EXPERIMENTAL PSYCHOLOGY AND ITS IMPLICATIONS FOR HUMAN DEVELOPMENT

Nelson Cowan

Department of Psychological Sciences, University of Missouri, Columbia, USA

Keywords: Experimental psychology, cognitive psychology, developmental psychology, human development, social psychology, social cognition, perception, memory, working memory, learning, long-term memory, attention, thinking, problem solving, reasoning, emotions, interpersonal relations

Contents

Summary

This article examines experimental psychology, the controlled study of behavior with an emphasis on determining cause-and-effect relationships. The following articles within this theme are introduced and then a single point is pursued with reference to the material to appear in these articles. The point is that there are both strengths and limits in human information processing. Humans use shortcuts or *heuristics* to think about information of various sorts, often without realizing that they are doing so. These heuristics often are useful in producing answers quickly but they are not infallible. As a result, there are illusions and mistakes that occur, often without one's awareness, in all areas of human thought. Limitations in human thought are discussed with reference to phenomena in the areas of perception**;** long-term memory and learning; attention and working memory**;** reasoning, problem solving, and decision making**;** human communication; human emotions**;** and human social cognition**.** Finally, shortcomings in adult cognition are compared to shortcomings that emerge during childhood development. In both cases the shortcomings can be considered types of self-centeredness in which one is insufficiently aware of information that one cannot get from one's own point of view (both physically and metaphorically speaking). Many of the world's problems are caused at least partly by peoples' general lack of awareness of

the extent to which human thought processes are imperfect and subject to error, and education in this regard seems essential for establishing the sustainable growth or maintenance of the human species in a healthy and happy state.

1. Introduction

In order to achieve a sustainable way of life on Earth, there will have to be cycles involving motivation followed by action. Specifically, there will have to be adequate motivation to understand the world better, followed by information-gathering activities; adequate motivation to digest the information gathered, followed by the construction of sound conclusions from that information; and adequate motivation to act on the conclusions so formed in order to implement changes that will improve our way of life. The relevance of psychology is as a means to understand what it will take to get people to make all of this happen. One must study the characteristics of the human mind to understand (1) how people can be motivated to proceed with an important action, and what can go wrong with peoples' motivation; as well as (2) how people gather evidence and form conclusions from that evidence, and what can go wrong with the thought processes whereby conclusions are formed. The articles subsumed under this theme heading are pulled together from many subdisciplines pertaining to these questions. All of them may be described as facets of experimental psychology, defined loosely as controlled empirical observations, but with special emphasis on laboratory experimentation in which manipulations yield evidence of cause-and-effect relationships between stimuli and responses (**see *Methods in Psychological Research***).
The present article provides brief overviews of the articles to come within this theme, in order to put them within a coherent framework, and then discusses some general principles of experimental and developmental psychology that should apply to all of them. These principles lead to a view of how psychology might be used to help create a sustainable way of life on our planet.

The first article treats the processes that occur as information from the outside world reaches the brain and individuals must perceive and identify it, decide which aspects of it to attend, retain it in memory, and learn it for future encounters with similar situations (**see *Attention, Perception, and Memory***).

The second article treats the higher-level mental processes that are not always driven by a single present stimulus in the outside world, but rather by the whole constellation of events and motivations: thinking, creativity, and problem solving. All of the processes in these two articles ordinarily come under the rubric of cognitive psychology. They help with theoretically driven predictions as to how individuals will behave in particular situations (**see *Thinking and Problem Solving***).

The third article deals with an aspect of the motivation underlying thoughts and behaviors, namely, human emotions and their relation to health. Traditionally, motivations and emotions have been investigated separately from cognitive psychology but we are entering an era in which more investigators are considering thoughts and emotions together. A good source for that type of effort is the 1999 book by Antonio Damasio *The Feeling of What Happens: Body and Emotion in the Making of*

Consciousness, as well as the journal *Cognition and Emotion* (see *Emotions and Human Health*).

The fourth article treats the neurological and biological bases underlying the processes of thinking and feeling mentioned so far. This is an area into which an increasing amount of grant funding and research activity is being channeled in order to make the most of recent technological advances in neuroimaging, in which pictorial representations of brain structures and neural processes within the brain are constructed along with statistical analyses of differences between the patterns of neural activity occurring under different task demands (see *Neurobiological Bases for Psychological Functioning*).

The final article takes a more traditional approach that has been complementary to the experimental approach for many years: an approach in which psychometric testing is used to examine individual differences in cognition and emotion. In some recent research, though, experimental techniques and psychometric techniques are being used together more closely than in the past so as to make use of both the precision in understanding what mental processes a particular task requires, which the experimental approach offers, and the statistical power to understand the similarities and differences reflected in individuals' abilities, which the psychometric approach offers. For examples of this dual approach, see the articles by Cowan, Engle, and Salthouse cited in the Bibliography at the end of this article (see *Psychology of Individual Differences with Particular Reference to Temperament*).

One topic seemingly related to the approach outlined here that is absent from the present sub-theme of the encyclopedia is social psychology, which has incorporated principles of cognitive and experimental psychology in order to gain a better understanding of social cognition and interaction. Also missing is developmental psychology, in which the normal adult state is seen to arise from changes occurring in childhood and is seen to decline in some ways in old age (along with a continuing increase in wisdom in some areas). These important directions in which one can go in applying basic experimental methods and results, for a more complete understanding of human changes and interactions in the natural settings of family and social life, are represented in separate articles: see *Developmental Psychology: Main Problems and Modern Tendencies* and *Social Psychology: A Topical Review*). The final section then goes further in making a transition between disciplines of theoretical science and disciplines of applied science within psychology (see *Tendencies and Perspectives of Psychology as a Science and as a Technology*).

2. Of Human Successes and Failures

One of the earliest and best known self-help books in psychology is the 1936 book by Dale Carnegie *How to Win Friends and Influence People*. In that book, a simple but important truth was articulated: the only way to get someone to do something is to get them to *want* to do it. From the point of view of cognitive psychologists, one might hasten to add that one must also get them to be able to do it. From that starting point, let us define the question to be addressed here as how one would be able to create the motivation and ability in humans to improve their world. Given that people may become

more set in their ways as they grow up, any successful approach would be best begun within a childhood education program.

The reason some kind of major, new education program is needed is that what one encounters presently in the world is vast human potential mixed with vast political obstacles taking the form of disagreements between individuals that thwart progress. The disagreements appear to stem from two sources: differences in peoples' beliefs, and differences in their perceived self-interests. It is often difficult to tell the two apart. Some may say that they hold a particular belief regarding what is best for the nation or world, whereas in fact they espouse that belief only for reasons of self-benefit. It may also occur that some people who have ambivalent or conflicting thoughts or emotions (as people are not always internally consistent) actually are able to convince themselves that there is no conflict between their self-interest and the common good. The psychological literature, especially in the field of social cognition, is full of examples of experiments showing that motivation often can control reasoning processes and beliefs rather than logic being the controlling factor.

Another factor that aggravates this tendency toward self-interest is that people's ability to process information is limited, so that they may not have sufficient means to arrive at the right answers. It may be especially when correct information is lacking that self-interest rushes in. For example, in the United States, as of the beginning of the presidency of George W. Bush in 2001, the Republican and Democratic parties had different views of how to stimulate the economy (by returning more money to taxpayers, or by using more of it to support public programs and to reduce the public debt faster?). This difference in political philosophy also tends to correspond to self-interest, with more Republicans in the country tending to be wealthy people who would benefit more from the proposed tax reductions, and more Democrats in the country tending to be less well-off people who would benefit more from public programs. The question of how best to stimulate the economy should be open to empirical testing, but there is no practical means to carry out the appropriate empirical tests.

What a new educational program should emphasize, however, is the areas of strength and weakness in people's thinking (i.e. *limits in human mental processes*). Across the areas of perception, memory, reasoning, emotions, communication, and social interaction a large variety of studies has shown that *people tend to be overly confident of their own mental processes and overly dismissive of the mental processes of other people who disagree with them*. We might be able to get people to work together more efficiently if they were made much more aware of these human shortcomings, which often amount to an egocentric frame of reference and a failure to see things from other points of view. What follows, therefore, is a description of strengths and limits in human mental processes of different types, why they may occur, what ill effects may come from a poor understanding of the limits, and how these ill effects might be counteracted.

3. Strengths and Limits of Human Information Processing

Across various areas of human cognition, similar patterns emerge. One finds that cognitive processes are very keen but were not designed to be perfect. Perception is not

completely veridical, one cannot attend to all of the stimuli in the environment at once, memories sometimes fail or are misleading, reasoning processes sometimes are illogical, and so on. Instead of perfection, one can speculate from an evolutionary perspective that mental processes were designed to be good enough to get by without using up too many of the organism's physiological resources. The way that is accomplished is through shortcuts or "heuristics" that generally give the right answer though they sometimes err. Careful attention to the ways in which cognitive processes break down can lead to a deeper understanding of the shortcuts that the mind uses to carry out its functions. An understanding of the failings of the mind can lead to an appreciation that the wise must allow for mistakes in their own mental processes. The result of this appreciation can only be greater tolerance of differences among individuals and groups, which is helpful in promoting peace and harmony throughout the world and in working together to solve any problems that humans face. Let us now contemplate strengths and weaknesses in various areas of human cognition.

3.1. Some Strengths and Limits of Perception

Like many other animals, humans are able to perceive as little as a single photon of light, a very soft sound, or a very gentle touch, and are able to perceive an incredible range of stimulus intensities and make fine distinctions between stimuli. Where humans truly excel in perception is in using previous knowledge to interpret the meaning of environmental stimuli. For example, one may categorize a stranger as someone who is likely to be friendly versus unfriendly to one's own group, on the basis of subtle differences in clothing, demeanor, speech accent or topic, or facial expression. (Other species carry out similar categorization processes but not on as many kinds of information as humans do.) As another example, one may recognize an object as a "chair" even if it does not resemble any chair that one has ever seen before, on the basis of its properties that would allow comfortable sitting for a human being.

Perception occurs quite rapidly, resulting in the identification of an object usually within a quarter of a second or less. This kind of finding comes from "backward recognition masking" studies in which two brief stimuli of the same sensory modality are presented in rapid succession; when the onsets of the two stimuli are less than a quarter of a second apart, recognition of the first stimulus in the pair is impaired, whereas recognition of the second stimulus remains unimpaired unless the stimuli are practically on top of one another. It is thought that a mental afterimage of a brief stimulus is used to continue the recognition process for a short while after the stimulus has ended, unless that afterimage is interrupted by another stimulus in the same modality.

Unfortunately, though, perception is fraught with illusions. Gestalt psychologists pointed out some of these illusions as a means of considering how the mind works. The illusions are not only restricted to very special situations. Instead, illusions are common in daily life. For example, consider the shape represented by an upside-down letter T. The length of the vertical bar typically is overestimated relative to the length of the crossbar. No one knows the entire reason for this effect, but part of it is that divided lines seem shorter than undivided lines. An irrelevant distance between the intersection and the end of the crossbar may be improperly taken into account, lowering the

perceived length of the crossbar. Another part of the illusion is that vertical lines seem slightly longer than horizontal ones, even in an L shape that is constructed so that the vertical and horizontal actually are the same length. Some of these illusions may contribute to important errors, such as pilot errors leading to airplane crashes in manually directed flights.

Illusions are common in ordinary objects. The moon looks much larger at the horizon than when high in the sky but a photograph will show no difference in the size of the image. One theory of why this illusion occurs is related to the use of distance to gauge the size of an object. A penny held up at the right distance can completely block out the moon because these objects cover the same area of the retina in the eye. Yet, the penny is judged to be much smaller than the moon because it is judged to be much closer. People generally maintain perceptual constancy by the implicit (not conscious) use of Emmert's law, in which the perceived size of an object is said to be proportional to the perceived distance times the retinal area covered. However, for objects as far away as the moon, there is no way to judge the perceived distance and so Emmert's law breaks down. The moon may be judged as if it were a flock of birds, which is much farther away when viewed at the horizon than when viewed overhead. However, the moon is so far away that there is very little proportional change in its distance from the observer when it is at the horizon versus overhead. If it is perceived to be closer when overhead it will be perceived to be smaller, also.

One can classify illusions in several ways. One way is to make a distinction between contrast illusions and assimilation illusions. In a contrast illusion, an object looks opposite from the context. In an assimilation illusion, it looks similar to the context. The difference may be in whether the context is perceived as part of the figure being judged (leading to assimilation) or a separate figure (leading to contrast). For example, if a small circle is surrounded by a larger circle, this makes the small circle seem larger than it really is (i.e. there is assimilation). However, if a small circle has a larger circle next to it, this makes the small circle seem smaller than it really is (i.e. there is contrast).

Another way to classify illusions is to distinguish between bottom-up sources of illusion and top-down sources. Bottom-up sources result from the way in which the nervous system is hooked together, whereas top-down sources result from knowledge that the individual has acquired over a lifetime. A bottom-up source is present, for example, when one views a black square with vertical and horizontal white bars forming a grid. The intersections of the grid then will look dark. The dark spots seem to be seen in most of the intersections, although less so in the particular intersection at which one is staring. This effect can be attributed to contrast effects between adjoining areas of brightness. The intersections are surrounded by more white than the lines in other places, and by contrast they look less white. At the center of one's vision the visual receptor cells take in less context and have higher acuity, explaining why the illusion is weaker at that point.

One can create a very powerful bottom-up perceptual effect with no equipment other than a well-lit room that can be darkened. Hold your hand over one eye in the lit room, preferably for 20 minutes. Then turn out the lights while still covering the one eye. Taking turns looking out with one eye and then the other, you will find that you are able

to see much better with the eye that had been covered than with the other eye. The covered eye was allowed to adapt to the dark, a process that ordinarily takes place gradually in the outdoors as the sun sets and results in much better sensitivity to small amounts of light.

Top-down sources of illusion often involve misleading the subject about a form of information that ordinarily is used to create perceptual constancy. Ordinarily, we use information about the perceived distance of an object, along with the retinal size (the portion of the eye's retina that is covered by the object) in order to judge the perceived size. Distance cues can fool us about the size of a drawing. Thus, two identical pictures of a person can be made to look very different in size if they are placed at different apparent distances in a perspective drawing. The one that looks closer will be judged smaller, given that the retinal sizes are identical.

A top-down source of illusion in audition, the phonemic restoration effect, strongly shows the role of knowledge. If we use a computer to remove several phonemes from a spoken sentence, replacing them with silence, the gap in the sentence will be clearly audible. However, if we then fill in the silent gap with an extraneous noise such as a cough, we hear the nonexistent phonemes behind the cough, making the speech sound complete again. It appears that our knowledge of the complete speech is enough to make us hear it that way, provided that the acoustic stimulus provides a good reason why the phonemic information did not actually reach the ear.

The implications of these illusions for ordinary perception are striking. It is fully possible for two normal individuals to witness the same event and to perceive something very different. The most likely reason for this to happen is that the two individuals may have different top-down information in memory, therefore interpreting the event differently. For example, on witnessing a robbery, a person prejudiced against blacks is more likely to perceive that the robber was black, given only fleeting information (or no relevant information) about the race of the robber. People also differ in how self-confident they are about their own perceptions being correct, as opposed to someone else's perceptions. It stands to reason that knowledge about the possibility of perceptual illusions would reduce a person's self-confidence of judgment and that this generally would be a good thing, allowing people who perceived an event differently to resolve their differences and arrive closer to the truth.

Illusions cannot be easily overcome through free will. Time and again, subjects who have been informed about the existence of an illusion, and who have been shown the basis of the illusion through a demonstration of it, continue to be susceptible to the illusion. Although it can be somewhat reduced through an awareness-raising session, often it cannot be eliminated. Thus, the best we can do is to keep in mind that our perceptions do not always accurately mirror reality. We can have the confidence of knowing that our perceptions typically capture what is important to us in the environment.

An exception to the ecological strength of perception is that it was designed through millions of years of evolution and cannot cope as well with the modern world. For example, we do not have a reliable perceptual means to detect harmful radiation from

non-natural sources, harmful substances in the air and water, and so on. It takes a scientifically trained mind to be aware that such harmful forces and substances may exist even though they cannot be seen. An untrained individual may believe that if nothing harmful is detected through the senses, than nothing harmful can exist. Diseases carried by bacteria and viruses are a middle case in which the cause itself cannot be detected, although its effect is soon detected, so that the disease is likely to be attributed to the wrong cause. Education cannot make our perceptions totally veridical but it can help us not to rely too directly on our perceptions in understanding the world. Perceptions can only be interpreted correctly with extended observations logically considered in light of the possibility of illusions that always must be taken into account.

-
-
-

Bibliography

Baddeley A.D. (1999). *Essentials of Human Memory*, 356 pp. Hove, U.K.: Psychology Press. [A good recent summary of research on human memory by a leading researcher.]

Baron R.A. and Byrne D. (2000). *Social Psychology*, 9th edn., 678 pp. Boston: Allyn and Bacon. [A good recent textbook on social psychology.]

Borod J.C., ed. (2000). *The Neuropsychology of Emotion*, 511 pp. New York: Oxford University Press. [A good recent account of how the brain handles emotions.]

Clark H.H. (1996). *Using Language*, 432 pp. Cambridge: Cambridge University Press. [A good recent textbook on the psychology of language.]

Cowan N. (1995). *Attention and Memory: An Integrated Framework* (Oxford Psychology Series, No. 26), 321 pp. New York: Oxford University Press. [A book describing the author's theoretical view and reviewing literature on human attention and memory, explaining the relation between them.]

Cowan N. (1999). The differential maturation of two processing rates related to digit span. *Journal of Experimental Child Psychology* **72**, 193–209. [A study indicating that multiple processing rates must be taken into account in order to understand thought processes.]

Cowan N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences* **24**, 87–114. [A review of literature on limits in how much people can keep in mind at one time.]

Engle R.W., Tuholski S.W., Laughlin J.E., and Conway A.R.A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General* **128**, 309–331. [A recent study showing how working memory tasks can be used to predict intelligence.]

Ferreira F., Bailey K.G.D., and Ferraro V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science* **11**, 11–15. [A good review of studies showing that people often do not completely process information in sentences.]

Gardner H. (1985). *The Mind's New Science: A History of the Cognitive Revolution*, 423 pp. New York: Basic Books. [A good history of the issues and methods of cognitive psychology.]

Gazzaniga M.S., ed. (2000). *The New Cognitive Neurosciences*, 2nd edn., 1419 pp. Cambridge, Mass.: MIT Press. [A good recent textbook on the relation between the mind and brain.]

Goldstein E.B. (1999). *Sensation and Perception*, 5th edn., 661 pp. Pacific Grove, Calif.: Brooks/Cole. [A good recent textbook on the way in which stimuli are perceived.]

Hitch G.J., Towse J.N., and Hutton U. (2001). What limits children's working memory span? Theoretical accounts and applications for scholastic development. *Journal of Experimental Psychology: General* **130**, 184–198. [A study showing that working memory tasks involve more than just one strategy and may involve switching of attention, not just sharing of attention between tasks.]

Kunda Z. (1999). *Social Cognition: Making Sense of People*, 602 pp. Cambridge, Mass.: MIT Press. [A good, detailed review of studies indicating that people often are unaware of their motives.]

Lane R.D. and Nadel L., eds. (2000). *Cognitive Neuroscience of Emotion*, 431 pp. New York: Oxford University Press. [A good review of the role of the brain in emotions.]

Miyake A. and Shah P., eds. (1999). *Models of Working Memory: Mechanisms of Active Maintenance and Executive Control*, 506 pp. Cambridge: Cambridge University Press. [A set of chapters explaining most of the main theories of working memory and attention.]

Salthouse T.A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review* **103**, 403–428. [A good summary of research indicating that the speed of processing is important for good-quality information processing by humans.]

Schachtman T.R. and Reed P. (1998). Optimization: some factors that facilitate and hinder optimal performance in animals and humans. *Learning and Behavior Therapy* (ed. W. O'Donohue), pp. 301–333. Boston: Allyn and Bacon. [A broad consideration of human cognitive strengths and weaknesses that emphasizes principles that apply across species.]

Sternberg R.J. (1999). *Cognitive Psychology*, 2nd edn., 584 pp. Fort Worth: Harcourt Brace. [A good recent textbook of cognitive psychology, the science of the mind and behavior.]

Biographical Sketch

Nelson Cowan received his Ph.D. in psychology from the University of Wisconsin, Madison, in 1980. After a postdoctoral fellowship at New York University and several years at the University of Massachusetts, Amherst, in 1985 he moved to the University of Missouri, Columbia, where he is currently professor. He is past associate editor of the *Journal of Experimental Psychology: Learning, Memory, and Cognition* and is presently associate editor of the *Quarterly Journal of Experimental Psychology* (Section A). He wrote *Attention and Memory: An Integrated Framework (*1995, Oxford University Press) as part of the Oxford Psychology Series and he conducts research on working memory and short-term memory and its relation to selective attention.