were responsible for reflected different ways of thinking. Freud's achievements and thought processes differed from Einstein's. For this reason, Gardner mentioned that there are various forms of creativity (Gardner, 2011c).

Environment for Promoting Creativity

One of the questions parents and educators may want to ask themselves is whether they want their children or students to grow up to be like one of the creative people just mentioned. When children stand out from others for doing things differently, they frequently get rejected (Schreuder, 1997). Considering that the creative people Gardner identified endured significant pressures and challenges, some adults may not perceive the experiences these individuals had as the ideal ones for their children. Fortunately, students can be creative as educators attempt to minimize the challenges associated with being creative. Promoting creativity is therefore a goal that educators should generally consider worthy and desirable to achieve. An environment encouraging discovery learning tends to be more motivating as well (Stapleton & Stefaniak, 2019).

The results of a nationally representative study conducted by Gallup and designed to explore the outcomes of assignments that promote creativity indicated that such assignments contribute to many benefits. Teachers who frequently assign creative activities were more likely to feel that their pupils show important components of learning, such as the development of problem-solving and critical-thinking skills. The majority of parents and teachers participating in the study felt that the most important educational strategies were those that promote creativity. Unfortunately, the study's findings indicated that although creative work contributes to many academic benefits, such work is too often not assigned (Gallup, 2019).

Encouraging students to develop some of the qualities the seven creative people Gardner identified can allow educators to provide the kind of environment students need to be creative. So what did Gardner mention about the characteristics of people who achieve breakthroughs? First, such people know their domain well. For example, without knowledge of music, it is impossible to write music. Creative people are also risk takers who are not easily subdued. And they invent something at a time when there is a need for it. For instance, Einstein's theory would have been harder to accept had he developed it a century earlier than the time he came up with it (Schreuder, 1997).

Unfortunately, the encouragement of creativity is usually a low priority in many schools. Students who take risks and reject standard practices are likely to contribute to a disruptive environment. Gardner suggested that most teachers would probably prefer for the development of creativity to occur during extracurricular activities after school rather than deal with such an environment on a regular basis (Gardner, 1995). He suggested that the development of creativity is often considered a luxury, which progressive schools might promote. Wealthy parents who can provide more than a basic education for their children may be able to offer an environment that promotes creativity, but it is unrealistic to expect the average school to provide it. Schools may have good reasons for not emphasizing the development of creativity. In addition to the possibility of having to deal with a more disruptive environment, teachers need to teach various subjects and to encourage civility (Gardner, 1995).

However, as noted earlier, a creative environment usually contributes to many benefits. To provide such an environment, Gardner mentioned a few strategies. First, children need to know that taking chances is fine. They need to be supported because doing things in a different way increases the chances of being rejected. Children also need to know that there are limitations to the chances they can take. Although encouraging creativity requires educators to accept more responsibilities, they experience a strong sense of fulfillment when they guide someone who goes on to make an important contribution to society (Schreuder, 1997).

Importance of Developing Creativity at an Early Age

Children display works showing their creativity at an early age. Such works consist of the scribbles early drawers create and the stories young children tell. These examples show their willingness to take the risks that characterize great inventors. Gardner discussed that adults may even draw upon these early activities when they are involved in creative endeavors (Gardner, 1991).

To develop into one of the seven creative people Gardner identified, young people need to have the basic skills of the domain they will use to create new products and ideas. Gardner discussed that it is in the middle years of childhood that children are most suited to develop skills in a domain and that adolescence is the best time to combine these skills with the creativity that they often display during earlier years (Gardner, 1991).

In one of his essays, he described what he believed was the best approach to develop creativity during the early years. In this essay, he also mentioned the influence of John Dewey and Jean Piaget on the American education system. According to these Western thinkers, childhood is not just a time of transition to adulthood but a time when children display their genius. The Western view emphasizes that children are born knowing how to solve problems and that those responsible for raising them need to permit children to mature at their own pace. Schools should therefore refrain from strict instruction. Instead, they need to supply an environment that allows children to flourish (Gardner, 1989).

Although many American schools are criticized for their failure to promote creativity, innovation is generally tolerated. Indeed, Gardner mentioned that according to the American view, the ideal method for dealing with a new problem is to offer many chances to investigate it with little instruction from a teacher. This way of exploring is frequently considered the optimal approach for finding out one's competence in relation to a problem. Students who can solve problems in new ways should be praised. However, aid may be appropriate if they become frustrated. In offering aid, educators should refrain from providing answers. Instead, it is best to offer suggestions and hints. Gardner (1989) indicated that those who are responsible for the most innovative achievements tend to proceed in a novel direction and make decisions on their own.

Gardner's views about the ideal environment for learning are in many ways similar to Jerome Bruner's cognitive constructivist approach. In fact, Gardner mentioned that Bruner increased his awareness of many issues (Gardner, 2011b). According to Bruner's constructivist approach to learning, children construct new knowledge by exploring things in the world. The teacher's role during this process involves setting up an environment that will allow students to discover associations between concepts rather than playing the role of an authority figure (Stapleton & Stefaniak, 2019).

Regrettably, it is not unusual to observe teachers instruct students in a manner antithetical to the philosophy of teaching based on the constructivist approach (Ellis, 2010). Such teachers lead students to become dependent and dominate the class instead of playing the role of facilitators. In contrast, teachers who implement a style of teaching based on Bruner's ideas provide students with opportunities to explore. Such teachers create an environment that promotes creativity and motivation. Bruner's approach to learning encourages creativity because it creates opportunities for students to learn actively, creating chances for them to be exposed to new ideas. And active learning not only contributes to motivation but to retention as well (Stapleton & Stefaniak, 2019).

These are some of the reasons it can be important for children to have opportunities to explore at a young age. However, as Gardner noted, in order for creative people to produce valuable outcomes, they need to have the skills and knowledge of a domain. Parents and teachers might ask whether children should be instructed to develop skills first and then have chances to be creative later or whether they should be allowed to explore first and then have opportunities to develop skills later. Gardner believed that the preferred approach included devoting the first seven years of children's lives to a creative approach that focuses on exploring and that after this period, instruction could focus on basic skills (Gardner, 1989). He reached this conclusion as a result of his understanding of developmental psychology and his observations in various countries. However, he acknowledged that it is possible to implement an approach focusing on skill development that leads to creative products (Gardner, 1989).

Although Gardner believed that the early years of life needed to focus on an environment emphasizing exploration, he indicated that some skill acquisition during this period is important as well. And he warned of the danger of providing an environment that promotes too much creativity without enough skill building. Also dangerous is an environment that promotes too much skill building without allowing enough opportunities to develop creativity (Gardner, 1989).

Conclusion

Howard Gardner's theory of multiple intelligences has proven to be a crucial theory that sheds light on the different ways students learn and the need to deliver instruction according to their needs. When students are provided with instruction that matches their needs, they tend to learn more and remain engaged. Unfortunately, too many instructors overlook many of the intelligences identified in *Frames of Mind*. This practice is detrimental for several reasons. First, teachers who focus on developing a limited set of intelligences typically fail to take advantage of how students may be gifted in certain areas. Second, developing only a few intelligences oftentimes makes students weak in these intelligences feel inferior and prevents them from learning new content.

Promoting creativity during instruction appears to be as important as personalizing instruction based on Howard Gardner's MI theory. Requiring students to complete creative assignments develops students' problem-solving and critical-thinking skills. A classroom environment encouraging discovery learning will likely enhance student motivation and develop creativity. Such an environment is believed to allow students to retain new content for a longer period. By personalizing instruction in a manner that allows students to learn through an approach based on discovery learning, instructors can create an environment that benefits students in many ways.

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