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Wants

► Goals and Goalsetting: Prevention and Treatment of Depression

Watson, John B. (1878–1958)

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Life Dates

John Broadus Watson was born in 1878 in Greenville, South Carolina. Due to the divorce of the parents he became a troublemaker in school and everyday life. However, despite his laziness and violence in school he was accepted to Furman University at the age of 15. After graduation he decided to go the University of Chicago in 1900. Here, Watson studied especially the British empiricists and he took some philosophy classes of John Dewey but confessed that he did not understand Dewey. The functionalist James Angell and neurologist Henry Donaldson had the greatest influence on him. In 1903, Watson received his doctorate at the age of 25 as the youngest person who ever attained a Ph.D. at the University of Chicago. At this time, he began a correspondence with Robert Yerkes who was involved in animal research but never accepted Watson's behaviorist position despite the friendship with him. In 1906, Watson began his collaborative research with Harvey Carr, a prominent functionalist at that time, on complex maze learning of rats. In 1907, Watson accepted an offer from the Carnegie Institute to study the migratory instinct of terns. This research was done in collaboration with Karl Lashley, later a leading figure in the field of neuropsychology. In consequence of this research efforts, Watson had national reputation when he was offered a position at Johns Hopkins University which he accepted. Due to a private scandal in 1920, Watson was asked to resign and he did. That marked the end of his scientific career in psychology. He now started with a career in advertising with enormous success until his retirement in 1945 at the age of 67. Watson died in 1958.

Theoretical Background

In the first years of the twentieth century, the field of psychology was in disagreement over the ideas of the nature of consciousness and the methods of studying it. Influenced by the Russian objective psychology and American functionalism, a new school of psychology emerged: the behaviorism. Watson can be considered as a pioneer of behaviorism. Watson began thinking about behaviorism in 1902 and submitted his doctoral thesis with the title *Animal Education: The Psychical Development of the White Rat* in 1903. In 1913 at Columbia University, Watson delivered a lecture entitled "Psychology as the Behaviorist Views It" and coined the term *Behaviorism*. Behaviorism assumes that behavior is observable and can be correlated with other observable events. There are events that precede and follow behavior. The goal of research is to explain relationships between antecedent conditions (stimuli), behavior (responses), and consequences (reward, punishment, or neutral effect). In opposition to methods of introspection, Watson proclaimed the idea of an objective study of behavior. His view of behaviorism was considered radical and was known for its extreme anti-mentalism and its radical reduction of thinking to implicit response. Although Watson was impressed by Thorndike's early animal research, he rejected Thorndike's law of effect as unnecessarily too mentalistic. For Watson the important thing about conditioning was that it causes events to be associated in time, i.e., it causes *contiguity*.

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Contribution(s) to the Field of Learning

Watson explained learning in terms of the principles of contiguity and frequency, what makes his explanation of learning more similar to that of Pavlov and Bechterev than it was to Thorndike. Watson believed that in a learning situation a trial always ends with the animal making the correct response. The correct response tends to occur more frequently than incorrect responses and the more often a response is made the higher the probability that it will be made again (i.e., the *law of frequency*). The final response in a learning situation will be the response next in the situation. This was called *law of recency.*

In his earlier research Watson used animal subjects and later shifted to the study of human behaviors at Johns Hopkins University. He did research in the fields of language and thinking, the role of instincts in behavior, and emotions. He wanted to develop techniques to allow him to condition and control the emotions of human subjects. He theorized that children have three basic emotional reactions: fear, rage, and love. This assumption provided the fundamental basis for his spectacular *experiment with Albert.*

Watson and Rosalie Rayner, his later wife, performed this experiment in 1920 on an 11-month-old infant named Albert. They showed Albert a white rat, and he expressed no fear of it. In fact, he reached out and tried to touch it. As Albert reached for the rat, a steel bar behind him was struck with a hammer. The loud, unexpected noise caused Albert to jump and fall forward. Again Albert was offered the rat, and just as he touched it, the steel bar behind him was again struck. Again Albert jumped and this time he began to cry. So as not to disturb Albert too much, further testing was postponed for a week. Then the rat was again presented to Albert and he was less enthusiastic and attempted to keep distance from the rat. Five more times Watson and Rayner placed the rat near Albert and struck the steel bar. Albert who had at first been attracted to the rat was now frightened of it. Five days later, Watson and Rayner found that Albert's fear of the rat was just as strong as it had been at the end of testing and that the fear had generalized to other furry objects such as a rabbit, a dog, a fur coat, and a Santa Claus mask.

Watson and Rayner demonstrated how experience rearranged the stimuli that caused emotional responses. They believed that all adult emotional reactions develop by the same mechanism that had operated in the experiment with Albert. It was left to Mary Cover Jones to show (under Watson's supervision) how a child's fear could be systematically eliminated.

The experiment with Albert had shown how fear was produced in a child. Now, it was the objective to eliminate fear in a subject who had already developed a fear. Watson and Jones found in Peter (a 3-year-old boy) a subject for another study. Peter was intensively frightened of white rats, rabbits, fur coats, frogs, and mechanical toys. Peter's fears could be eliminated or reduced through counterconditioning on him. The study with Peter was one of the first examples what is called today *behavior therapy.*

Watson dealt with many topics, but his favorite and most important topic to him was children. After his resignation from the profession of psychology at Johns Hopkins, he and his wife decided to publish their ideas about education in 1928. In their "psychological care of the infant and the child" we can read, for example, this advice to parents: "Never hug and kiss them [children], never let them sit on your lap. If you must, kiss them once on the forehead when they say good night. Shake hands with them in the morning. Give them a pat on the head if they have made an extraordinary good job of a difficult task. Try it out. In a week's time you will find how easy it is to be perfectly objective with your child and at the same time kindly. You will be utterly ashamed at the mawkish, sentimental way you have been handling it" (Watson and Watson 1928, pp. 81–82). In consequence, one of Watson's sons remembered his father as bright, charming, and reflective but "unable to express and cope with any feelings of emotion of his own, and determined unwittingly to deprive . . . my brother and me of any emotional foundation" (Hannush 1987, p. 138).

The *legacy of Watson* is that his behaviorism gained widespread acceptance for some decades worldwide and he changed psychology's focus on description and explanation of consciousness to the prediction and external control of behavior. Furthermore, he made overt behavior the almost-exclusive subject matter of experimental psychology. However, although many psychologists agree on the importance of overt behavior as primary subject matter of psychology they do not agree with the radical behaviorism of Watson. Rather they use the observation of overt behavior to index the covert cognitive or physiological processes thought running within the organism. This kind of behaviorism has been called *methodological behaviorism* and must be distinguished from the radical behaviorism of Watson.

Cross-References

▶ Behaviorism and Behaviorist Learning Theories
▶ Fear Conditioning in Animals and Humans
▶ History of the Sciences of Learning
▶ Pavlov, Ivan
▶ Skinner, B.F.
▶ Thorndike, E.L.

References

Hannush, M. J. (1987). John B. Watson remembered: An interview with James B. Watson. *Journal of the History of the Behavioral Sciences, 23*, 137–152.

Harris, B. (1979). Whatever happened to little Albert? *The American Psychologist, 34*, 151–160.

O'Donnell, J. M. (1985). *The origins of behaviorism: American psychology, 1870–1920.* New York: New York University Press.

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review, 20*, 158–177.

Watson, J. B. (1928). *The ways of behaviorism.* New York: Harper & Brothers.

Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology, 3*, 1–14.

Watson, J. B., & Watson, R. (1928). *The psychological care of the infant and the child.* New York: W.W. Norton.

Way of Life

▶ Culture in Second Language Learning

Ways of Learning and Thinking

▶ Styles of Learning and Thinking: Hemisphericity Functions

Ways of Thinking and Practicing

▶ Alignment of Learning, Teaching, and Assessment

Ways to Seek Knowledge

▶ Social Interaction Learning Styles

Weariness

▶ Boredom in Learning

Weather Prediction Task

▶ Multiple-Cue Probability Learning

Web 2.0 Technologies

This term refers to social networking software and technologies that facilitate participatory interactions across time and space online. Technologies available on the Web that allow users to contribute their own knowledge and socially interact with one another.

Web Science

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Synonyms

Science for the Internet; Science for the Web

Definition

The Web is the largest human information construct in history and it is transforming society (O'Hara and Hall 2008). Understanding what the Web is, engineering its

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future, and ensuring its social benefit necessitate new interdisciplinary approaches and research methodologies. Web Science (http://webscience.org/webscience.html) is a new interdisciplinary field that studies the Web as both a piece of engineering and infrastructure (micro level) and a phenomenon that impacts society and human activity (macro level).

Web Science employs interdisciplinary research approaches (Berners-Lee et al. 2006, Hendler et al. 2008). Due to the size and the dynamicity of the Web, we may consider it as a complex natural phenomenon that deserves to be studied as such, with the help of all classical means used by the natural sciences (observations, experiments, simulations, models, abstractions, generalizations, interpretations, forecasts). At the same time, the Web represents also the first realistic natural laboratory for controlled experiments on human behavior especially when humans (and machines) perform the highest intellectual activities of information processing; studying the ways in which the Web transforms society and human activity thus requires the use of interpretative approaches found in social sciences. Modeling and analysis of the Web also requires formalisms from computer science, mathematics, and statistics.

Theoretical Background

\Web Science was launched in November 2006 by scientists affiliated to the Massachusetts Institute of Technology and the University of Southampton in order to introduce a holistic approach to researching the Web as an infrastructure; and a phenomenon that affects society and human activity. Other institutions soon expanded that effort (Shadbolt and Berners-Lee 2008; Hendler et al. 2008). The scale of the impact that technical innovation on the Web can have on society, e.g., the societal impact of the growth of blogosphere, established the need for Web Science.

The study of such impact on a macro level needs new methods of analysis different to those that have so far been employed on the micro level to study or engineer the introduction of technical changes in systems, applications, or protocols. Continuing innovation on the Web that involves the rise of semantics (Shadbolt and Berners-Lee 2008) and linked data (O'Hara and Hall 2009) is expected to lead to a similar impact on society rapidly expanding from a micro level to a macro or global level.

Web Science draws from a set of complementary disciplines and brings together aspects of Computer Science, Sociology, Psychology, Biology, and Economics (Shadbolt and Berners-Lee 2008) but in terms of research activities it is seen as more than the intersection of these research areas and less than their union. The basic premise is that the combined Web-related research efforts from these disciplines will have an effect larger than its parts: the notion of emergence of constructive patterns from interconnected autonomous agents, be them human or artificial.

The main expectations of Web Science are that it will enable a more thorough study of the Web ecosystem where simple rules can give rise to complex phenomena and that it will address the need for a holistic approach to researching the Web infrastructure integrating both social and technical methodologies. It is thus expected to address needs for the Web to be both engineered and understood and to thereby gain an insight into what phenomena may be coming with the Web and how they may impact society and human activity (Shadbolt and Berners-Lee 2008).

Learning About the Web

The question of what forms the curriculum of the subject of Web Science is under active debate (http://webscience.org/curriculum.html). The chosen areas should contribute to understanding, engineering, and ensuring the social benefit of the Web. In the previous section we show that Web Science is an interdisciplinary subject, and research in Web Science will require contributions from a wide range of subjects including Mathematics, Sociology, Computer Science, Law, Ecology, Artificial Intelligence, and Economics. This provides particular challenges for the design of Web Science courses as it becomes necessary to take a truly integrated interdisciplinary approach rather than teaching about each of the contributory subjects in isolation.

The initial pass at the Web Science curriculum emerged after the Network for Web Science Workshop on Web Science Curriculum in September 2008 in Athens which suggested six topics:

1. The History of the Web. This covers the history of the Internet and the work of the pre-Web hypertext visionaries, as well as the Web timeline.

2. Building the Web. This covers the technologies, standards, and algorithms that are used to engineer the Web as well as aspects of governance and community inclusion in the process.
3. The Web in Society. This covers the coevolution of society and the Web, and will include issues of privacy, IP and copyright, and collective intelligence.
4. Deploying the Web – Operationalizing Web Science for a World of International Commerce. This covers the basics of information systems, online markets, and E-Commerce as well as the associated technologies.
5. Analyzing the Web. The study of methodologies to analyze the Web graph and data mining the information it contains.
6. Understanding Web Users. The study of methodologies to analyze the behavior of users on the Web.

While these topics create a coherent curriculum that addresses the objectives of Web Science, the interdisciplinary nature of such courses presents issues both in finding suitably qualified teachers and learning resources, and in coping with the diversity of students when they may also come from a range of disciplinary backgrounds. Consequently many Web Science courses have tended to concentrate on building the Web and be attended by those with a technical background.

Learning on the Web

Although not incorporated into the early visualizations of Web Science, there is a strong case for learning technologies claiming a place in its Universe. Learning technologies typically incorporate components of computer science and Web engineering (the technological aspect) plus psychology and sociology (the educational aspect). The development and effective delivery of learning on the Web requires both educational and technological insight. In addition, such applications necessarily have to encompass affordances and epistemologies derived from different disciplines and fields of study in which they seek to operate. These demands speak for the inherent interdisciplinarity of learning technologies and make a clear argument to place learning technology as an obvious member of the Web Science universe very profoundly interconnected and synergic with business, work, and entertainment technologies.

Important Scientific Research and Open Questions

Web Science will model the Web infrastructure and its architectural principles and research the relationship between computer-mediated human interactions and social conventions.

It is anticipated that a number of research challenges will be addressed (Shadbolt and Berners-Lee 2008) including the following:

- Innovation on Web infrastructure to foster and drive social interactions by extending it with social properties and policies
- Analysis of the Web as an ecosystem that is related to population dynamics, consumers and producers, business activity, journalism, and government
- Provenance of information on the Web and challenges for a Web of trust
- Legal challenges related to Intellectual Property Rights on the Web
- The Web as a network of data on which information can be linked, interpreted, and related to human activity
- Affordances and challenges of the Web in collaborative innovation and collective intelligence processes
- Affordances and challenges of the Web in addressing social or cultural divides
- Architectures and pedagogy for learning on the Web

Web Science has an ambitious research vision in terms of bringing together research methodologies from different disciplines. This presents a significant challenge, as research in the field needs to be evaluated rigorously on the combination of research methodologies that it employs and on its impact on Web Science and related disciplines. In addition, training Web scientists requires significant effort in terms of building Web Science curricula, Web Science knowledge bases, and modeling and analysis instruments. Addressing these challenges successfully will enable further research in the field and provide new insights on the Web evolution and its impact.

Cross-References

► Advanced Learning Technologies
► Information Gathering and Internet Learning
► Interdisciplinary Learning

► Network Communities
► Online Learning
► Social Networks Analysis and the Learning Sciences

References

Berners-Lee, T., Hall, W., Hendler, J., Shadbolt, N., & Weitzner, D. J. (2006). Creating a science of the Web. *Science, 313*(5788), 769–771.

Hendler, J., Shadbolt, N., Hall, W., Berners-Lee, T., & Weitzner, D. J. (2008). Web science: an interdisciplinary approach to understanding the web. *Communications of the ACM, 51*(7), 60–69.

O'Hara, K., & Hall, W. (2008). Web science. *Association of Learning Technologies Newsletter, 12*.

O'Hara, K., & Hall, W. (2009). Semantic web. In J. M. Bates, M. N. Maack, & M. Drake (Eds.), *Encyclopedia of library and information science* (2nd ed.). New York: Taylor & Francis.

Shadbolt, N., & Berners-Lee, T. (2008). Web science emerges. *Scientific American, 8*, 32–34.

Web-Based Experiment Control for Research on Human Learning

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Synonyms

Evidence-based eLearning; Methodologies of learning research through the Internet; Online experiments on learning; Online methods for learning research; Research on e-learning; Software for human learning research; Web-based research on learning; Web-labs for the study of learning

Definition

Web-based experiment control software for research on human learning refers to any type of computer program designed to control the execution of human learning experiments via the Internet. These programs are designed to test the predictions of the different theories of learning, and to understand under which conditions learning progresses more rapidly, more smoothly, or more durably, which conditions allow for better learning and which ones induce more forgetting and interference. An additional purpose of this type of software is to compare the learning that occurs in the standard, well-controlled, psychology laboratory to that which occurs through the Internet. In order to fulfill all these objectives, such software needs to present the learning materials in a relatively homogeneous fashion through different computers and configurations and needs to allow for the manipulation of independent variables that are common in the area of learning such as number of trials, number and type of cues, number and type of outcomes, particular combinations of cues and outcomes, timing between them, and contexts in which the different phases of the experiment take place. The software also needs to accurately store the dependent variables (subjective judgment of causality, predictive responses, the timing in which the participant's responses take place, learning curve, and so on).

Theoretical Background

Since the 1980s most of the research that has been conducted on how human learning works, which variables affect the learning process, and how human learning can be explained (and thus, predicted, controlled, and improved) has been conducted through personal computers. Research participants (usually college students) were presented with stimuli whose parameters were controlled by a computer in the laboratory. These parameters included key factors such as timing, relationship to other stimuli, emotional content, or semantic and instructional value, in addition to more basic aspects such as size, color, intensity, location, or sensory modality. The speed and quality of the participants learning was automatically assessed through the registration of the way and time in which they responded to those stimuli. The development of ► methodologies of learning research and the corresponding software was normally undertaken by the psychology researchers themselves, and therefore a huge and heterogeneous variety of experimental software exists today that can be used in the standard (offline) psychology laboratory. The natural evolution of such programs in the age of the Internet has resulted in that some of them have been adapted to be run online (see Matute et al. 2007a). The main advantage of this adaptation is that the Internet has certainly come to facilitate the exchange and homogeneity of procedures and software among researchers and has multiplied the number (and heterogeneity) of participants that can take part in each experiment. There are also some potential risks of doing research on learning through the Internet, such as, for instance, the possibility of some participants repeatedly taking part in the same experiment. However, the potential risks have been explored and several solutions have been suggested that make the impact of these problems almost negligible (e.g., Kraut et al. 2004; Vadillo and Matute 2009).

Just like any other experimental psychology software, these web-based programs designed to conduct research on learning through the Internet will normally comprise several versions of themselves. The reason for this is that each version needs to include a different level of an independent variable whose effect on the learning process is to be investigated. The program will then execute one or the other version each time that a different user (research participant) clicks the link to start the experiment. For instance, a program designed to test the effect of massive versus distributed learning, would comprise at least two different versions that will be assigned at random to each participant. One of these versions would use massive training, with the learning trials being presented in a very rapid succession, one after the other, while the other version could use much longer intertrial intervals. Of course these variables could also be manipulated in a within-subjects design, with each participant receiving all conditions in a counterbalanced order.

There are many different research questions, theoretical perspectives, and backgrounds from which web-based research on human learning is nowadays being conducted. In general, we could say that online research on learning is being conducted to explore (a) methodological developments (to know whether online experiments are as reliable as laboratory ones), (b) generality of already known phenomena (to test whether well-known learning effects can also be observed outside of the laboratory), and (c) novel predictions of learning theories (to run new experiments that could either be run in the laboratory or through the Internet, in which case the researchers can benefit from the larger samples available in the web). Therefore, different web-based programs have been designed to investigate online different forms of learning such as, for instance, ► probability learning (e.g., Birnbaum, and Wakcher 2002), ► associative learning (Vadillo et al. 2006), or ► causal learning and illusions of control. As an example, in an experiment designed to study how the illusion of control is acquired in the Internet, participants could be instructed to terminate stimuli that are being presented by the computer. The termination of the stimuli, however, does not depend on the participants' responses, but on a preprogrammed schedule. The result is that participants trying to terminate the stimuli will normally learn an illusory causal relationship between their behavior and the termination of the stimuli. This is an example of how several learning effects, in this case an illusion of control, can be equally acquired not only in the laboratory but also through the Internet (Matute et al. 2007b).

Important Scientific Research and Open Questions

One of the hottest current debates to which these programs could contribute by providing the necessary evidence is the issue of whether learning through the Internet is better, worse, or similar than more traditional forms of learning. Both professional and lay people's discussions on these topics are often vehement but the scientific evidence is still scarce. Indeed, a debate exists on whether these two things are actually comparable (there are many variables that differ between traditional learning in the classroom and web-based learning at home). Experiments that compare how people learn through the web and how they do in the classroom using exactly the same materials is one of the comparisons that is needed, and this is what these programs can best do. The few experiments that have so far been conducted on this topic are showing, for instance, that using the identical ► e-Learning or digital learning program in the classroom and through the Internet produces results that are almost identical in both locations. This has been shown in several simple ► associative learning tasks and through several different computer programs (Vadillo et al. 2006). On some occasions, however, it has been observed that the same simple associative learning program produces slightly better and faster learning in the classroom, when the instructor is present (though silent) and everything is controlled, as compared to the Internet, where the participants are possibly exposed to a much greater number of distractions while they perform the experiment (Vadillo and Matute 2009).

Thus, increasing the variability of these programs and the scope of tasks and domains to which they can be applied is of course one of the greater challenges for the future. Although associative learning is one of the few areas where these web-based experimental control programs have initiated their development, their extension to other areas, so that online and offline learning can also be compared in more complex domains, is a must. ► Information gathering and Internet learning is becoming so common in our generation and the ones to come that understanding the particulars of Internet-based learning and how this compares to more traditional forms of learning should be a research priority. Indeed, the popular assumption that because much learning currently takes place online it is necessarily better than more traditional forms of learning has not yet been supported by evidence. An ► evidence-based learning science will surely require that, in the future, most research tools used to investigate the learning processes are equipped with a web-based version.

If ethical norms for learning research (and for human research in general) are important, this issue becomes even more critical when the research is conducted through the Internet. Ethical codes of conduct for scientists conducting research with human participants require, for instance, that the scientists guarantee the voluntariness, anonymity, and informed consent of the participants. Whereas this is relatively easy task to accomplish when the experiment is conducted in the University laboratory or in the school classroom, some additional (and different) measures need to be taken when the experiment is conducted through the Internet. For instance, providing an informed consent screen that the participant has to accept before starting the experiment does not guarantee that the participant has been informed. Most people would click on the accept button without even reading the information on the screen. Several good strategies to solve this and other ethical potential problems have already been discussed (e.g., Kraut et al. 2004).

Another challenge for the future will be adapting these programs to run experiments on ► machine learning. Whereas humans have been the only users of this type of experimental software in the psychology laboratory, the fact that these experiment control programs are now being run on the web suggests that machine learning systems could soon be accessing these programs (whether in controlled or in uncontrolled ways) and providing their data as if they were human participants. This could be positive, as it could be used to test the degree of learning in artificial intelligence and machine learning. This should also allow to test the predictions of our theories of learning as the similarity of machine learning with human learning and be contrasted (see e.g., ► learning algorithms). But it will be important that these programs incorporate a means by which both types of data, natural and artificial learning, could be easily discriminated.

Finally, an additional potential problem of current software for Internet-based research is its lack of a broad scope approach. Most of the available software is based on technologies that do not comply with any standard and that are proprietary or poorly adapted to heterogeneous execution environments. Ideally, the technologies used for this type of research should be more flexible and should allow, for example, to compare the results of experiments conducted in different languages, using the same web applications properly localized, or providing a similar user experience (UX) to those who access the web experiment from mobile devices with limitations regarding interactivity, connection speed, computing power, and energy consumption.

Cross-References

► Associative Learning
► Causal Learning & Illusions of Control
► Evidence-Based Learning
► e–Learning and Digital Learning
► Information Gathering and Internet Learning
► Learning Algorithms
► Machine Learning
► Methodologies of Learning Research: Overview
► Probability Learning

References

Birnbaum, M. H., & Wakcher, S. V. (2002). Web-based experiments controlled by JavaScript: An example from probability learning. *Behavior Research Methods, Instruments, and Computers, 34*, 189–199.

Kraut, R., Olson, J., Banaji, M., Bruckman, A., Cohen, J., & Couper, M. (2004). Psychological research online: Report of board of scientific affairs' advisory group on the conduct of research on the internet. *American Psychologist, 59*, 105–117.

Matute, H., Vadillo, M. A., & Bárcena, R. (2007a). Web-based experiment control software for research and teaching on human learning. *Behavior Research Methods, 39*, 689–693.

Matute, H., Vadillo, M. A., Vegas, S., & Blanco, F. (2007b). The illusion of control in Internet users and college students. *CyberPsychology & Behavior, 10*, 176–181.

Vadillo, M. A., & Matute, H. (2009). Learning in virtual environments: Some discrepancies between laboratory- and Internet-based research on associative learning. *Computers in Human Behavior, 25*, 402–406.

Vadillo, M. A., Bárcena, R., & Matute, H. (2006). The internet as a research tool in the study of associative learning: An example from overshadowing. *Behavioural Processes, 73*, 36–40.

Web-Based Instruction

► Everyday Learning: Instruction and Technology Designs

Web-Based Learning

► Actor Network Theory and Learning
► e-Learning and Digital Learning

Web-Based Research on Learning

► Web-Based Experiment Control for Research on Human Learning

Web-Labs for the Study of Learning

► Web-Based Experiment Control for Research on Human Learning

Well-Being

► Affective and Emotional Dispositions of/for Learning

Well-Being and Learning in School

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Synonyms

Positive emotions and learning in school

Definition

Although there are various definitions for the term "well-being," it is agreed that well-being in school represents a set of ► subjective feelings and attitudes toward school. Moreover, ► enjoyment (some use the term "happiness") is recognized as a core element of well-being in general as well as at school. Well-being in school is defined as an indicator of the quality of scholastic life, and contributes to students' physical and psychological health and development. As such it is strongly connected to learning. Well-being in school consists of cognitive, emotional, and physical components, i.e., a learner's thoughts, feelings, and bodily sensations. Consequently, it differs significantly from an individual's cognitive appraisals like satisfaction, or from discrete positive emotions like enjoyment. Well-being in school can be described through the relationship of positive and negative aspects of school life (cf. Hascher 2008): The more positive the experience, the greater the well-being. A high level of well-being indicates the supremacy of positive emotions and evaluations over the negative; the greater the difference between positive and negative dimensions, the greater the students' well-being.

Well-being can be differentiated into short- or long-term dimension. Short-term well-being (► state well-being) represents positive emotions and cognitions toward an actual situation, e.g., the enjoyment and positive evaluation of a physics lesson. Long-term well-being in school (► trait well-being) indicates an individual's general feelings toward and evaluations of the school context, e.g., feeling well in school on the whole. It is proposed that habitual well-being is a result of frequent experiences of short-term well-being, e.g., the combination of repeated experiences of enjoyment in school and feelings of competence during learning with very few negative occurrences. Habitual well-being, however, is not a simple accumulation of actual well-being because experiences of high personal relevance can have a greater impact on well-being than situations of low relevance.

Theoretical Background

Well-being in school as a specific concept and its relationship to learning characterizes a relatively new research field. Several reasons are responsible for this late development:

1. Well-being research originally focuses on the well-being of adults and was not related to learning processes. In 1969, Bradburn was the first to describe subjective well-being through the balance of positive and negative affect in everyday life (see the "► Affect-Balance-Scale"). Theory building was only advanced many years later when well-being was defined as an individual and social value as well as a basic psychological need which goes far beyond ephemeral feelings. Today, multicomponent approaches, as suggested by (Ryff and Keyes 1995), are widely accepted. Well-being, thus, consists of a clearly defined set of affective, cognitive, social, and physiological characteristics.
2. Affective aspects of school and their impact on learning were neglected for many years due to the predominance of cognitive approaches to learning and instruction. The effect of emotional variables in school focused on test anxiety or was tested in experimental settings, outside of schools (cf., Isen 1984). Although this research highlighted the importance of the role of positive emotions and attitudes for learning and academic success, interest in the role of emotions in learning and instruction has only been loosely associated with well-being research.
3. Noncognitive approaches to scholastic learning were primarily related to student motivation. Although some theories had integrated affective elements earlier (e.g., Csikszentmihalyi 1975), emotional aspects were not investigated on their own but defined as indicators of a specific motivational orientation, e.g., enjoyment as an indicator of intrinsic motivation. Consequently, even relevant results related to well-being were not recognized.
4. Additionally, educational research failed to conceptualize well-being in school specifically, using it as a generic term for any positive aspect in schools and learning contexts. Furthermore, there was a lack of theoretical approaches on the relationship between well-being and learning. Thus, indirect findings on emotions and affect were conflated with the general term "well-being" and well-being in school was, e.g., confounded with the absence of negative emotions toward school or with the concept of social climate.

Important steps in scholastic well-being and learning research were taken as soon as well-being in school was associated with general well-being research. Analogous to general well-being, well-being in school was defined as a distinct quality of subjective evaluation and experience. It was acknowledged that well-being in school has also to be conceptualized as a multicomponent construct rather than a simplified psychological phenomenon of enjoyment or fun. Well-being in school, thus, was described by six dimensions (Hascher 2010):

1. Positive attitudes and emotions toward school in general
2. Enjoyment in school
3. Positive academic self-concept
4. Absence of worries about school
5. Absence of physical complaints in school
6. Absence of social problems in school

The need for differentiation between several well-being components was supported by the pattern of findings among these components, e.g.:

- Students report low degrees of physical complaints in relation to learning.
- The reported amount of social problems in the classroom is relatively small.
- Worries about learning and learning outcomes in school are more frequent.
- A lack of enjoyment in school, mainly in relation to academic tasks, can be found.

The variety of predictors of student well-being (such as pre-experiences) and learning (such as pre-knowledge) can be divided into three dimensions:

1. Well-being and learning in school are influenced by environmental conditions: primarily the school context. School characteristics like school type, school culture, educational focus, and infrastructure and facilities influence well-being and learning differently.

2. Well-being and learning are influenced by personality variables. Aspects like gender, self-efficacy, motivation, and frustration tolerance have an impact because they influence students' abilities to manage academic challenges.
3. Basically, effects on well-being and learning in school are related to person-environment interaction. The school context will be influential with regard to a student's interpretation and evaluation, and the impact of students' characteristics depends on their importance with respect to the scholastic setting.

Important Scientific Research and Open Questions

Generally, well-being research is driven by two goals: (1) One is the identification of quality of life aspects, in order to prevent harmful influences and illness. (2) In line with the salutogenetic approach to health research, well-being is a central topic for positive psychology in its aim to support emotional balance and good health. Accordingly, school-based research is motivated by the intention to figure out crucial predictors, as well as consequences of well-being and learning, and their interplay. On one hand, well-being in school is an indicator of a scholastic setting which enables learning processes and supports students in reaching important academic and social goals. Its main function lies in the maintenance of a positive basis for learning at school. On the other hand, learning is crucial for the occurrence of well-being because successful learning is an important source of enjoyment in school. Thus, well-being and learning in school are interdependent concepts which influence each other. From a theoretical point of view, however, it is helpful to analyze their relationship separately: (a) How does well-being affect learning? (b) How does learning contribute to well-being?

Research on well-being and learning in school can be differentiated into three perspectives:

1. Macro-level perspective: The support of student learning and development is the main function of a school. Well-being is a crucial basis for any kind of learning and an educational value it its own right. It is an indicator of the quality of a learning environment, as well as an indicator of the fit of school and students' scholastic development. Well-being surveys could show that schools differ in terms of student well-being and learning, thereby pointing to the influence of school culture variables. Generally, students attending schools with high academic ambitions (high track schools) score better in terms of well-being in comparison to schools with a moderate academic aspiration (low track schools). Furthermore, there is a trend that well-being is higher and learning outcomes are better in lower grades than in advanced grades. An increase of well-being can be found toward the end of compulsory education.
2. Meso-level perspective: The most influential context for well-being and learning is the classroom. The quality of instruction is determined by the teacher's instruction as well as the students' participation. In addition to a positive social classroom climate, a teacher's individual reference standard and care of students support well-being and learning. In student-orientated instruction, higher levels of well-being are reported in comparison to teacher-centered lessons even if the learning outcomes are not comparably better. Also differences in learning domains could be found: Highly demanding (and often selective) subjects like mathematics are more often associated with lower well-being than subjects with lower achievement pressure (such as history or geography).
3. Well-being and learning in school – micro-level perspective: Individual perspective is also relevant in terms of well-being and learning in school, e.g., subjective emotional and cognitive learning precursors, as well as learning results. Accordingly, high achievers show better levels of well-being than low achievers. Self-efficacy beliefs and experiences with academic learning are influential, while positive affect fosters task-related self-belief, willingness for exertion, and hope of success. Girls score higher on positive emotions and attitudes toward school, but also on negative components like physical complaints and worries. Intrinsic motivation is positively related to well-being and learning in contrast to extrinsic motivation. Test anxiety correlates negatively with well-being and learning in school.

Despite increasing interest in well-being and learning, this topic needs further attention in terms of theoretical and methodological development. There is still a lack of theories of well-being in school, academic learning, and the relationship between well-being and learning. Currently, very few instruments that assess student well-being are available (cf. Hascher 2008; Van Petegem et al. 2007). Furthermore the question of how well-being correlates with other learning and achievement emotions, like pride or boredom, has still to be addressed. Also little is known about the specific influence of different instructional designs on well-being and learning.

Cross-References

► Affective and Emotional Dispositions for Learning
► Boredom of Learning
► Emotion Regulation
► Emotional Learning
► Emotions: Functions and Effects on Learning

References

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety.* San Francisco: Jossey-Bass.

Hascher, T. (2008). Quantitative and qualitative research approaches to assess student well-being. *International Journal of Educational Research, 47*, 84–96.

Hascher, T. (2010). Wellbeing. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (3rd ed., Vol. 6, pp. 732–738). Oxford: Elsevier.

Isen, A. M. (1984). Toward understanding the role of affect in cognition. In R. Wyer & T. Srull (Eds.), *Handbook of social cognition* (Vol. 1, pp. 174–236). Hillsdale: Erlbaum.

Ryff, C. D., & Keyes, C. L. M. (1995). The structure of psychological well-being revisited. *Journal of Personality and Social Psychology, 69*, 719–727.

Van Petegem, K., Aelterman, A., Van Keer, H., & Rosseel, Y. (2007). The influence of student characteristics and interpersonal teacher behaviour in the classroom on students' well-being. *Social Indicators Research.* doi:s11205-007-9093-7. Springer.

Weltanschauung

"A Weltanschauung is a definition of the situation: it influences what problems are perceived, how these problems are interpreted, and what learning ultimately results" (Hedberg 1981).

References

Hedberg, B. (1981). How organizations learn and unlearn. In P. Nystrom & W. Starbuck (Eds.), *Handbook of organizational design* (Vol. 1, pp. 3–27). Oxford: Oxford University Press.

Wertheimer, Max (1880–1943)

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Life Dates

Max Wertheimer was born in 1889 in Prague. He began to study law at the University of Prague, but then he became increasingly interested in psychology, philosophy, and physiology. In consequence, from 1901 to 1904 he studied these subjects at the University of Berlin, where he studied with Carl Stumpf, and at the University of Würzburg where he earned his doctorate in 1904 under the supervision of Oswald Külpe. From 1904 to 1910, Wertheimer worked at the universities of Prague, Berlin, and Vienna. He served as professor at the University of Frankfurt from 1910 to 1916, the University of Berlin from 1916 to 1929, and then again at the University of Frankfurt from 1929 to 1933. When Hitler became Chancellor in 1933, Wertheimer decided to leave Germany and accepted an offer from the New School for Social Research in New York City. He lived with his family in New Rochelle, New York, until his death in 1943.

When Wertheimer was working at the University of Berlin, he met two excellent doctoral students, namely, Kurt Koffka and Wolfgang Köhler, who later became his research assistants at the University of Frankfurt. Wertheimer, Koffka, and Köhler worked together so closely on developing the fundamental concepts of Gestalt theory that this trio is usually considered the founder of the school of Gestalt psychology. In the early days of Gestalt theory Wertheimer met Carl Jung and Albert Einstein, the latter of whom informed him in a series of interviews about the development of the principles of the general theory of relativity. In 1946, Solomon Asch wrote that he "thinking of Max Wertheimer has penetrated into nearly every region of psychological inquiry and has left a permanent impress on the minds of psychologists and on their daily work. The consequences have been far-reaching in the work of the last three decades, and are likely to expand in the future" (Asch 1946, p. 81).

Contribution(s) to the Field of Learning

Wertheimer's ideas concerning learning culminated in his book *Productive Thinking*, the only book he ever wrote, published posthumously. His ideas about productive thinking were based on personal experiences, his experiments, and particularly on interviews with people who were considered to be outstanding problem solvers, such as Albert Einstein.

Based on these sources, Wertheimer contrasted the Gestalt conception of insightful learning with the behaviorist view on learning, which he characterized as simple rote memorization governed by external reinforcement and the laws of association. From the perspective of Gestalt psychology, learning does not need external reinforcement but rather is intrinsically reinforced. Wertheimer believed that individuals are motivated to learn and solve problems because it is personally satisfying, not because of external reinforcement. Learning and problem solving in accordance with Gestalt principles aim at a comprehension of the situation and the structure of the problem and occur insightfully. Features of the productive thinking process include (1) grouping and reorganizing the components of a situation, (2) functioning in relation to characteristics of the whole rather than its parts, (3) avoiding a simple collation of successions of parts or random occurrences, and (4) structural mapping which leads to sensible expectations and assumptions. In Wertheimer's approach, productive thinking starts with a problem. Structural features and specific requirements of the problem cause tension and initiate field forces in the brain that prompt the individual to modify or revise the situation in order to proceed from a bad gestalt to a better one, which leads to the solution of a given problem. According to Wertheimer, "in gaining insight into the solution of a problem . . . the student should cognitively arrange the components of the problem until a solution based on understanding is reached. Exactly how this process is done will vary from student to student" (Hergenhahn and Olson 2005, p. 281).

Wertheimer's seminal work on productive thinking and problem solving was adopted and continued by some of his disciples, such as Karl Duncker, George Katona, and Abraham Luchins. Furthermore, it must be stated that in the Gestalt tradition of Wertheimer, Duncker, and Luchins, modern cognitive psychologists have continued to explore the structural processes of thinking, reasoning, and problem solving. The legacy of Wertheimer has been captured by Asch as follows:

> To understand [persons] we must see [them] in [their] setting, in the context of [their] situation and the problems [they are] facing. If we wish to understand a given quality in a person we must not isolate it; we must see it in relation to [that person's] other qualities. For this reason, also, the "same" quality in two persons is often not the same psychologically.. . . When the phenomena being observed have order and structure, it is dangerous to concentrate on the parts and to lose sight of their relations. (Asch 1952, p. 600)

Important Scientific Research and Open Questions

Wertheimer's experiments on apparent movement can be considered as a typical example of the way he operated as a scientist. According to anecdotal evidence, it was in 1910 on a train from Vienna to the Rhineland that Wertheimer developed the idea that perceptions are different from the sensations that comprise them. To test this idea, Wertheimer got off the train in Frankfurt, bought a toy stroboscope, and began to experiment in a hotel room. Wertheimer was perceiving motion where none actually existed. Then he went to the University of Frankfurt and continued the experiment with a tachistoscope, a device which can flash lights on and off for measured fractions of a second. Flashing two lights successively, he found that if the time between the flashes was 200 ms or longer he perceived the lights flashing on and off successively. If the time between flashes was only 30 ms or less, both lights appeared simultaneously to the perceiver. But if the time between the flashes was about 60 ms, it appeared to the receiver that one light was moving from one position to the other. Wertheimer called this apparent movement the *phi phenomenon*. He published the results of his experiments on apparent movement in 1912 in the article "Experimental Studies of the Perception of Movement," which is usually considered as the birth of Gestalt psychology. Of course, Wertheimer did not discover apparent motion, but his explanation was novel and unique. Whereas Wundt and Helmholtz emphasized the role of learning in experiences like the phi phenomenon, Wertheimer was able to demonstrate that explanations based on learning were not plausible. Again using a tachistoscope, he conducted an ingenious experiment to show that the phi phenomenon could occur simultaneously in two directions. An explanation based on sensations and learning was not tenable. Wertheimer explained the phi phenomenon by arguing that the brain contains structured fields of forces that exist prior to any sensorial experience (for more details see the entry on ► Gestalt Psychology). According to this view, organized brain activities dominate perceptions but not the sensory stimuli that evoke the activities.

From 1910 to 1914, Wertheimer continued to explore the new paradigm, and together with Koffka and Köhler he focused on Gestalt principles of perceptual organization as well as on the foundation of the Law of Prägnanz. Wertheimer's ideas featured the notion of psychophysical isomorphism and the view that thinking proceeds from the whole to the parts, treating a problem as a whole, and permitting the whole to command or dominate over the parts. Accordingly, a particular interest of Wertheimer and his group consisted in the factors of *perceptual grouping*. Based on numerous experiments, the early Gestalt theory culminated in the formulation of what have been called the Gestalt principles (or laws) of perceptual organization, which include (1) proximity (elements that are close in space tend to be grouped together and perceived as one or a few objects), (2) similarity (perceptual elements that have some similar characteristics tend to be grouped), (3) closure (elements which appear to complete some shape or object tend to be grouped), and (4) simplicity (i.e., the tendency to organize objects into simple figures).

Wertheimer considered reductionism as a fundamental problem of his time; he was particularly interested in the holistic nature of problem solving and proposed two modes of human thinking: productive and reproductive. Productive thinking solves a problem through insight into a situation, whereas reproductive thinking solves a problem by referring to previous experiences and what has already been learned.

In Wertheimer's view on problem solving, productive thinking starts with a problem. The structural features and requirements of the problem cause tension, the strain of which produces vectors that prompt the individual to modify the situation in an improved direction. The process of resolving a problem entails proceeding from a bad gestalt to a better one. The solution of the problem occurs with a flash of insight. Mayer (1995) captures the notion of insight by stating that insight occurs when a problem solver moves suddenly from a state of not knowing how to solve a problem to knowing how to solve it. Gestalt psychologists offered several ways of conceptualizing what happens during insight: Insight may involve building a schema in which all the parts fit together. However, insight may also involve reorganizing the situation or restating the initial and final state in a new way that makes the problem easier to solve. Finally, insight may involve searching for analogues (i.e., a similar problem that the problem solver already knows how to solve).

Beyond his seminal work on perceptual grouping, Wertheimer's far-reaching contributions to the field of learning also include his efforts to apply Gestalt theory to education.

Cross-References

► Gestalt Psychology of Learning
► History of the Sciences of Learning
► Köhler, Wolfgang

References

Asch, S. E. (1946). Max Wertheimer's contributions to modern psychology. *Social Research, 13*(1), 81–102.
Asch, S. E. (1952). *Socialpsychology.* Englewood Cliffs: Prentice-Hall.
Hergenhahn, B. R., & Olson, M. H. (2005). *An introduction to theories of learning* (7th ed.). Englewood Cliffs: Prentice-Hall.
Mayer, R. E. (1995). *Thinking and problem solving: An introduction to human cognition and learning*. Glenview: Scott & Foresman.
Wertheimer, M. (1912). Experimentelle Studien über das Sehen von Bewegung (Experimental Studies of the Perception of Motion). *Zeitschrift für Psychologie, 61*, 161–265.
Wertheimer, M. (1945). *Productive thinking.* New York: Harper.
Wertheimer, M. (1965). Relativity and Gestalt: A note on Albert Einstein and Max Wertheimer. *Journal of the History of the Behavioral Sciences, 1*, 86–87.

Whole

► Configural Cues in Associative Learning

Whole-Part-Whole Learning

► Metatheories of Learning

Whole-Person Learning

► Experiential/Significant Learning
► Person-Centered Learning

Will to Power

The fundamental impulse of all living things to extend their influence, increase their power, and continually confront and overcome resistance.

Willingness

► Motivational Variables in Learning

Wireless Community Network

► Network Communities

Wishful Thinking

► Magical Thinking and Learning

Wittgenstein on Learning

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Life Dates

Ludwig Wittgenstein (1889–1951) was born to a wealthy family in Vienna, Austria. His first university studies were in aeronautical engineering at Manchester University where his interest in pure mathematics led to a meeting with Frege who advised him to move to Cambridge University and study with Bertrand Russell. At Cambridge, Wittgenstein developed an interest in the foundations of logic and the implications for philosophy. He returned to Austria in 1913 and joined the Austrian army to fight in World War I. He was taken captive in 1917 and spent the remainder of the war in a prison camp where he wrote the notes for the only book published in his lifetime, *Tractatus Logico-Philosophicus*; in that volume he examined the foundational relationships of logic, language, and the world. After briefly exploring careers in architecture, gardening, and teaching, he returned to Cambridge in 1929 where he conducted seminars and took notes that would become known as the *Philosophical Investigations*, which was published 2 years after his death in 1951. Wittgenstein is widely regarded as one of the deepest thinkers and most influential philosophers of the twentieth century (Hacker 1996; Malcolm 1958).

Theoretical Background

Wittgenstein's (1922) *Tractatus* consists of seven major propositions with numerous subordinate and supporting propositions concerning the nature of thought, language, and the world loosely translated as follows [comments in brackets represent this author's elaboration]:

1. The world is all that is the case. [This can be regarded as a definition of the word "world".]
2. What is the case, a fact, is the existence of states of affairs. [What exists are relationships of things – not objects in isolation.]
3. A logical picture of facts is a thought. [This is a cornerstone of Wittgenstein's early thinking.]
4. A thought is a proposition with a meaning. [Reality is connected first with thought and then with language.]
5. A proposition is a truth function of elementary propositions. [This leads to a two-valued logic and a correspondence theory of truth.]
6. The general form of a truth function is a function of elementary propositions, a set of any propositions, and their negations. [This closely follows Frege's definition of a proposition.]
7. What we cannot speak about we must pass over in silence. [A great deal falls into this category.]

This small volume was every influential in the field of analytic philosophy (an approach that rejects idealism and in which the analysis of words and statements plays a central role) and was closely associated with logical positivism, in which statements that are not verifiable are regarded as meaningless (Hacker 1996). Many of the statements in the *Tractatus* and the seven major propositions taken together certainly lend themselves to an interpretation linked with logical positivism. Many modern philosophers consider their major task to be distinguishing sense from nonsense, and Wittgenstein certainly belongs to that major tradition. As many who preceded Wittgenstein have noted, such an enterprise is nonending. For example, while Socrates is being held for execution, he is visited by his good friend Crito who tells Socrates that he has arranged for his escape. Rather than accept Crito's plea to escape, Socrates argues that together they must again reconsider the nature of virtue to see if prior reasoning was flawed in some way (Jowett 1900). Like Socrates, Wittgenstein was willing to revisit his reasoning throughout his life.

As it happened, Wittgenstein and others found flaws in the *Tractatus*. In a sense, Wittgenstein and others wanted to and in fact did speak about many of the things that should be passed over in silence according to a narrow reading of the *Tractatus*. Wittgenstein did not abandon the close links among thought, language, and the world. Rather, he looked more carefully at those connections and in particular at the nature of language. His later analysis gave up the notion that meaning was determined by truth functions of elementary propositions. The revised view of meaning was that it was the use of words that determined meaning; usage is not nearly so univocal and simple as proposed in the case of elementary propositions. Use is embedded in language games and involves communities of users. A language game consists of rules that are accepted and generally followed by those belonging to a particular group of users or speakers; the rules are not strict but somewhat fluid and context sensitive as one might expect in a natural language setting. If one imagines a situation involving a skilled automobile mechanic and an assistant, the mechanic might say, for example, "Give me the gun" referring to the grease gun that is nearby. Those same words could easily be imagined to have a different meaning in a different situation. In a broader sense, a language game can be considered as a loose set of rules to govern external manifestations in the form of statements of particular internal scripts or schema that those involved in the situation are likely to easily understand.

Wittgenstein kept many notes that were not published in *Philosophical Investigations*, such as his notes on color, perception, and psychology (Anscombe and von Wright 1980). Much of Wittgenstein's discussion of psychology involved an exploration of things he observed and things people say, with a particular interest in perception. For example, he noticed that it did not seem possible to produce a brown translucence. Is that a result of something in the objects or in our perception of objects? Wittgenstein was clearly concerned with the nature of the self, especially as a thinking and perceiving entity, throughout his lifetime. It is clear even in the *Tractatus* that Wittgenstein regarded the individual as a basic unit of analysis. He says, for example, at *Tractatus 5.63* that "I am my world." At *Tractatus 5.632* he goes on to say that the self is not a part of the world – rather, the self is a limit of the world. Consistent with this holistic view of what it is to be a person, Wittgenstein says at *Tractatus 6.43* that the world of the happy person is not the same as that of the unhappy person – the world waxes and wanes as a whole.

Contributions to the Field of Learning

What can be gleaned from the writings of Wittgenstein that are relevant for the learning sciences? While Wittgenstein has had significant and direct influence on philosophical thinking, his influence on learning is much more indirect. However, Wittgenstein's view of a person as a unified whole is quite consistent with how many psychologists view the impact of mood on behavior and how learning researchers are inclined to think about motivation and emotion as key facilitators of a learning process. Moreover, two aspects from Wittgenstein's world form the basis for much of current learning research – namely, the notion of internal representations and the concept of language games.

At *Tractatus 2.1*, Wittgenstein says that we picture facts to ourselves. We create internal representations of things we experience. This is an amazing insight however obvious it may seem to a casual reader. We create internal representations of things we experience in order to make sense of those experiences. In fact, this statement can be regarded as the fundamental tenet of mental models and a cornerstone of constructivism. People naturally create internal representations to make sense of their experiences and surroundings. We cannot stop doing so. We are natural builders of mental models and makers of meaning. What Wittgenstein did not mention in the *Tractatus* was that we also have the ability to picture to ourselves things that are not facts. Fortunately, in addition to the ability to create mental models to interpret experience, people have a second amazing ability, namely, the ability to communicate with others; we play language games. We can share representations of our internal pictures with others, and in doing so come to understand our own thinking better as well as share in and benefit from the thoughts of others. These two natural human capabilities – the ability to create internal representations and the ability to engage in language games – can be taken as the fundamental nature of consciousness. Both of these abilities show up in modern learning theories and research on learning. While Wittgenstein was focused in coming to understand the boundaries of sense and what it is to be a thinking person in the world, he articulated the foundation for much of modern learning theory.

Cross-References

► Collaborative Learning
► Communities of Learning
► Constructivism
► Model-Facilitated learning
► Naturalistic Epistemology
► Situated Learning
► Zone of Proximal Development

References

Anscombe, G. E. M., & Rhees, R. (Eds.) (1953). *Philosophical Investigations* (trans: Anscombe, G. E. M.). Oxford: Blackwell.

Anscombe, G. E. M., & von Wright, G. H. (Eds.) (1980). *Remarks on the Philosophy of Psychology* (trans: Anscrombe, G. E. M.). Oxford: Blackwell.

Hacker, P. M. S. (1996). *Wittgenstein's place in twentieth-century analytic philosophy.* Oxford: Blackwell.

Jowett, B. (trans.) (1900). *The Dialogues of Plato.* New York: Collier & Son.

Malcolm, N. (1958). *Ludwig Wittgenstein: A memoir.* Oxford: Oxford University Press.

Wittgenstein, L. (1922). *Tractatus Logico-Philosophicus* (trans: Ogden, C. K.). London: Routledge.

Woodworth, R.S. (1869–1962)

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Life Dates

Robert S. Woodworth (Belchertown, Massachusetts, October 17, 1869–New York City, New York, July 4, 1962) was the son of a Congregationalist minister and a mother who taught moral philosophy at a women's seminary that she helped to found. After receiving a bachelor's degree from Amherst College in 1891, Woodworth taught high school and college mathematics. Inspired by the work of William James and G. Stanley Hall, Woodworth entered Harvard in 1895 for graduate study in philosophy and psychology. Working under Josiah Royce, William James, and physiologist Henry Bowditch, he received a master's degree in 1897. Woodworth accepted a fellowship under James McKeen Cattell at Columbia University, where he was also influenced by anthropologist Franz Boas. For his dissertation, Woodworth studied the accuracy of hand movements under varied conditions and received the PhD in 1899. He spent 1902–1903 as assistant to noted physiologist Charles Sherrington in Liverpool, and accepted Cattell's offer to join the Columbia University faculty in 1903. Woodworth remained at Columbia for his entire career, succeeding Cattell as executive officer of the psychology department, and continuing to teach until 1958, after becoming Professor Emeritus in 1942. He served as the 23rd president of the American Psychological Association (APA), chair of the Division of Anthropology and Psychology of the National Research Council, president of the Social Science Research Council, and helped to found the Society for Research in Child Development and the Psychological Corporation. Woodworth was awarded the APA's first Gold Medal in Psychology in 1956 for his contributions toward systematizing knowledge and building the discipline. Considered a *Dean* of American psychology, he was known for his careful syntheses of empirical and theoretical problems and for his diverse interests, ranging from imageless thought to the Woodworth Personal Data sheet, generally considered to be the first personality test.

Contributions to the Field of Learning

After finishing his dissertation, Woodworth and his close friend Edward L. Thorndike began a series of studies on transfer of training, published in the *Psychological Review* (e.g., Thorndike and Woodworth 1901). They hoped to test an old and popular idea known as *formal discipline*, which maintained that the study of Latin or geometry would produce general intellectual strengthening in a manner analogous to muscular exercise. Formal discipline had been an influential idea in education, although it was much disputed in the late 1800s. In their experiments, Thorndike and Woodworth trained their subjects to estimate the size of rectangles, and tested for transfer to estimating the size of triangles and other shapes. They also tested for transfer on various letter and word cancelation tasks. They found little or no evidence of transfer, and concluded that transfer was unlikely except when the two tasks contained identical elements. Their work helped inspire a large literature and long debate over transfer of training. Woodworth later summarized this literature in his 1938 *Experimental Psychology.*

Woodworth contributed to the field of learning in a global, indirect way. In his *Dynamic Psychology* (1918), based on a series of eight lectures at the American Museum of Natural History in 1916–1917, he laid the groundwork for the study of motivation. He saw a dynamic approach as the solution to the conflict between consciousness and behavior as the basic objects of study. In his second lecture, he outlined the advantages and deficiencies of both behavioristic and introspectionist approaches, and argued that in their extreme and exclusionary versions, "neither party has rightly envisaged the real problem for psychology" (1918, p. 34). Instead, he proposed an emphasis on cause and effect or *dynamics*, which required the study of consciousness, behavior, *and* physiology to provide a coherent account of human feelings and actions. The two basic concerns of a dynamic approach were how we do something (the mechanism), and why we do something (the drive). For Woodworth, drives were not limited to a fixed set of native or inherited instincts. Instead, a mechanism for skill at numbers or music could in turn become a drive or motive for engaging in those activities. In general, any mechanism could furnish drive or lend drive to other mechanisms, and motivation can arise from any system of the body, Woodworth maintained. He then used this general position to analyze problems of learning and originality, and of abnormal and social behavior. Woodworth retained this emphasis on dynamics throughout his career. In the second edition of his best-selling introductory psychology textbook (Woodworth 1929), he described the fundamental model for psychology as S-O-R, stimulus–organism–response, to emphasize the contribution of the organism, especially in terms of motivation and individual differences. This simple terminology was Woodworth's way of overcoming the deficiencies of Watsonian S-R behaviorism, and Woodworth later emphasized the continuous, reciprocal interaction between the person and the environment. The S-O-R formulation was used in many subsequent textbooks and theoretical discussions. Woodworth's balanced perspective brought a calming voice to debates over heredity and environment by emphasizing the importance of both in a widely respected report prepared for the Social Science Research Council (Woodworth 1941).

Woodworth also helped shape the study of learning by writing one of the most influential psychology textbooks of the mid-twentieth century: his 1938 *Experimental Psychology*, known popularly as the *Columbia Bible* (see Winston 2006). From long before its publication, when it was used in mimeographed form by generations of Columbia graduate students, through the 1960s, it was the premier guide for experimental research. *Experimental Psychology* was used around the world. Although the book lacked any overall theoretical framework, it covered a very broad range of topics in a way that was eminently useful. Research in all major areas of learning, including memory, forgetting, conditioning, maze learning, practice, transfer, attention, reading, and problem solving were examined. His interpretive summaries of the literature showed a thorough and balanced analysis of what was understood and what needed further explanation. The book provided a model for the careful weighing of evidence and confirmed Woodworth's position as the premier generalist of experimental psychology. Although he cannot be counted as a learning theorist, Woodworth helped shape the general framework for the intense study of learning that characterized American experimental psychology from the 1930s to the 1970s.

Note: Portions of this entry are adapted from Winston (2006), with permission of the American Psychological Association and Taylor & Francis Group.

Cross-References

- ▶ Behaviorism and Behaviorist Learning Theories
- ▶ Motivation and Learning
- ▶ Retention and Transfer
- ▶ Thorndike, Edward L.

References

Thorndike, E. L., & Woodworth, R. S. (1901). The influence of improvement in one mental function upon the efficiency of other functions (I.). *Psychological Review, 8*, 247–261.

Winston, A. S. (2006). Robert Sessions Woodworth and the creation of an eclectic psychology. In D. A. Dewsbury, L. T. Benjamin Jr., & M. Wertheimer (Eds.), *Portraits of pioneers in psychology* (Vol. VI, pp. 50–66). Washington, DC: American Psychological Association/Lawrence Erlbaum.

Woodworth, R. S. (1918). *Dynamic psychology.* New York: Columbia University Press.

Woodworth, R. S. (1929). *Psychology: A science of mental life* (2nd ed.). New York: Holt.

Woodworth, R. S. (1938). *Experimental psychology.* New York: Holt.

Woodworth, R. S. (1941). *Heredity and environment: A critical survey of recently published material on twins and foster children* (Social Science Research Council Bulletin No. 47). New York: Social Science Research Council.

Word Learning

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Synonyms

Lexical acquisition; Lexical development

Definition

The phrase *word learning* generally describes the act of learning the meaning of a word. A word is an arbitrary symbol used to refer to, or stand for, some concept in the world (e.g., an object or event). Word learning occurs when the word is linked (i.e., mapped) to that concept. Word learning is commonly measured using either comprehension (e.g., pointing or looking) or production (e.g., saying the word) tasks. Research using these tasks suggests that comprehension typically precedes production, both for individual words (e.g., the word "ball" is likely to be understood before it is used) and in the developing lexicon (e.g., a 16-month-old toddler may comprehend a couple of hundred words but produce less than 50) (Fenson et al. 1994).

The study of word learning is part of the much larger study of language development. While words are learned continuously throughout the life span, research tends to focus on learning in young children (i.e., 0–6 years). Likewise, while there are many different types of words (e.g., nouns, verbs, adjectives, etc.) research tends to focus on the learning of nouns (e.g., ball). Research helps to document the timeline for word learning and explain the processes that support it.

Theoretical Background

A majority of children begin producing their first words at the end of their first year of life (Fenson et al. 1994), although this word-learning milestone (like many others) can vary dramatically from child to child. At the beginning, the pace of word learning is usually slow (i.e., 1–3 words/week) and over the next 6 months, the lexicon gradually expands to about 50 words. The meanings for many of these early words are still works-in-progress as children use them either too broadly (i.e., to overextend them) or too narrowly (i.e., to under-extend them). Overextending the word "ball" may mean using it to refer to any round object whereas under-extending the word "ball" may mean using it to refer only to one example of a ball (e.g., a soccer ball). The types of words that make up children's developing lexicon tend to vary by language, but for English-speaking children many of these words are nouns. Also, the process of learning a word may be slower for children learning multiple languages and thus the size of their lexicon may be smaller during the earliest stages of word learning.

After the 50-word mark, the pace of word learning usually quickens – in some cases considerably. Several researchers have observed a vocabulary spurt in young children during which the pace of learning rapidly accelerates from just a few words a week to several words a day. However, other researchers question whether such a spurt actually occurs (Bloom 2000) and, if so, whether it is universal. The change in pace, whether resulting in a spurt or not, may signal an important shift in children's understanding of words. One possibility is that children realize that "things have names" (i.e., the so-called naming insight) and begin actively seeking words rather than passively receiving them. This accelerated pace of word learning continues through the preschool years. In fact, preschool children can begin forming a rough hypothesis about the meaning of a new word after only a single exposure to that word. This quickly formed mapping between the word and the hypothesis (sometimes called a fast mapping) can last several weeks even with no additional exposure to the word.

The challenge when learning any word, whether it is the first word or the thousandth and whether the word is learned quickly or slowly, is to figure out what the word means. This is sometimes described as an induction problem because, in theory, the set of possible meanings for any word could be unlimited (Markman 1989). This is illustrated nicely in Quine's "gavagai" example (1960). Imagine that an explorer in a foreign land sees a rabbit while a native speaker says "gavagai." How does the explorer determine the meaning of gavagai? Obviously it could mean "rabbit," but it could also mean "food" or even a superstition like "there will be a storm tonight." In theory, to determine the meaning of gavagai the explorer must consider all the possible meanings and then decide which of those possible meanings is most likely to be correct. However, if children really considered all the possible meanings then the pace of learning a word, and ultimately of building a lexicon, would be very slow. Because word learning is not slow, it is likely that not all possible meanings are considered. How children limit this set of possible meanings and ultimately how some meanings come to be favored over others is one of the most hotly studied (and debated) questions in language development.

Important Scientific Research and Open Questions

Research suggests that there are several different assumptions children make when deciding which meanings to favor (see Woodward and Markman 1998 for detailed review). Some of these assumptions are based on social knowledge and beliefs about how and why speakers communicate. Children pay special attention to social cues (e.g., gaze, joint attention, pointing) and make pragmatic assumptions (e.g., conventionality, contrast) when learning a word (Tomasello 1995). Social cues are helpful because they can indicate the subject of a speaker's attention. For example, children assume that a speaker's gaze will direct them to the correct referent. Gaze can be especially helpful when it is shared by both the speaker and the child (i.e., known as joint attention). Pragmatic assumptions are helpful because they can indicate the subject of the speaker's intention (Bloom 2000). For example, conventionality suggests that children assume that a speaker who intends to refer to a familiar thing will use the conventional word (e.g., a speaker who intends to refer to a ball will use the word "ball").

Other assumptions are based on linguistic knowledge and beliefs about the nature of words and the language used to frame them. Children honor a set of word-learning assumptions (sometimes called lexical principles or constraints) (e.g., taxonomy, mutual exclusivity) and track cues provided in the syntax (e.g., the presence of the article "a") when learning a word. Word-learning assumptions are helpful because they constrain the set of possible meanings that are considered for a word (Markman 1989). For example, taxonomy suggests that children assume that similar things should be labeled with the same word. Syntactic cues are helpful because they narrow the type of word, and ultimately the type of referent, that children expect. For example, children assume that an indefinite article (i.e., like "a" or "an") signals an upcoming common noun (e.g., a child who hears "this is a ball" assumes that "ball" refers to a thing and not a person's name or an action).

These assumptions assist the word learning process by leading children to favor some meanings over others. As a result, the number of meanings that children consider for a word is reduced. However, though they sometimes make similar predictions about which meanings will be favored, it is important to understand that these assumptions come from very different theoretical perspectives and therefore offer very different explanations for why some meanings will be favored. In addition, these explanations are not always viewed as being congruent. For example, word-learning assumptions are thought to be unique to the domain of word learning (i.e., they are domain-specific) and suggest that word learning may be different (or special) when compared to other types of learning. In contrast, pragmatic assumptions are not thought to be unique to the domain of word learning (i.e., they are domain-general) and suggest that word learning may not be so special. As research continues it will lead to a better understanding of what assumptions, if any, are unique to word learning, whether there are neural correlates to these assumptions, how word learning is affected by the development of other constructs like memory and intelligence, and what aspects of word learning differ across cultures and across typical and atypical development.

Cross-References

► Language Acquisition and Development
► Word Learning and Lexical Development Across the Life Span

References

Bloom, P. (2000). *How children learn the meanings of words*. Cambridge, MA: MIT Press.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D., Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59* (5, Serial No. 242).

Markman, E. M. (1989). *Categorization and naming in children: Problems of induction*. Cambridge, MA: MIT Press.

Quine, W. V. O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development*. Hillsdale: Erlbaum.

Woodward, A. L., & Markman, E. M. (1998). Early word learning. In W. Damon, D. Kuhn, & R. Siegler (Eds.), *Handbook of child psychology* (Cognition, perception and language, Vol. 2, pp. 371–420). New York: Wiley.

Word Learning and Lexical Development Across the Lifespan

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Synonyms

Lexical acquisition; Lexicalization

Definition

The scientific study of word learning across the lifespan is concerned with how adult language users come to acquire words in their own language, and how these lexical representations develop over time. This can be distinguished from the study of vocabulary acquisition in children and in second language learning, though these fields share common goals in seeking to understand the processes involved in the acquisition of novel word forms, meanings, and the linking of forms to meaning.

Theoretical Background

It is sometimes assumed that a language contains a relatively fixed set of words, and that by adulthood, the word learning process is essentially complete. However, it is easy to underestimate the lexical resources available to adult language users. The 2006 Google n-gram corpus contains approximately 13 million distinct English words. Focusing just on lower case words with alphabetic symbols still leaves 1.5 million words. Estimates of the size of nature of adults' mental lexicons vary enormously. One conservative rough estimate is that adult native speakers of English know 20,000 word families (Nation and Waring 1997), while other estimates put the figure closer to 60,000 individual words. These figures suggest that we never come close to acquiring all the words that exist in a language, and there is a great deal of individual variation on what portion of the ever-growing available word space will be captured.

Words are acquired by children at a prodigious rate. To reach adult competence, from birth, we must learn at least 1,000 words a year on average. This remarkable growth in vocabulary overshadows the fact that as adults, we continue to acquire novel words throughout our lifetime. Infrequent words are typically learned later in life, and new words are constantly being introduced due to technological innovations, foreign imports, and proper names. While we may increase the size of our lexicons as we age, access in later life can be limited by normal aging and dementia, which are associated with word finding difficulties and memory loss.

Perhaps the most important question in adult native word learning research is how a word becomes ► lexicalized, that is, represented in a specialized lexical memory system, and hence exhibits behaviors similar to that of existing words. However, ► lexicalization should not be taken to mean that word learning is an all-or-nothing process, that once a word is lexicalized, learning ceases to occur. Instead, researchers are increasingly emphasizing the dynamic state of the mental lexicon. This is particularly true of exemplar models of lexical processing, where a word form is based on a composite made up of all previous encounters of that word. Given a dynamic view of the mental lexicon, the lexicalization process may never reach completion. Instead of a relatively fixed and stable repository of long-term knowledge, word forms and meanings can be thought to undergo a continual process of lexical development based on exposure and use throughout life.

While there is no agreed consensus on the limits of what can properly be termed part of the mental lexicon, at a minimum, a lexical entry should provide form information, a link to a meaning, and syntactic class. Words are characterized by a hierarchical structure, and can be decomposed into multiple levels of arbitrary sound-meaning correspondences. For the purposes of recognition, words have representations across multiple input modalities, and words also have the power to be easily outputted, most obviously in speech, but also in modalities such as writing, typing, or signing. Given the myriad different forms of memory associated with a word, lexical learning involves learning across a wide variety of memory systems. Knowledge of word form and meaning can be considered part of declarative memory, while production part of procedural memory. As such, studies of word learning can potentially be informative about learning in these different memory systems, and their interaction.

Important Scientific Research and Open Questions

The multi-faced nature of words makes studying word learning a complex task. Given that word learning in adults can be taken to involve the learning of a new form, a meaning, and a link between form and meaning, efforts to study word learning have often focused on one or more of these components. In the case of form, much research has looked at how a newly acquired word becomes entrenched as a word within an individual's mental lexicon. Researchers have used a variety of different paradigms to assess the representational status of a novel word. Following a single lexical encounter, we are immediately able to recognize and reproduce that word, supported by form-based representations. However, rapid storage of word does not necessarily lead to a status like that of existing words. Studies of word learning have shown that some lexical behaviors take time to develop (Gaskell and Dumay 2003; Leach and Samuel 2007). For example, behavior that relies upon integration and interaction with other words in the lexicon, such as participation in the process of lexical competition during auditory word recognition, is not available for rapidly acquired form-based representations (Gaskell and Dumay 2003). An explanation for this time-course dissociation is that word forms and meaning are initially stored using an episodic memory system involving the medial temporal lobes. Over time, words become consolidated in long-term memory in the neocortex specialized for lexical representation. This systems-level consolidation involves a paradigmatic case of the integration of new information with existing knowledge. Further research in this area should see increased understanding of how systems-level memory theories can explain lexical development in adults, and how these theories can be applied to understanding word learning in children and in L2 learners. Furthermore, studies of word learning in adults will also potentially be useful in understanding the role of consolidation in memory more generally.

While studies of form-only learning have revealed much about the word learning process, some would argue that a word without meaning is missing an essential part of lexical representation. Accordingly, much research has looked at the role of meaning in the acquisition process (cf. Leach and Samuel 2007). In second language learning, acquisition of a novel form typically involves pairing that form with a preexisting native form, and to a preexisting meaning. In contrast, native word learning usually involves creating a direct mapping from a word form to a novel meaning. As such, a full account of word learning will need to account both acquisition of novel forms and of novel meanings.

We are in the early stages of understanding the neural basis of word learning, and this will continue to be an active area of investigation for much time to come. A fruitful strategy has been to find neural markers for nonword processing, and comparing these with processing of existing words. In electroencephalography, a neural response called the N400 is heighted for nonwords. Given sufficient training, this brain response can be reduced as a novel word becomes more word like. In functional magnetic resonance imaging, modality specific areas have been identified which are associated with nonword processing, principally the left lateral fusiform gyrus for orthographic forms and the left superior temporal gyrus for auditory forms. As a word begins to become lexicalized, reduction of activity in these areas should occur, and the brain response to novel words will become more like that of existing members of the mental lexicon.

A further important line of research in word learning with children and neuropsychological patients has indicated that there are close links between verbal working memory and word learning (Baddeley et al. 1998). We expect to find increasing evidence for the role of short-term memory processes in leading to long-term acquisition of words in adults. This relationship is also prevalent in computational models of word learning (Gupta and MacWhinney 1997). A guiding principle has been the use of frameworks which can account for short-term and working memory processing alongside language learning, with a focus on memory for serial order. These models also reflect the trend of seeking to understand word learning as a consequence of general learning and memory principles, rather than as an outcome of a specific modular mechanism for language learning.

Cross-References

- ► Memory Consolidation and Reconsolidation
- ► Second Language Learning
- ► Vocabulary Learning
- ► Vocabulary Learning in a Second Language
- ► Word Learning

References

Baddeley, A. D., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*, 158–173.

Dumay, N., & Gaskell, M. G. (2007). Sleep-associated changes in the mental representation of spoken words. *Psychological Science, 18*, 35–39.

Gaskell, M. G., & Dumay, N. (2003). Lexical competition and the acquisition of novel words. *Cognition, 89*, 105–132.

Gupta, P., & MacWhinney, B. (1997). Vocabulary acquisition and verbal short-term memory: Computational and neural bases. *Brain and Language, 59*, 267–333.

Leach, L., & Samuel, A. G. (2007). Lexical configuration and lexical engagement: When adults learn new words. *Cognitive Psychology, 55*, 306–353.

Nation, P., & Waring, R. (1997). Vocabulary size, text coverage, and word lists. In N. Schmitt & M. McCarthy (Eds.), *Vocabulary: Description, acquisition, pedagogy* (pp. 6–19). New York: Cambridge University Press.

Word Spellings

► Mental Graphemic Representations

Work Experience

► Learning in Practice and by Experience

Work-Avoidance Goal

Students deliberately avoid engaging in academic tasks and/or attempt to minimize the effort required to complete academic tasks.

Work-Based Learning

► Learning in Practice and by Experience

Worked Example Effect

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Synonyms

Example-based learning; Learning from examples; Learning from model answers; Studying expert solutions; The worked example effect

Definition

A *worked example* provides a step-by-step solution to a problem or task. The *worked example effect* occurs when learning is enhanced by studying worked examples to problems rather than by trying to solve the original problems. It is a form of *direct instruction*. In learning new material learners are shown fully worked examples to study instead of trying to work out the solution steps. The most effective format is for learners to study a worked example and then immediately after, try to solve a problem with similar features. This example-problem pair format is repeated over a number of iterations building to a complete set of problems that students need to learn in order to master the new materials. Extensive research has shown that for novices in particular, this pairing methodology of study-solve, leads to superior performance compared with a strategy that asks students to solve problems without first being exposed to worked examples.

Theoretical Background

In domains such as mathematics, teachers have historically given students worked examples. However, the way worked examples are structured may not always lead to an optimum learning environment. A traditional mathematics textbook approach to learning new concepts and procedures is to show some initial worked examples based on the new materials and then ask students to practice what they have learned in a following exercise. In many cases, the exercise set contains more challenging problems than they had previously encountered. Practice is an important part of consolidating learning but under these circumstance students were often required to problem solve. Additional worked examples would then usually only be shown to students when they failed to find solutions to the problems they attempted. To create the worked example effect, worked examples must be structured very differently to this scenario. Instead of showing a small sequence of worked examples initially, a larger set of worked examples is shown throughout the practice period in the paired study-practice format.

The worked example effect has been extensively researched within the theoretical framework of cognitive load theory (CLT: see chapter *Cognitive Load Theory* for more information). To explain why studying worked examples is a more effective learning strategy than problem solving, CLT researchers have used an argument based on working memory load (see chapter *Working Memory and Information Processing* for more information on WM). Asking students to problem solve in a domain in which they are unfamiliar increases working memory load significantly due to the number of searches that often required to solve the problem. In particular, problem solvers often rely on the general problem-solving heuristic of means-ends analysis (see Sweller 1999). Means-ends analysis requires simultaneous consideration of the goal and the current problem state, while trying to manipulate problem-solving operators to reduce the difference between the two states. This method places a heavy demand on a very limited WM and interferes with learning. Although learners may solve the problem, they do not necessarily learn much from the experience as WM resources are absorbed by trying to locate and apply operators rather than recognizing key aspects and relationships within the problem. In contrast, when studying worked examples, learners can focus on the operators and how they transform one solution step to the next without extensive searching. From the perspective of CLT, problem solving creates *extraneous* cognitive load, because much of the effort in solving the problem is superfluous to learning. Whereas, worked examples reduce extraneous load freeing up WM that can generate *germane* cognitive load – the load directly invested in schema formation (see van Merriënboer and Sweller 2005, for more information on the different types of cognitive load).

Early evidence for the worked example effect came from studies involving mathematical and scientific domains. For example, studies into algebra acquisition demonstrated that worked examples were superior to problem solving (see Cooper and Sweller, 1987; Sweller and Cooper, 1985). Results from these studies indicated that not only was performance better, but also that learning time was significantly shorter. Furthermore, it was found that schema automation could be achieved more quickly through worked examples than problem solving, provided that sufficient practice was allowed. With schema automation students were more able to solve transfer problems. If the training period was fairly short, automation was not achieved, resulting in a lack of transfer. Nevertheless, even when transfer was not found, worked example groups outperformed problem-solving groups on similar problems. Other studies in different mathematical domains such as geometry and word problems produced similar results (see Sweller 1999 for a summary). Significantly, Trafton and Reiser (1993) demonstrated the effectiveness of pairing problems together (study one- solve one).

Following these early studies, significant enhancements and extensions to the basic methodology of worked examples have been added. One such extension has been the *variability effect*. Of great interest in the field of learning and instruction is whether a learning strategy leads to transfer or not. Cooper and Sweller concluded that for transfer to occur from worked examples sufficient practice was needed to automate appropriate schemas. Studies by Paas and van Merriënboer (1994), Quilici and Mayer (1996) found further that problem variability could accelerate the transfer of knowledge. To explain why, van Merriënboer and Sweller (2005) argued that variability of problem situations enables learners to identify similar features as well as differences across a number of different conditions. Variability is achieved by changing the contexts and conditions under which a task is performed, learners then have the opportunity to engage in deeper processing, building more flexible, and well connected schemas. Thus, variability is a strategy that generates germane cognitive load as it leads directly to schema acquisition enabling new knowledge to be more readily adaptable to novel situations.

A second enhancement to worked examples is called the *completion* or *completion problem* effect. One concern about the use of worked examples is that they lead to *passive* learning rather than the more effective *active* learning. What is the guarantee that learners will study the worked examples in enough depth to benefit from them? One answer has been to employ the paired alternation strategy (study one-solve one); another is to provide learners with completion problems. A completion problem is a partial worked example where the learner has to complete some key steps in the solution. Instead of the paired strategy students are only presented completion problems. Considerable experimental evidence has been collected by Paas, van Merriënboer and colleagues (for a summary see Sweller 1999) supporting their effectiveness. To explain why they work, Sweller (1999) argued that the inclusion of a small element of problem solving is sufficient to ensure that learners attend to key information and subsequently go into enough depth. Equally important is that WM is not overloaded because full problem solving is avoided.

A third evolution of worked examples is to combine them with *self-explanations*. The work of Michelene Chi has been particularly influential in demonstrating that learners who attempt to explain solution steps mentally to themselves while studying examples learn more than learners who do not. It is generally thought that learners who engage in such internal mental dialogs process information at a deeper level. Studies by Renkl, Atkinson and colleagues have shown that self-explanations can be effectively combined with worked examples to facilitate learning (see Atkinson et al. 2003).

Substantial research has shown that studying a set of worked examples is more effective than a strategy that requires learners to problem solve an identical set of problems. This evidence suggests that problem solving is an ineffective learning strategy. However, this is not always the case as it has also been found that the effectiveness of worked examples depends on the prior knowledge of the learner. For learners with high levels of prior knowledge, problem solving has been shown to be superior to studying worked examples. CLT researchers have named this phenomenon the *expertise reversal* effect (see Kalyuga et al. 2003). The expertise reversal effect, or sometimes referred to as the *aptitude-treatment-interaction*, occurs when a learning strategy that is effective for learners with low prior knowledge becomes ineffective or harmful for learners with greater prior knowledge. Kalyuga et al. explain this effect by *redundancy*. Asking experienced learners (more experts) to study solutions to problems, or steps in a solution, that they are already familiar with is redundant. By processing unnecessary information extraneous cognitive load is created, which interferes with the learning of new material. In contrast, by problem solving, learners are more actively engaged in creating new knowledge. For more expert learners, problem solving does not impact negatively on WM because of pre-existing knowledge.

If worked examples is the best strategy for novice learners, and problem solving is superior for more expert learners, then how can the transition from novice to expert be best managed? Researchers have acknowledged the importance of this question and one solution has been to employ a *fading* strategy (see Atkinson et al. 2003). Fading occurs when more and more steps within a worked example are omitted, leaving the learner to problem solve within the framework of the worked example. As the expertise of the learner develops more steps are left out, consequently the learner follows a development sequence from full worked examples (all steps shown) to problem solving (no steps shown). Two types of fading have been identified: backward and forward. *Backward fading* occurs when the last steps of the solution are omitted first, whereas *Forward fading* occurs when the initial steps of the solution are left out. Studies indicate that the backward-fading strategy leads to better learning outcomes than a forward-fading strategy (see Atkinson et al. 2003).

Important Scientific Research and Open Questions

There is substantial evidence that learners, particularly those in the initial stages of cognitive skill acquisition, benefit from studying worked examples more so than an equivalent episode of problem solving. A number of innovations have been made to complement the use of worked examples, namely, variability, completion problems, self-explanations, and fading strategies. These innovations facilitate more active learning and transfer, maintain attention, as well as assist the transition from novice to expert. Nevertheless, a number of open questions still remain. With the various auxiliary strategies that have been used in conjunction with worked examples, such as self-explanations, the number of possible interactions that occur has expanded. This makes it difficult at times to predict how worked examples can best be modified to suit all conditions. Certainly more ongoing research is needed to unravel the complexity caused by grouping various forms of learning strategies together.

In spite of the wealth of research evidence in support of the use of worked examples, there have been some ongoing criticisms. One criticism has been that worked examples have only been compared with "lousy" control conditions, because in most cases, worked examples have only been compared with problem solving, with little support (Schwonke et al. 2009). However, Schwonke et al. found that worked examples could be more effective than a cognitive tutor that provided significant problem-solving support. This finding is important, but rare in the literature, suggesting that further research of this nature could be fruitful. A second criticism is that worked examples may only be effective in well-defined domains such as mathematics, science, engineering, and computing. Undoubtedly most of the initial research into worked examples focused on these domains, but more recent research conducted by Sweller and colleagues has found that worked examples are effective in domains such as English literature, foreign language acquisition, visual arts, and music instruction. Nevertheless, the research conducted in these more arts-based domains is relatively sparse compared with the more scientific-based domains. More research, therefore, could be conducted outside the scientific fields.

Other criticisms have tended to be more ideologically based. Some educationalists, particularly those who have constructivist views, consider worked examples to be a form of direct instruction, lacking the much valued active learning and problem-solving methodologies. In a highly cited paper, Kirschner et al. (2006) point out many of these views arguing that most of the strategies that are proposed in place of worked examples, such as discovery learning and problem solving, have a very weak research and theory base in contrast to that of worked examples. The many variations of worked examples ensure that students engage in active learning and problem solving. However, it has been found that a one-size-fits-all model of problem solving is inappropriate; learners need to carefully graduate to problem solving as expertise increases. Consequently, an open question might be, if worked examples have very limited use, then the onus is on other researchers to scientifically prove it. The research into worked examples suggests otherwise.

Cross-References

► Cognitive Load Theory
► Constructivist Learning
► Schema-Based Learning
► Working Memory
► Working Memory and Information Processing

References

Atkinson, R. K., Renkl, A., & Merrill, M. M. (2003). Transitioning from studying examples to solving problems: Combining fading with prompting fosters learning. *Journal of Educational Psychology, 95*, 774–783.

Cooper, G., & Sweller, J. (1987). Effects of schema acquisition and rule automation on mathematical problem-solving transfer. *Journal of Educational Psychology, 79*(4), 347–362.

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*, 23–31.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 46*, 75–86.

Paas, F. G. W. C., & Van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology, 86*(1), 122–133.

Quilici, J. L., & Mayer, R. E. (1996). Role of examples in how students learn to categorize statistics word problems. *Journal of Educational Psychology, 88*(1), 144–161.

Schwonke, R., Renkl, A., Krieg, C., Wittwer, J., Aleven, V., & Salden, R. (2009). The worked-example effect: Not an artefact of lousy control conditions. *Computers in Human Behavior, 25*, 258–266.

Sweller, J. (1999). *Instructional design in technical areas.* Camberwell, Australia: ACER.

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction*, *2*(1), 59–89.

Trafton, J. G., & Reiser, R. J. (1993). The contribution of studying examples and solving problems to skill acquisition. In M. Polson (Ed.), *Proceedings of the 15th Annual Conference of the Cognitive Science Society* (pp. 1017–1022). Hillsdale, NJ: Lawrence Erlbaum Associates.

Van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*, 147–177.

Worked Examples

A worked example typically consists of a problem statement and a procedure or algorithm (presented in a step-by-step format) for solving the problem. This is then used as a guide to solving similar problems.

Workflow Design

► Meta-learning
► Multistrategy Learning

Working Group

► Group Dynamics and Learning

Working Memory

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Synonyms

Short-Term memory

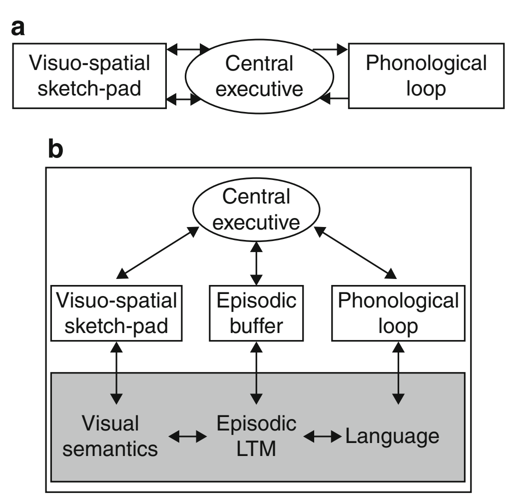
Definition

Working memory is the application of short-term memory (STM) to tasks that require the management of information. Because STM is limited in capacity and duration, its effective use in tasks such as learning, reading, and reasoning depends on making effective decisions. Working memory is the control center for managing cognitive operations such as attention, encoding, integration, temporary storage, and retrieval from long-term memory (LTM).

Theoretical Background

Theories of working memory begin with the capacity and retention limitations of STM. George Miller (1956) argued that the limited capacity of STM constrained performance on tasks such as ► absolute judgment and ► memory span. He proposed that STM holds approximately seven chunks of information. Peterson and Peterson (1959) subsequently found that information is quickly lost from STM if attention is not directed at that information. For example, students were often unable to recall three consonants following an 18-s retention interval in which they counted backward by threes. These and other experiments contributed to establishing STM as a key component in early human cognitive architectures (Atkinson and Shiffrin 1968).

The concept of a working memory was advanced by a model proposed by Baddeley and Hitch (1974). Figure 1a shows the three components of their model. The *phonological loop* provides for speech-based storage and rehearsal of verbal information. Although the



Working Memory. Fig. 1 Working memory models (From Baddeley 2001. Copyright 2001 by the American Psychological Association. Reprinted with permission) phonological coding of verbal information had been emphasized in models of STM, Baddeley and Hitch realized that visual/spatial information would require its own storage component – the *visuospatial sketchpad*. And finally, the *central executive* was needed to manage the application of working memory to different tasks.

Much of the research on working memory was directed at determining which of the three components were needed to carry out different tasks. For instance, Baddeley (1992) reports a study in which participants reproduced a recently viewed chessboard. As chess players attempted to reproduce the board, they performed a secondary task that was designed to limit the use of a particular component of working memory. The participants either tapped a series of keys in a predetermined pattern to limit the use of the visuospatial sketchpad, repeated a word to limit the use of the phonological loop, or generated strings of random letters to limit the use of the central executive. The chess players' ability to reproduce the board declined when tapping keys or generating random letters suggesting that the visuospatial sketchpad and central executive are needed for this task. Other tasks require other combinations of the three components.

The Baddeley and Hitch (1974) model influenced research on working memory for the next 26 years before Baddeley (2000) decided to expand the model (Fig. 1b). One major addition was the linkage of working memory to LTM because information needs to be transferred in both directions between the two stores. A second major addition was inclusion of an episodic buffer to integrate information in the visuospatial sketchpad and phonological loop. For instance, you may form a visual mental map when someone gives you verbal directions.

Other theoretical developments have emphasized the role of attention in working memory, particularly in Cowan's (1995) book *Attention and Memory: An Integrated Framework*. Engle et al. (1999) built upon these ideas by focusing on the role of the central executive in maintaining some activities in working memory while blocking out other interfering activities. The implication is that greater capacity means that more items can be kept active in working memory but this is caused by a greater ability to control attention, not by a larger memory store (Engle 2002).

Important Scientific Research and Open Questions

In addition to the experimental research on working memory, psychometric and brain imaging studies are making important contributions. Kane and his collaborators (Kane et al. 2004) took a psychometric approach to explore the generality of working-memory capacity. They administered memory span tests for verbal working memory, visuospatial working memory, verbal STM, and visuospatial STM, as well as tests of verbal and spatial reasoning and of general ► fluid intelligence. The working-memory construct was a better predictor of general fluid intelligence and the STM construct was a better predictor of domain-specific reasoning. The findings support the proposal that attention underlies the broad predictive value of working memory capacity (Engle 2002) while domain-specific storage is more related to the domain-specific requirements of complex tasks.

Although Kane's findings are consistent with Baddeley's (2000) model, Postle (2006) has argued that Baddeley's model is a victim of its own success. Experimental research has shown the necessity of distinguishing between the phonological loop and visuospatial sketchpad, but neuroimaging findings have revealed many additional kinds of processing. For instance, the content of working memory is neurally dissociable for visual attributes such as orientation, motion, manipulable versus nonmanipulable objects, and faces versus houses. In addition, working memory recruits other sensory areas in the brain when the task involves auditory, tactile, or olfactory stimuli. This would require a working memory model with hundreds of domain-specific buffers, each responsible for processing a different kind of information.

Postle's (2006) proposed solution is that working memory works through the coordinated recruitment of information by directing attention to brain systems that have evolved to accomplish different sensory and action-related functions. His proposal is consistent with the Cowan (1995) and Engle (2002) models that focus on the centrality of attention. However, Postle would eliminate the visuospatial sketchpad and phonological loop in Baddeley's model because of their limitations in representing many different stimulus characteristics. Instead, the relation between working memory and LTM would become more central as attention is directed to various brain regions that process a multimodal stream of data.

A departure from the traditional emphasis on the capacity demands of processing *stimuli* is Ashcraft and Krause's (2007) claim that emotional states such as anxiety can also attract working memory capacity. When two-column addition problems required a carry (such as 27 + 14), students with high math anxiety had less working memory capacity to mentally perform the task. Ashcraft and Krause argue that preoccupation with one's anxiety requires part of working memory capacity. Studying the educational consequences of this finding is part of their current research agenda.

Fortunately, the educational consequences of a limited working-memory capacity have been extensively studied for many other tasks. One of the goals of ▶ cognitive load theory (Sweller 2003) has been to improve learning by eliminating unnecessary cognitive load. Research by Sweller and his colleagues has discovered many instructional design principles that have produced the goal-free, worked example, problem completion, split-attention, modality, redundancy, element interactivity, expertise reversal, and guidance fading effects. The extensive instructional contributions derived from cognitive load theory should serve as a model for using cognitive theory to improve instruction.

Sweller (2003) has also become interested in studying the analogy between human information processing and natural selection. He argues that both cognitive and evolutionary systems must continually adapt their behavior to a complex environment and that there is a single natural system of information that underlies both of these processes. Sweller's (2003) analogy to natural selection, Postle's (2006) theoretical formulations from neuroimaging studies, and Ashcraft and Krause's (2007) research on the effect of anxiety on working-memory capacity all represent open questions that have occurred by extending thinking about working memory in interesting new directions.

There is also a lingering open question that dates back to Miller's (1956) famous article on the magic number seven. Although the number 7 represented the approximate number of items that could be held in STM for memory-span and absolute-judgment experiments, it likely overestimates the number of chunks that can be held in working memory. Cowan (2005) effectively argues in his book *Working Memory Capacity* that four chunks is a more accurate measure.

Cross-References

▶ Capacity Limitations of Memory and Learning
▶ Human Cognitive Architecture
▶ Learning and Fluid Intelligence Across the Life Span

References

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*, 243–248.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 2, pp. 89–195). Orlando: Academic.

Baddeley, A. D. (1992). Is working memory working? The fifteenth Bartlett lecture. *Quarterly Journal of Experimental Psychology, 44A*, 1–31.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4*, 417–423.

Baddeley, A. D. (2001). Is working memory still working? *The American Psychologist, 56*, 849–864.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 17–90). Orlando: Academic.

Cowan, N. (1995). *Attention and memory: An integrated framework.* Oxford: Oxford University Press.

Cowan, N. (2005). *Working memory capacity.* New York: Psychology Press.

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science, 11*, 19–23.

Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanism of active maintenance and executive control.* New York: Cambridge University Press.

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General, 133*, 189–217.

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

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

Postle, B. R. (2006). Working memory as an emergent property of the mind and brain. *Neuroscience, 139*, 23–38.

Sweller, J. (2003). Evolution of human cognitive architecture. In B. Ross (Ed.), *The psychology of learning and motivation* (Vol. 43, pp. 215–266). San Diego: Academic.

Working Memory and Information Processing

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Synonyms

Active memory; Immediate memory; Primary memory; Short-term memory

Definition

Working memory is an adaptive system for maintaining task-relevant information in an active and accessible state for the purpose of completing complex cognitive and behavioral tasks – hence the term *working* memory. Despite continued debate over the specific nature of working memory, there are several basic assumptions that all researchers ascribe to its concept: (1) that it is limited in capacity, (2) it is structurally and/or functionally distinct from long-term memory, and (3) specific control processes (such as rehearsal and retrieval) act on the information held within working memory to keep it active for ongoing use.

Theoretical Background

The concept of working memory was borne out of growing dissatisfaction with the earlier concept of short-term memory or short-term store, that is, a system used for the sole purpose of storing some amount of information for a limited time. Researchers felt that a short-term store was far too rigid and that such a passive store was insufficient for explaining how humans carry out and complete the many complex activities set before them each day, and with such relative ease. Thus, there was a need for a new type of construct that was flexible and dealt with both the storage *and* processing of information in the interim.

Miller et al. (1960) are often credited for coining the term working memory, but it is Atkinson and Shiffrin (1968) treatment of the construct that first laid groundwork for the modern conception. In the Atkinson and Shiffrin model of memory, information is argued to pass through three separate stores or stages: *the sensory store*, *the short-term store*, and *the long-term store*. Recognizing the empirical pitfalls accompanying a fixed short-term store, Atkinson and Shiffrin paired with it multiple control processes, dubbing this new dynamic construct a person's working memory, a system, they argued "in which decisions are made, problems are solved and information flow is directed" (1971, p. 83). These control processes included *rehearsal*, *coding*, and *retrieval*. Rehearsal was argued to be the primary process through which information is both maintained in the transient short-term store and transferred to the more permanent long-term store. In the absence of rehearsal, forgetting occurs as traces are argued to decay, usually within 30 s. Coding referred to the type of information that is transferred (i.e., what aspects of the information being processed are registered in the long-term store). Retrieval was important for getting the information already stored in the long-term store back into working memory for current processing or output.

The work of Atkinson and Shiffrin (1968) represented an obvious advancement in how memory researchers conceptualized short-term memory (and the human memory system more broadly), however, with praise came critique and it was not long before researchers began proposing alternatives. Arguably the most celebrated of these alternatives is the *multi-component model of working memory* proposed by Baddeley and Hitch (1974). In their seminal chapter in the Psychology of Learning and Motivation, Alan Baddeley and Graham Hitch proposed a model of working memory characterized by multiple stores, each with a capacity for processing specific types of information. In its original formulation, the Baddeley and Hitch model of working memory contained three distinct components: two slave systems, the *phonological loop* and the *visuo-spatial sketchpad*, headed by a supervisory, master system, the *central executive*. As suggested by their names, the phonological loop and visuospatial sketchpad are responsible for the storing and processing of auditory and visual content, respectively. The central executive acts upon the subsidiary components as a coordinator, organizing the interplay between the two buffers and long-term memory. Its primary functions include the allocating of attention to the slave systems when necessary, planning future actions and behaviors to solve problems, and for the control of information processing, more generally. More recent work by Alan Baddeley (2000) has seen the addition of a fourth component, the *episodic buffer*, argued to provide temporary storage of information held in a multimodal code, which is capable of binding information from the subsidiary systems and long-term memory into a unitary episodic representation. The basis for the multi-component model arose out of work examining the costs associated with doing two tasks concurrently – the logic being that if two tasks rely on the same processing mechanisms, they should show interfering effects on one another. Baddeley and Hitch found that two tasks interfered with each other only to the extent that they were of similar kind. Specifically, they showed a double dissociation: Verbal tasks interfered with verbal short-term memory but not visual short-term memory, and visual tasks interfered with visual short-term memory but not verbal short-term memory, thus, giving reason for separate buffers responsible for different modes of information.

Baddeley and Hitch's working memory model has been both an empirical and theoretical *tour de force* and is still widely considered the single most influential model of working memory among many researchers in the fields of cognitive psychology and neuroscience today. Despite its popularity, however, the multi-component model of Baddeley and Hitch is not without its detractors, one of the more vocal critics being Nelson Cowan, who regards working memory not as a separate multi-component system, but as a part of long-term memory.

Cowan's (1999) *embedded-processes model of working memory* proposes that maintenance, rehearsal, and retrieval processes work upon activated traces of long-term memory, rather than separate representations held in the domain-specific storage structures of Baddeley and Hitch's model. In the embedded-processes model, memory is considered a unitary construct but with three distinct levels of activation: (a) inactive representations of long-term memory, (b) an activated subset of long-term memory considered the short-term store, and (c) a subset of the activated representations in the short-term store available to conscious awareness labeled the *focus of attention*. The short-term store and the focus of attention collectively make up working memory and are subject to specific limitations. In the short-term store, any number of long-term memory representations can be activated at any one time but the level of activation decreases over time, typically in the realm of 10–20 s unless reactivated. In contrast, the focus of attention is limited by its capacity rather than by time. Specifically, Cowan argues individuals can maintain only 3–5 unrelated items in the focus at once, all of which are susceptible to displacement back into the short-term store by new information. Cowan also posits that managing the memory system is a central executive, similar to the model of Baddeley and Hitch, that is responsible for all control processes. The focus of attention, in particular, is regulated (in part) by the central executive while also being controlled by involuntary mechanisms. Beyond the coding of new information, the central executive is also integral to the activation of stored representations in long-term memory.

Important Scientific Research and Open Questions

One of the more significant findings in research on working memory is that working memory capacity measures strongly predict a broad range of higher-order cognitive capabilities, including language comprehension, reasoning, and even general fluid intelligence. These *complex span tasks* require the simultaneous maintenance of some information in the face of distraction from secondary processing activity (e.g., remembering a list of words in serial order while solving complex math problems). Statistical techniques such as structural equation modeling have been used to demonstrate that variance common to these complex span tasks are positively related to variance across a number of attention, memory, and intelligence measures such as the anti-saccade task, delayed-free recall, and Raven's Advanced Progressive Matrices, to name a few (Unsworth and Spillers 2010).

Given the broad implications of working memory for higher-order cognition, a hot topic of recent research has been the idea that working memory can be trained. Though no one disagrees that working memory is limited, researchers have argued that in theory, working memory is like a muscle, that if exercised or trained, could increase its capacity for performing a number of complex cognitive tasks. For example, Chein and Morrison (2010) had participants perform an initial battery of tasks (including measures of working memory and fluid intelligence) before beginning a 4-week training regimen on a complex working memory span measure. Chein and Morrision found that after training, participants performed better on certain tasks (e.g., those requiring cognitive control or reading comprehension) in a follow-up cognitive battery compared with a control group of participants who were not trained in the interim. Although the work of Chein and Morrison (2010) and others have found positive support for training, these effects are not robust and have not been generally consistent from study to study. Therefore, the validity and implications of working memory training remains an open question and will likely serve to drive working memory research for years to come.

The concept of working memory owes much of its existence to research with brain-injured patients who show deficits in short-term memory functioning but not long term and vice versa. With the advent of EEG, MEG, and fMRI technology, however, researchers have been able to manipulate and observe the brain nonsurgically and within healthy individuals. Converging evidence from these approaches has implicated the *prefrontal cortex* (PFC) as the primary contributor to working memory functioning. Specifically, the PFC has been found to play a pivotal role in both the active maintenance of information and the strategic retrieval of representations from long-term memory. The *anterior cingulated cortex* (ACC) has also been suggested by researchers as an important component of working memory, used for monitoring the amount of control needed in a given task and biasing the PFC accordingly. Finally, to the extent that working memory is believed to interact with long-term memory (as suggested by Nelson Cowan and others), the *medial temporal lobe* (MTL) is argued to contribute to the processing of information in working memory, given its role in the formation and storage of long-term memories (Unsworth and Engle 2007). Thus, working memory can be considered neurally as a distributed network in the brain in which several different areas act in parallel to process, maintain, and store information.

Cross-References

- ► Human Cognition and Learning
- ► Human Information Processing
- ► Memory Dynamics
- ► Short-Term Memory and Learning
- ► Verbal Behavior and Learning

References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence (Ed.), *The psychology of learning and motivation* (Vol. 2, pp. 89–195). New York: Academic.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47–89). New York: Academic.

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Science, 4*(11), 417–423.

Chein, J. M., & Morrison, A. B. (2010). Expanding the mind's workspace: Training and transfer effects with a complex working memory span task. *Psychonomic Bulletin & Review, 2*, 193–199.

Cowan, N. (1999). An embedded-processes model of working memory. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 62–101). Cambridge: Cambridge University Press.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the Structure of Behaviour.* New York: Holt, Rinehart & Winston.

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review, 114*, 104–132.

Unsworth, N., & Spillers, G. J. (2010). Working memory capacity: Attention control, secondary memory, or both? A direct test of the dual-component model. *Journal of Memory and Language, 62*, 392–406.

Working Model

► Mental Models

Working with Dreams, or the Elements Within Dreams

► Ego State Theory: Utilization of Dreams

Work-Integrated Learning System(s)

► Integrated Learning Systems

Workload Measurement

► Cognitive Load Measurement

Workplace Learning

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Synonyms

Learning through practice; On-the-job learning; On-the-job training; Practice-based learning

Definition

The term workplace learning usually refers to the processes of learning through and for engaging in paid employment: on-the-job learning or learning through work. As a term, workplace learning emphasizes that particular contributions to individuals' learning provided and secured through engaging in work activities and interactions within workplaces or work practices. These contributions are often taken as being of a different kind than those accessible through participating in educational institutions. A particular quality associated with workplace learning experiences is that they are held to be authentic instances of the occupational practices individuals need to learn. In this way, these experiences provide access to knowledge that is more readily applicable to the target occupational practice of which it is an instance than the knowledge accessed in settings whose experiences are not perceptibly aligned with the occupational, such as those in educational institutions. However, the term workplace learning also emphasizes learning, rather than teaching or training, thereby positioning it as being often as something occurring outside of educational provisions. The outcomes can lead to a concern that, in the absence of teaching and teachers, this learning may be less rich, ad hoc, narrow, and reductionist.

Theoretical Background

Considerations about learning through work or on-the-job learning have long existed and been emphasized over human history as a way in which individuals learn occupational practices. Indeed, across human history the vast majority of human learning of these practices has occurred through practice. Across cultures as diverse as those from Europe, Central Asia and China, the capacities required to feed and provide shelter for populations, build artifacts and structures for practical, cultural, religious, and state purposes have overwhelmingly been learnt through the practices that generate them (i.e., work). However, within Western culture dating back to Ancient Greece was a fostering of beliefs by the likes of Socrates and Plato, that the work of artisans and artists were best learnt through practice, often with the family's business. Specialized educational provisions were restricted to the professions, because it was held that only the complexity of these occupations required that kind of preparation. The others could be learnt through observation, imitation, and practice. These family-based settings and mode of support for learning persisted and were seen as effective across much of Western history, exemplified by apprenticeships. Yet, with the advent of mass education, learning through practice and in workplaces has become seen to be less desirable because such settings lack the qualities attributed to legitimate learning environments such as schools, colleges, and universities. Indeed, the absence of trained teachers, written curriculum, and classroom-type arrangements led to workplaces being described as informal learning environments (Marsick and Watkins 1990), with claims that only concrete (i.e., nontransferable) learning arises within them. However, ironically, it was concerns about the lack of the transferability of knowledge learnt in educational institutions that lead to development and wide embracing of explanatory accounts of learning and practice provided by the situated cognition movement. Indeed, it is' concepts like such as communities of practice and apprenticeship models of learning that has led to a fresh interest in learning through workplace settings. This interest is intense when the goals of educational programs are about understanding the world of work, and more so when specifically developing the capacities required for effective performance within occupations. Consequently, in recent times there has been growing interest in understanding learning through workplace experiences and, sometimes, how these experiences can be linked to the curriculum within higher education and vocational education institutions. Indeed, at this time, all sectors of education are taking an interest in workplaces as learning environments. Schools are interested in assisting students understand the world of work beyond school as well as developing employable capacities. Vocational education, which has long engaged with workplaces, still sees these experiences as being essential to preparation for specific occupations and the assessment of student achievement. Moreover, as programs in universities increasingly have specific occupational outcomes, the contributions of workplace experiences are becoming ever more central to higher education curriculum. Therefore, theoretical explanations of learning through work and the means of directing those experiences for particular learning outcomes are becoming gradually more the focus of educators' and researchers' considerations across all educational sectors.

Much of the theoretical explanations of learning in workplaces came initially from anthropological-like studies emphasizing the importance of participating directly or indirectly in settings where culturally derived practices, such as occupations, to learn about and come to practice them. These explanations are also informed by theories, such as social constructivism, activity systems, communities of practice, habitus, and distributed cognition, which emphasized the social and cultural contributions to individuals' construction of knowledge in workplaces and through work activities. A key emphasis within these theoretical explanations is how social forms, structures, and partners shape learning experiences within social settings such as workplaces and provide access to knowledge and ways of knowing that have historical and cultural geneses. Hence, the contributions of these physical and social settings are at the forefront of many of the discussions about providing and mediating access to the knowledge required for work activities. Indeed, many of the advances within these theoretical positions that have been used more widely over last two decades (e.g., cognitive apprenticeships, communities of practice, activity systems) have been founded in enquiries into learning in workplace settings. These contributions have done much to emphasize that beyond direct teaching there are a range of sources that shape individuals' learning outcomes arising from their participation in physical and social settings. From anthropology came accounts of the importance of being able to participate in and observe these practices and engage with artifacts, norms, and forms, from Russian-inspired psychological movements have come the importance of being guided by expert partners (i.e., Zone of Proximal Development) and individuals' learning through appropriating socially derived practices, as with appropriation. More recently, has come the idea that some workplaces are inherently more generative of learning that is expansive or restricted (Fuller and Unwin 2004). In all, it is suggested that the norms, practices, and artifacts available in the settings can be richly informative.

However, augmenting these explanations is the need to account for the active engagement of learners in the process of constructing knowledge. More than merely engaging in a social setting and being socialized by that experience, individuals are selective in how and what they engage with and through which their learning is mediated. Bolstering this view is a growing acceptance that learning is an ongoing process and not differentiated from everyday thinking and acting (Rogoff and Lave 1984). That is, learning is merely a part of everyday cognition, because knowledge is constructed through engaging in goal-directed activities from which there are particular cognitive legacies (i.e., kinds of learning). Theoretical explanations acknowledging the agency of the learner emphasize the importance of individuals' active engagement and learning through participation in practice. These accounts suggest that it is necessary to consider how individuals construe and construct what they experience in workplaces or any other settings. Indeed, when the contributions of learning through work practice are considered much of it is dependent upon the actions of the learners. For instance, Billett (2001) identifies the combination of engagement in everyday activities, indirect guidance through observing and listening, opportunities to engage in practice and direct guidance by more experienced partners. Yet, to a greater or lesser degree, all of these contributions require active engagement and intentionality by learners. So, beyond what is available to them in the social and physical setting of the workplace, they ultimately elect how and what they engage with and what kind of learning arises for them. Of course, some theorists who privilege the suggestion of the social world view such sentiments as being close to individual determinism. They argue that there are clear constraints on individuals' activities and interactions in workplace settings, which are the product of social forms, norms, and structures.

To both accommodate the contributions of the personal and the social and reconcile these tensions, Billett (2006) proposes that learning through work can be explained as a duality. On the one hand, there is the affordances – the degree by which the workplace is invitational to individuals to engage and participate, and on the other hand, there is how individuals elect to engage with what they are afforded. He suggests that interaction between affordances and engagement comprises a relational interdependence between the social and personal. By emphasizing dualities, rather than dualisms, he proposes that learning is an active process exercised continually by individuals yet, it occurs in ways which are relational in terms of personal bases for construing and constructing knowledge, on the one hand, and a diverse ways in which workplace settings exercise their affordances. Yet, beyond these relational negotiations, there is an interdependence underpinning individuals' learning through work. Individuals need to engage with and utilize knowledge from workplace settings in order to learn and practice. However, individuals secure the continuity of the social setting, occupation, and cultural practice by engaging in, remaking, and transforming that practice at particular points in time, in particular situations and in response to specific problems they are addressing. Work is conducted in workplaces that have particular practices and meet the needs of particular clientele, whose needs and responses to those needs are not consistent and change over time. Hence, there is interdependence between the social and personal imperatives that comprise the negotiations between what individuals know and come to experience when learning through work.

Conceptions associated with not only what the workplace affords individuals, but also how individuals engage are important in advancing conceptions of curriculum, pedagogy, and epistemology for the workplace. As noted, what has been found is that in workplace learning environments much of the emphasis of the learning process is on how individuals engage with the activities and interactions they encounter. Consequently, key bases for their learning such as observing and listening, engaging in activities and engaging in practice of those activities are shaped by individuals' efforts. Therefore, although concepts of curriculum and pedagogic in educational settings are largely premised upon what individuals other than the learners do (with the exception of the "experienced" curriculum), what the learners do is central to conceptions of curriculum and pedagogic within workplace settings. For instance, in her classical study of tailoring apprentices, Lave (1990) indicates that although the curriculum was set out in terms of a series of activities in which the apprentices engaged, most of their learning occurred through progressing through a set of activities largely without the direct guidance of more expert partners. Moreover, given the importance of the agency of the learner, considerations of personal epistemologies seem to sit well within considerations and augmenting practice-based curriculum and pedagogy.

Important Scientific Research and Open Questions

There are important scientific agendas for understanding more about workplace learning experiences that include the processes of that learning and the kinds of learning that occur. Viewing learning settings as being both a social and physical environment that affords experiences and places where individuals elect how and to what degree they engage and learn, and viewing these as relational seems to be helpful for understanding processes of learning through diverse workplace experiences and for work. However, the nature of these relations and their outcomes need to be understood much more fully. One example of this situation is how workers who are relatively socially isolated come to learn the knowledge required for work. That is, many and perhaps most workers engage in practice and learn in the absence of more experienced coworkers, particularly across working life beyond their initial preparation. Therefore, it is important to understand how this learning progresses in contemporary workplaces. This question is also central to understanding more fully how inter-psychological processes (i.e., those between individuals and social sources) progress, when the access to expert guidance is either remote or absent.

What Are the Kinds of Knowledge That Are Learnt Through Different Kinds of Workplace Learning Experiences?

There are also considerations of what kinds of knowledge are learnt through particular kinds of workplace experiences. Although erroneously it is suggested that "practice" or procedural knowledge is best learnt through workplace experiences, (and theory or conceptual knowledge is learnt through educational institutions) it has been shown that conceptual, procedural, and dispositional dimensions occupational knowledge are learnt through practice. Yet, beyond these findings, and in order to inform what knowledge is best learnt in practice and educational settings.

A more comprehensive account of the kinds of learning that arise through particular kinds of workplace experiences is warranted. In particular, we need to know more about how forms of knowledge that is difficult to learn (e.g., conceptual knowledge) can be best learnt. This kind of knowledge is becoming important to contemporary work practice.

Cross-References

- ► Affordances
- ► Anthropology of Learning and Cognition
- ► Authenticity in Learning Activities and Settings
- ► Constructivist Learning
- ► Guided Learning
- ► Informal Learning
- ► Lifelong and Worklife Learning
- ► Situated Learning
- ► Socialization-Related Learning
- ► Vocational Learning

References

Billett, S. (2001). *Learning in the workplace: Strategies for effective practice*. Sydney: Allen and Unwin.

Billett, S. (2006). Relational interdependence between social and individual agency in work and working life. *Mind, Culture and Activity, 13*(1), 53–69.

Fuller, A., & Unwin, L. (2004). Expansive learning environments: Integrating organisational and personal development. In H. Rainbird, A. Fuller, & A. Munroe (Eds.), *Workplace learning in context* (pp. 126–144). London: Routledge.

Lave, J. (1990). The culture of acquisition and the practice of understanding. In J. W. Stigler, R. A. Shweder, & G. Herdt (Eds.), *Cultural psychology* (pp. 259–286). Cambridge: Cambridge University Press.

Marsick, V. J., & Watkins, K. (1990). *Informal and incidental learning in the workplace*. London: Routledge.

Rogoff, B., & Lave, J. (Eds.). (1984). *Everyday cognition: Its development in social context*. Cambridge: Harvard University Press.

World Music Education

► International Perspectives in Music Instruction and Learning

► Multicultural Issues in Music Instruction and Learning

Worlds from Ideas

► Cognitive Artifacts, Technology, and Physics Learning

Worldviews

► Culture in Second Language Learning

Writing Proficiency

► Learning to Write

Written Language

► Verbal Behavior and Learning

Written Prose

► Learning to Write in a Second Language

Written Text and Discourse

► Learning to Write in a Second Language

Würzburg School

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Synonyms

Würzburg school of thought

Definition

The *Würzburg School* or *Würzburg School of thought* is the term for a new methodological approach of controlled introspection or systematic experimental self-observation and new insights in the psychology of thought at the beginning of the twentieth century. The term was probably characterized by Albert Edouard Michotte (1881–1965) in a publication of 1907 and was initially used in French literature before it experienced a worldwide success. The name *Würzburg School* implied a strong reference to Oswald Külpe who was the head of the psychological institute between 1896 and 1909. But it would be historically incorrect to designate Külpe as the leading character of the Würzburg School. Besides Oswald Külpe there was a group of young scientists like Narziss Ach, Karl Bühler, Karl Marbe, August Mayer, Johannes Orth, Otto Selz, and Henry J. Watt who were usually counted as members of the Würzburg School.

Theoretical Background

At the end of the nineteenth century, two theoretical approaches were wide spread and dominating within psychology: (1) the old Aristotelian conviction that the soul never thinks without an image, which was one of the main fundaments of ► associationism represented by British empiricists like ► John Locke (1632–1704), David Hume (1711–1776), and ► John Stuart Mill (1806–1873) or in Germany by ► Hermann Ebbinghaus (1850–1909), Georg Elias Müller (1850–1934), and Theodor Ziehen (1862–1950); (2) Wilhelm Wundt's (1832–1920) opinion that only elementary psychical processes and sensations were accessible by experimental methods.

From his point of view, higher mental processes can only be analyzed by the comparative methods of an ethnopsychology (Völkerpsychologie).

In 1894, Oswald Külpe (1862–1915), the longstanding assistant of Wundt in Leipzig, was appointed for the chair of philosophy and aesthetics at the University of Würzburg. From today's perspective, it is astonishing that Külpe was not the first choice of the University. In fact, he was number three on the appointments list after Theodor Lipps (1851–1914) who went to Munich and Richard Falckenberg (1851–1920) who remained in Erlangen. But the University of Würzburg seems to have a lucky hand with number three appointments because only a few years before in 1888, Wilhelm Conrad Röntgen the discoverer of the X-rays, was number three on the appointment list as well. In 1894, Röntgen was the head of the University of Würzburg and signed Külpes certificate of appointment.

Similarly as his teacher Wundt in Leipzig, Külpe founded the psychological institute in Würzburg in 1896 supported by Karl Marbe (1869–1953). At that time, Marbe has just finished his "Habilitation" (postdoctoral qualification) and started to work as a private lecturer in the newly founded institute. While Külpe was more interested in philosophical questions, Marbe began to work experimentally on psychological topics and methods. In 1900, he initiated an experiment with the goal of analyzing the qualitative differences of associations in detail instead of simply classifying them according to logical criteria as it was common use.

August Mayer (1874–1947) and Johannes Orth (1872–1949), two of Marbe's students, performed this experiment by using a rather simple task: either Mayer or Orth shouted one of more than 400 different stimulus words to their subjects with the instruction to react verbally on that stimulus word. Directly thereafter, the subjects had to tell the experimenter all conscious experiences (Bewusstseinsvorgänge) between hearing the stimulus word and their reaction word. The crucial point of Mayer's and Orth's results is the fact that their subjects reported in many trails conscious processes which were completely imageless and neither perceptions nor acts of will and they were virtually unable to describe them in more detail. These newly discovered conscious experiences were completely incompatible with the associanistic doctrine. Following a suggestion of Marbe, Mayer and Orth called them *states of consciousness* (Bewusstseinslagen). In 1901, Marbe was able to replicate the new phenomenon of the states of consciousness in his studies of judgments. He used again the new method of *controlled introspection*. Contrary to Mayer and Orth, he chose more difficult judgment tasks in order to provoke extensive conscious processes.

Marbe emphasized that judgments are without doubt higher mental acts and that the method of controlled introspection is – in contradiction to Wundt's view – applicable to investigate them experimentally.

Another evidence against associationism was worked out by Narziß Ach (1871–1946). He started his investigations at the University of Würzburg in the summer term of 1900 with a variety of reaction time and hypnotic experiments and continued them in the following years in Göttingen. In addition to Marbe's research on judgments, he turned toward another higher mental process: the analysis of the will. Ach used the introspective method too, but he called it *systematic experimental self-observation.* Similar to Henry J. Watt (1879–1925), who was another member of the Würzburg School, he improved this method by fractioning the observing period into three parts: (1) a fore-period including the time between a ready-signal and the appearance of the stimulus; (2) the main-period between the perception of the stimulus and the reaction, which includes the actual experience to be investigated; and (3) the after-period following the reaction in which the subjects described their experiences. The consideration of the collected self-observations of the fore- and main-period revealed once again states of consciousness which were subsumed by Ach under his broader concept of *awareness (Bewusstheit),* which means the presence of an imageless knowing that something is of importance or not in the concrete case. Besides the concept of awareness, Ach drew the even more important conclusion that the course of the thinking process is not only determined by associative and persevering reproductive tendencies, but additionally by *determining tendencies.* The usually unconscious determining tendencies arise with the acceptance of the task by the subject. They have their origin in the goal presentation and act like ► attitudes in the sense of or according to the goal presentation in order to realize it.

Since Ach and Marbe had left Würzburg, Karl Bühler (1879–1963) continued the experiments about thought under the guidance of Külpe. In his investigations, Bühler applied rather difficult comprehension and decision tasks, e.g., "Did the Middle Ages knew the pythagorean theorem?" or "Does the monism really imply the negation of the personality?" A careful analysis of the protocols of his subjects led Bühler to the following conclusions: First of all, he reasoned that only the thoughts can be regarded as the essential parts of our thinking experiences and they can be completely imageless. These thoughts can be differentiated into several types. Some of the most important are mentioned below:

- The Regelbewußtsein (consciousness of a rule): This means e.g., the knowing how to solve a problem in general or the consciousness of a method of solution.
- The Beziehungsbewußtsein (consciousness of relation): This type of consciousness subsumes thoughts which are in some kind of relation to each other, e.g., one is the opposite or the consequence of the other or which includes relations in itself.
- The Intentionen (intentions): The most striking thought experiences are the intentions, which are signitive acts of meaning in the sense of Husserl (1859–1938).
- The Aha-Erlebnis (the aha experience): The aha experience is the sudden completion of understanding following usually to a moment of hesitation.
- The Erinnerungserlebnis (the experience of remembering): This is a kind of an imaginary conscious relation to earlier experiences without reliving them.

Already Bühler's first publication led to an extensive methodological and theoretical controversy between Wilhelm Wundt and himself. To some extent, it was this public controversy which made the Würzburg School very popular in broad scientific circles.

It is arguable whether Otto Selz (1881–1942) should be added to the scholars of the Würzburg School (e.g., Mandler 2007). The fact is that he joined Külpe as recently as in 1910 after Külpe followed his appointment to the University of Bonn in 1909. Selz had already finished his doctoral thesis with Theodor Lipps in Munich (1909) and started his investigations of thinking with Külpe and Bühler in Bonn. He finalized these studies in 1912 with the disputation of his postdoctoral thesis: "On the laws of the ordered thought process."

As an extension to his predecessors, Selz regarded thinking as a holistic process integrating reproductive thinking and productive thoughts under the guidance of an overall task which leads to *schematic anticipations.* The most primitive drive in mental life is the desire for something. This desire implies an anticipation of its final state and this anticipation has to be schematic because not all conditions for reaching the desired goal are known. For this reason, the schematic anticipations can be considered as the driving and goal-directed forces for all mental operations. Selz was the first who directed the scientific focus on the processes of thought and not on its contents and who developed an early process-theory of thinking. In view of this performance, it is even more remarkable that Selz is still neglected to a great extent.

Important Scientific Research and Open Questions

The approaches of the Würzburg School – which meanwhile is about 110 years old – led to various results still of significance. First of all, the discovery of imageless thoughts, states of consciousness, or awareness produced considerable doubts about the correctness of associationism. Second, "the Würzburgers" demonstrated in many investigations that higher mental processes are experimentally accessible. Third, Henry J. Watt, Narziß Ach, and Otto Selz worked out the importance of the task which motivates and directs the way of thinking by determining tendencies or schematic anticipations.

Nowadays, we can find several traces of the thoughts of the Würzburg School in scientific literature. Gollwitzer (1999) for example introduced the concept of *implementation intentions* which can be related to Ach's *determining tendencies*. In the imagery-debate, Stephen Kosslyn and James Pomerantz (1977) and Zenon Pylyshyn (1973) argued about the cognitive reflections of perceptions especially about the questions if they are figurative ideas or imageless propositional concepts. And Selz is recognized to be a pioneer of a theory of human problem solving (Newell et al. 1958). Finally, the seminal work of the Würzburg School and the following investigations, concepts, and theoretical approaches have to be regarded as the longstanding attempt to solve the still open question about the language of the mind.

Cross-References

► Anticipation and Learning
► Associationism
► Attitudes: Formation and Change
► Ebbinghaus, Hermann
► History of the Sciences of Learning
► Locke, John
► Mill, John Stuart

References

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *The American Psychologist, 54*(7), 493–503.

Kosslyn, S. M., & Pomerantz, J. (1977). Imagery, propositions and the form of internal representations. *Cognitive Psychology, 9*(1), 52–76.

Mandler, G. (2007). *A history of modern experimental psychology. From James and Wundt to cognitive science*. Cambridge, MA: MIT Press.

Michotte, A. E. (1907). A propos de la "method d'introspection" dans la psycholgie expérimentale. *Revue Néo-Scolastique, 14*, 507–532.

Newell, A., Shaw, J. C., & Simon, H. A. (1958). Elements of a theory of human problem solving. *Psychological Review, 65*(3), 151–166.

Pylyshyn, Z. W. (1973). What the mind's eye tells the mind's brain. A critique of mental imagery. *Psychological Bulletin, 80*(1), 1–24.

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