Future Skills in a Digital World

Skills of the Intelligence Age

Contents

Chapter 1

Critical thinking

Critical thinking is the objective analysis of facts to form a judgment.[1] The subject is complex, and there are several different definitions which generally include the rational, skeptical, unbiased analysis or evaluation of factual evidence.

1.1 History

Critical thinking was described by Richard Paul as a movement in two waves (1994).[2] The "first wave" of critical thinking is often referred to as a 'critical analysis' that is clear, rational thinking involving critique. Its details vary amongst those who define it. According to Barry K. Beyer (1995), critical thinking means making clear, reasoned judgments. During the process of critical thinking, ideas should be reasoned, well thought out, and judged.[3] The U.S. National Council for Excellence in Critical Thinking[4] defines critical thinking as the "intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action."[5]

1.2 Etymology

In the term **critical thinking**, the word *critical*, (Grk. κριτικός = *kritikos* = "critic") derives from the word **critic** and implies a critique; it identifies the intellectual capacity and the means "of judging", "of judgement", "for judging", and of being "able to discern".[6]

1.3 Definitions

Traditionally, critical thinking has been variously defined as:

- "the process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information to reach an answer or conclusion"[7]
- "disciplined thinking that is clear, rational, open-minded, and informed by evidence"[7]
- "reasonable, reflective thinking focused on deciding what to believe or do"[8]
- "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based"[9]
- "includes a commitment to using reason in the formulation of our beliefs"[10]
- the skill and propensity to engage in an activity with reflective scepticism (McPeck, 1981)
- disciplined, self-directed thinking which exemplifies the perfection of thinking appropriate to a particular mode or domain of thinking (Paul, 1989, p. 214)
- thinking about one's thinking in a manner designed to organize and clarify, raise the efficiency of, and recognize errors and biases in one's own thinking. Critical thinking is not 'hard' thinking nor is it directed at solving problems (other than 'improving' one's own thinking). Critical thinking is inward-directed with the intent of maximizing the rationality of the thinker. One does not use critical thinking to solve problems—one uses critical thinking to improve one's process of thinking.[11]
- "an appraisal based on careful analytical evaluation"[12]

Contemporary critical thinking scholars have expanded these traditional definitions to include qualities, concepts, and processes such as creativity, imagination, discovery, reflection, empathy, connecting knowing, feminist theory, subjectivity, ambiguity, and inconclusiveness. Some definitions of critical thinking exclude these subjective practices.[13]

1.4 Logic and rationality

Main article: Logic and rationality

The ability to reason logically is a fundamental skill of rational agents, hence the study of the form of correct argumentation is relevant to the study of critical thinking.

"First wave" logical thinking consisted of understanding the connections between two concepts or points in thought. It followed a philosophy where the thinker was removed from the train of thought and the connections and the analysis of the connect was devoid of any bias of the thinker. Kerry Walter's describes this ideology in her essay Beyond Logicism in Critical Thinking, "A logistic approach to critical thinking conveys the message to students that thinking is legitimate only when it conforms to the procedures of informal (and, to a lesser extent,, formal) logic and that the good thinker necessarily aims for styles of examination and appraisal that are analytical, abstract, universal, and objective. This model of thinking has become so entrenched in conventional academic wisdom that many educators accept it as canon" (Walters, 1994, p. 1). The adoption of these principals parallel themselves with the increasing reliance on quantitative understanding of the world.

In the 'second wave' of critical thinking, as defined by Kerry S. Walters (Re-thinking Reason, 1994, p. 1), many authors moved away from the logocentric mode of critical thinking that the 'first wave' privileged, especially in institutions of higher learning. Walters summarizes logicism as "the unwarranted assumption that good thinking is reducible to logical thinking" (1994, p. 1).

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1.4.1 Inductive versus deductive thinking

Inductive thinking involves drawing on many different facts, concepts, or opinions to come to a larger conclusion. Examples of inductive reasoning include differential diagnosis, inquiry-based education, and trial and error. Deductive Reasoning involves addressing the known first, and attempt to discover more information about why the known is what it is. Examples of deductive reasoning include root cause analysis and top down learning.

1.4.2 Critical thinking and rationality

Kerry S. Walters (Re-thinking Reason, 1994) argues that rationality demands more than just logical or traditional methods of problem solving and analysis or what he calls the "calculus of justification" but also considers "cognitive acts such as imagination, conceptual creativity, intuition and insight" (p. 63). These "functions" are focused on discovery, on more abstract processes instead of linear, rules-based approaches to problem solving. The linear and non-sequential mind must both be engaged in the rational mind.

The ability to critically analyze an argument – to dissect structure and components, thesis and reasons – is important. But so is the ability to be flexible and consider non-traditional alternatives and perspectives. These complementary functions are what allow for critical thinking; a practice encompassing imagination and intuition in cooperation with traditional modes of deductive inquiry.

1.5 Functions

The list of core critical thinking skills includes observation, interpretation, analysis, inference, evaluation, explanation, and metacognition. According to Reynolds (2011), an individual or group engaged in a strong way of critical thinking gives due consideration to establish for instance:[14]

- Evidence through reality
- Context skills to isolate the problem from context
- Relevant criteria for making the judgment well
- Applicable methods or techniques for forming the judgment
- Applicable theoretical constructs for understanding the problem and the question at hand

In addition to possessing strong critical-thinking skills, one must be disposed to engage problems and decisions using those skills. Critical thinking employs not only logic but broad intellectual criteria such as clarity, credibility, accuracy, precision, relevance, depth, breadth, significance, and fairness.[15]

1.6 Procedure

Critical thinking calls for the ability to:

- Recognize problems, to find workable means for meeting those problems
- Understand the importance of prioritization and order of precedence in problem solving

- Gather and marshal pertinent (relevant) information
- Recognize unstated assumptions and values
- Comprehend and use language with accuracy, clarity, and discernment
- Interpret data, to appraise evidence and evaluate arguments
- Recognize the existence (or non-existence) of logical relationships between propositions
- Draw warranted conclusions and generalizations
- Put to test the conclusions and generalizations at which one arrives
- Reconstruct one's patterns of beliefs on the basis of wider experience
- Render accurate judgments about specific things and qualities in everyday life

In sum:

"A persistent effort to examine any belief or supposed form of knowledge in the light of the evidence that supports or refutes it and the further conclusions to which it tends."[16]

1.7 Habits or traits of mind

The habits of mind that characterize a person strongly disposed toward critical thinking include a desire to follow reason and evidence wherever they may lead, a systematic approach to problem solving, inquisitiveness, evenhandedness, and confidence in reasoning.[17]

According to a definition analysis by Kompf & Bond (2001), critical thinking involves problem solving, decision making, metacognition, rationality, rational thinking, reasoning, knowledge, intelligence and also a moral component such as reflective thinking. Critical thinkers therefore need to have reached a level of maturity in their development, possess a certain attitude as well as a set of taught skills.

1.8 Research

Edward M. Glaser proposed that the ability to think critically involves three elements:[16]

1. An attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range of one's experiences
2. Knowledge of the methods of logical inquiry and reasoning
3. Some skill in applying those methods.

Educational programs aimed at developing critical thinking in children and adult learners, individually or in group problem solving and decision making contexts, continue to address these same three central elements.

The Critical Thinking project at Human Science Lab, London, is involved in scientific study of all major educational system in prevalence today to assess how the systems are working to promote or impede critical thinking. [18]

Contemporary cognitive psychology regards human reasoning as a complex process that is both reactive and reflective.[19]

The relationship between critical thinking skills and critical thinking dispositions is an empirical question. Some people have both in abundance, some have skills but not the disposition to use them, some are disposed but lack strong skills, and some have neither. A measure of critical thinking dispositions is the California Measure of Mental Motivation.[20]

1.9 Education

John Dewey is one of many educational leaders who recognized that a curriculum aimed at building thinking skills would benefit the individual learner, the community, and the entire democracy.[21]

Critical thinking is significant in academics due to being significant in learning. Critical thinking is significant in the learning process of internalization, in the construction of basic ideas, principles, and theories inherent in content. And critical thinking is significant in the learning process of application, whereby those ideas, principles, and theories are implemented effectively as they become relevant in learners' lives.

Each discipline adapts its use of critical thinking concepts and principles. The core concepts are always there, but they are embedded in subject-specific content. For students to learn content, intellectual engagement is crucial. All students must do their own thinking, their own construction of knowledge. Good teachers recognize this and therefore focus on the questions, readings, activities that stimulate the mind to take ownership of key concepts and principles underlying the subject.

Historically, teaching of critical thinking focused only on logical procedures such as formal and informal logic. This emphasized to students that good thinking is equivalent to logical thinking. However, a second wave of critical thinking, urges educators to value conventional techniques, meanwhile expanding what it means to be a critical thinker. In 1994, Kerry Walters[22] compiled a conglomeration of sources surpassing this logical restriction to include many different authors' research regard-

ing connected knowing, empathy, gender-sensitive ideals, collaboration, world views, intellectual autonomy, morality and enlightenment. These concepts invite students to incorporate their own perspectives and experiences into their thinking.

In the English and Welsh school systems, *Critical Thinking* is offered as a subject that 16- to 18-year-olds can take as an A-Level. Under the OCR exam board, students can sit two exam papers for the AS: "Credibility of Evidence" and "Assessing and Developing Argument". The full Advanced GCE is now available: in addition to the two AS units, candidates sit the two papers "Resolution of Dilemmas" and "Critical Reasoning". The A-level tests candidates on their ability to think critically about, and analyze, arguments on their deductive or inductive validity, as well as producing their own arguments. It also tests their ability to analyze certain related topics such as credibility and ethical decision-making. However, due to its comparative lack of subject content, many universities do not accept it as a main A-level for admissions.[23] Nevertheless, the AS is often useful in developing reasoning skills, and the full Advanced GCE is useful for degree courses in politics, philosophy, history or theology, providing the skills required for critical analysis that are useful, for example, in biblical study.

There used to also be an Advanced Extension Award offered in Critical Thinking in the UK, open to any A-level student regardless of whether they have the Critical Thinking A-level. Cambridge International Examinations have an A-level in Thinking Skills.[24]

From 2008, Assessment and Qualifications Alliance has also been offering an A-level Critical Thinking specification.[25]

OCR exam board have also modified theirs for 2008. Many examinations for university entrance set by universities, on top of A-level examinations, also include a critical thinking component, such as the LNAT, the UKCAT, the BioMedical Admissions Test and the Thinking Skills Assessment.

In Qatar, critical thinking was offered by AL-Bairaq which is an outreach, non-traditional educational program that targets high school students and focuses on a curriculum based on STEM fields. The idea behind AL-Bairaq is to offer high school students the opportunity to connect with the research environment in the Center for Advanced Materials (CAM) at Qatar University. Faculty members train and mentor the students and help develop and enhance their critical thinking, problem-solving, and teamwork skills.[26]

1.9.1 Efficacy

In 1995, a meta-analysis of the literature on teaching effectiveness in higher education was undertaken.[27] The study noted concerns from higher education, politicians and business that higher education was failing to meet society's requirements for well-educated citizens. It concluded that although faculty may aspire to develop students' thinking skills, in practice they have tended to aim at facts and concepts utilizing lowest levels of cognition, rather than developing intellect or values.

In a more recent meta-analysis, researchers reviewed 341 quasi- or true-experimental studies, all of which used some form of standardized critical thinking measure to assess the outcome variable.[28] The authors describe the various methodological approaches and attempt to categorize the differing assessment tools, which include standardized tests (and second-source measures), tests developed by teachers, tests developed by researchers, and tests developed by teachers who also serve the role as the researcher. The results emphasized the need for exposing students to real-world problems and the importance in encouraging open dialogue within a supportive environment. Effective strategies for teaching critical thinking are thought to be possible in a wide variety of educational settings.[28]

1.10 Importance in academia

Critical thinking is an important element of all professional fields and academic disciplines (by referencing their respective sets of permissible questions, evidence sources, criteria, etc.). Within the framework of scientific skepticism, the process of critical thinking involves the careful acquisition and interpretation of information and use of it to reach a well-justified conclusion. The concepts and principles of critical thinking can be applied to any context or case but only by reflecting upon the nature of that application. Critical thinking forms, therefore, a system of related, and overlapping, modes of thought such as anthropological thinking, sociological thinking, historical thinking, political thinking, psychological thinking, philosophical thinking, mathematical thinking, chemical thinking, biological thinking, ecological thinking, legal thinking, ethical thinking, musical thinking, thinking like a painter, sculptor, engineer, business person, etc. In other words, though critical thinking principles are universal, their application to disciplines requires a process of reflective contextualization.

Critical thinking is considered important in the academic fields because it enables one to analyze, evaluate, explain, and restructure their thinking, thereby decreasing the risk of adopting, acting on, or thinking with, a false belief. However, even with knowledge of the methods of logical inquiry and reasoning, mistakes can happen due to a thinker's inability to apply the methods or because of character traits such as egocentrism. Critical thinking includes identification of prejudice, bias, propaganda, self-deception, distortion, misinformation, etc.[29] Given research in cognitive psychology, some educators believe that schools should focus on teaching their students criti-

cal thinking skills and cultivation of intellectual traits.[30]

Critical thinking skills can be used to help nurses during the assessment process. Through the use of critical thinking, nurses can question, evaluate, and reconstruct the nursing care process by challenging the established theory and practice. Critical thinking skills can help nurses problem solve, reflect, and make a conclusive decision about the current situation they face. Critical thinking creates "new possibilities for the development of the nursing knowledge."[31] Due to the sociocultural, environmental, and political issues that are affecting healthcare delivery, it would be helpful to embody new techniques in nursing. Nurses can also engage their critical thinking skills through the Socratic method of dialogue and reflection. This practice standard is even part of some regulatory organizations such as the College of Nurses of Ontario - Professional Standards for Continuing Competencies (2006).[32] It requires nurses to engage in Reflective Practice and keep records of this continued professional development for possible review by the College.

Critical thinking is also considered important for human rights education for toleration. The Declaration of Principles on Tolerance adopted by UNESCO in 1995 affirms that "education for tolerance could aim at countering factors that lead to fear and exclusion of others, and could help young people to develop capacities for independent judgement, *critical thinking* and ethical reasoning."[33]

Critical thinking is used as a way of deciding whether a claim is true, partially true, or false. It is a tool by which one can come about reasoned conclusions based on a reasoned process.

1.11 See also

- Global Critical Thinking Project
- Cognitive bias mitigation
- Critical theory
- Demarcation problem
- Dialectic
- Discourse analysis
- Disinformation
- Freedom of thought
- Freethought
- Outline of human intelligence – topic tree presenting the traits, capacities, models, and research fields of human intelligence
- Outline of thought – topic tree that identifies many types of thoughts, types of thinking, aspects of thought, related fields
- *Sapere Aude*

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1.14 External links

Media related to Critical thinking at Wikimedia Commons Quotations related to Critical thinking at Wikiquote

- Critical thinking at PhilPapers
- Critical thinking at the Indiana Philosophy Ontology Project
- "Informal logic". *Stanford Encyclopedia of Philosophy*.
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Chapter 2

Intellectual honesty

Intellectual honesty is an applied method of problem solving, characterized by an unbiased, honest attitude, which can be demonstrated in a number of different ways:

- One's personal beliefs do not interfere with the pursuit of truth;
- Relevant facts and information are not purposefully omitted even when such things may contradict one's hypothesis;
- Facts are presented in an unbiased manner, and not twisted to give misleading impressions or to support one view over another;
- References, or earlier work, are acknowledged where possible, and plagiarism is avoided.

Harvard ethicist Louis M. Guenin describes the "kernel" of intellectual honesty to be "a virtuous disposition to eschew deception when given an incentive for deception".[1]

Intentionally committed fallacies in debates and reasoning are called **intellectual dishonesty**.

2.1 See also

- Academic honesty
- Conflict of interest
- Epistemic feedback
- Good faith
- Intellectual
- List of fallacies
- Scientific method
- Sophism
- Systemic bias

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Chapter 3

Collaboration

For other uses, see Collaboration (disambiguation).
For the definition in music, between two or more artists, see Featuring.
See also: Cooperation and coordination

Collaboration is the process of two or more people

Catalan castellers collaborate, working together with a shared goal

or organizations working together to realize or achieve something successfully.[1] Collaboration is very similar to, but more closely aligned than, cooperation. Most collaboration requires leadership, although the form of leadership can be social within a decentralized and egalitarian group.[2] Teams that work collaboratively can obtain greater resources, recognition and reward when facing competition for finite resources.[3]

Structured methods of collaboration encourage introspection of behavior and communication.[2] These methods *specifically* aim to increase the success of teams as they engage in collaborative problem solving.

Forms, rubrics, charts and graphs are useful in these situations to objectively document personal traits with the goal of improving performance in current and future projects. Collaboration is also present in opposing goals exhibiting the notion of adversarial collaboration, though this is not a common case for using the word.

3.1 Classical examples of collaboration

Following are some examples of successful collaboration efforts in the past.

3.1.1 Trade

The trade of goods is an economic activity providing mutual benefit

Trade originated with the start of communication in prehistoric times. Trading was the main facility of prehistoric people, who bartered goods and services from each other when there was no such thing as the modern day currency. Peter Watson dates the history of long-distance

commerce from circa 150,000 years ago.[4] Trade exists for many reasons. Due to specialisation and division of labor, most people concentrate on a small aspect of production, trading for other products. Trade exists between regions because different regions have a comparative advantage in the production of some tradable commodity, or because different regions' size allows for the benefits of mass production. As such, trade at market prices between locations benefits both locations.

3.1.2 Community organization

Organization and cooperation between community members provides economic and social benefits

Main article: intentional community

The members of an intentional community typically hold a common social, political or spiritual vision. They also share responsibilities and resources. Intentional communities include cohousing, residential land trusts, ecovillages, communes, kibbutzim, ashrams, and housing cooperatives. Typically, new members of an intentional community are selected by the community's existing membership, rather than by real-estate agents or land owners (if the land is not owned by the community).

Hutterite, Austria (16th century) Housing units are built and assigned to individual families but belong to the colony and there is very little personal property. Meals are taken by the entire colony in a common long room.

Oneida Community, Oneida, New York (1848) The Oneida Community practiced *Communalism* (in the sense of communal property and possessions) and *Mutual Criticism*, where every member of the community was subject to criticism by committee or the community as a whole, during a general meeting. The goal was to eliminate bad character traits.

Early Kibbutz settlements founded near Jerusalem (1890) A Kibbutz is an Israeli collective community. The movement combines socialism and Zionism in a form of practical Labor Zionism, founded at a time when independent farming was not practical or perhaps more correctly—not practicable. Forced by necessity into communal life, and inspired by their own ideology, the kibbutz members developed a pure communal mode of living that attracted interest from the entire world. While the kibbutzim lasted for several generations as utopian communities, most of today's kibbutzim are scarcely different from the capitalist enterprises and regular towns to which the kibbutzim were originally supposed to be alternatives.

3.1.3 Collaboration under capitalism

Ayn Rand utterly rejected the notion that one should live an isolated life. She recognized that a crucial way we "develop ourselves" and pursue our rational self-interest is by building strong relationships with other people, whether in business, friendship, romance, or any other kind of life-serving relationship. Rand wrote hundreds of pages about the virtues and benefits of collaborating with others to mutual advantage. She also recognized that, as participants in capitalism, "we're all connected" through the voluntary division of labor in the free market, where value is exchanged always for value. In presenting her theory of rational egoism, Rand explained why acting in one's self-interests often entails "looking out" for others to protect the innocent from injustice, to aid our friends and allies, and to protect and support our friends and loved ones.[5]

3.1.4 Game theory

Game theory is a branch of applied mathematics and economics that looks at situations where multiple players make decisions in an attempt to maximize their returns. The first documented discussion of it is a letter written by James Waldegrave, 1st Earl Waldegrave in 1713. Antoine Augustin Cournot's *Researches into the Mathematical Principles of the Theory of Wealth* in 1838 provided the first general theory. It was not until 1928 that this became a recognized, unique field when John von Neumann published a series of papers. Von Neumann's work in game theory culminated in the 1944 book The *Theory of Games and Economic Behavior* by von Neumann and Oskar Morgenstern.

3.1.5 Military-industrial complex

The term **military-industrial complex** refers to a close and symbiotic relationship among a nation's armed forces, its private industry, and associated political and commercial interests. In such a system, the military is dependent on industry to supply material and other support, while the defense industry depends on government for revenue.

Skunk Works Skunk Works is a term used in engineering and technical fields to describe a group within an organization given a high degree of autonomy and unhampered by bureaucracy, tasked with working on advanced or secret projects. Founded at Lockheed in 1943, the team developed highly innovative aircraft in short time frames, even beating its first deadline by 37 days.[6] Creator of the organization, Kelly Johnson is said to have been an 'organizing genius' and had fourteen basic operating rules.[6]

Manhattan Project The Manhattan Project was the project to develop the first nuclear weapon (atomic bomb) during World War II by the United States, the United Kingdom and Canada. Formally designated as the Manhattan Engineer District, it refers specifically to the period of the project from 1941–1946 under the control of the U.S. Army Corps of Engineers, under the administration of General Leslie R. Groves. The scientific research was directed by American physicist J. Robert Oppenheimer.

While the aforementioned persons were influential in the project itself, the value of this project as an influence on organized collaboration is better attributed to Vannevar Bush.[6] In early 1940, Bush lobbied for the creation of the National Defense Research Committee. Frustrated by previous bureaucratic failures in implementing technology in World War I, Bush sought to organize the scientific power of the United States for greater success.[6]

The project succeeded in developing and detonating three nuclear weapons in 1945: a test detonation of a plutonium implosion bomb on July 16 (the Trinity test) near Alamogordo, New Mexico; an enriched uranium bomb code-named "Little Boy" on August 6 over Hiroshima, Japan; and a second plutonium bomb, code-named "Fat Man" on August 9 over Nagasaki, Japan.

3.1.6 Project management

The 2,751 Liberty ships built in four years by the United States during World War II required new approaches in organization and manufacturing

As a discipline, Project Management developed from different fields of application including construction, engineering, and defense. In the United States, the forefather of project management is Henry Gantt, called the father of planning and control techniques, who is famously known for his use of the "bar" chart as a project management tool, for being an associate of Frederick Winslow Taylor's theories of scientific management, and for his study of the work and management of Navy ship building. His work is the forerunner to many modern project management tools including the work breakdown structure (WBS) and resource allocation.

The 1950s marked the beginning of the modern project management era. Again, in the United States, prior to the 1950s, projects were managed on an ad hoc basis using mostly Gantt charts, and informal techniques and tools. At that time, two mathematical project scheduling models were developed: (1) the "Program Evaluation and Review Technique" or PERT, developed as part of the United States Navy's (in conjunction with the Lockheed Corporation) Polaris missile submarine program;[7] and (2) the "Critical Path Method" (CPM) developed in a joint venture by both DuPont Corporation and Remington Rand Corporation for managing plant maintenance projects. These mathematical techniques quickly spread into many private enterprises.

In 1969, the Project Management Institute (PMI) was formed to serve the interest of the project management industry. The premise of PMI is that the tools and techniques of project management are common even among the widespread application of projects from the software industry to the construction industry. In 1981, the PMI Board of Directors authorized the development of what has become *A Guide to the Project Management Body of Knowledge* (PMBOK), standards and guidelines of practice that are widely used throughout the profession. The International Project Management Association (IPMA), founded in Europe in 1967, has undergone a similar development and instituted the IPMA Project Baseline. Both organizations are now participating in the development of a global project management standard.

3.1.7 Academia

Black Mountain College Founded in 1933 by John Andrew Rice, Theodore Dreier and other former faculty of Rollins College, Black Mountain was experimental by nature and committed to an interdisciplinary approach, attracting a faculty which included many of America's leading visual artists, poets, and designers.

Operating in a relatively isolated rural location with little budget, Black Mountain College inculcated an informal and collaborative spirit, and over its lifetime attracted a venerable roster of instructors. Some of the innovations, relationships and unexpected con-

nections formed at Black Mountain would prove to have a lasting influence on the postwar American art scene, high culture, and eventually pop culture. Buckminster Fuller met student Kenneth Snelson at Black Mountain, and the result was the first geodesic dome (improvised out of slats in the school's back yard); Merce Cunningham formed his dance company; and John Cage staged his first happening.

Not a haphazardly conceived venture, Black Mountain College was a consciously directed liberal arts school that grew out of the progressive education movement. In its day it was a unique educational experiment for the artists and writers who conducted it, and as such an important incubator for the American avant garde. Black Mountain proved to be an important precursor to and prototype for many of the alternative colleges of today ranging from the University of California, Santa Cruz to Hampshire College and Evergreen State College, among others.

Learning Community

The Evergreen signature clock tower

Dr. Wolff-Michael Roth and Stuart Lee of the University of Victoria assert[8] that until the early 1990s the individual was the 'unit of instruction' and the focus of research. The two observed that researchers and practitioners switched[9][10] to the idea that knowing is 'better' thought of as a cultural practice.[11][12][13][14] Roth and Lee also claim[8] that this led to changes in learning and teaching design in which students were encouraged to share their ways of doing mathematics, history, science, with each other. In other words, that children take part in the construction of consensual domains, and 'participate in the negotiation and institutionalisation of … meaning'. In effect, they are participating in **learning communities.**

This analysis does not take account of the appearance of Learning communities in the United States in the early 1980s. For example, The Evergreen State College, which is widely considered a pioneer in this area, established an intercollegiate learning community in 1984. In 1985, this same college established The Washington Center for Improving the Quality of Undergraduate Education, which focuses on collaborative education approaches, including learning communities as one of its centerpieces.

3.1.8 Classical music

Main article: Classical music written in collaboration

Although relatively rare compared with collaboration in popular music, there have been some notable examples of music written in collaboration between classical composers. Perhaps the best-known examples are:

- *Hexameron*, a set of variations for solo piano on a theme from Vincenzo Bellini's opera *I puritani*. It was written and first performed in 1837. The contributors were Franz Liszt, Frédéric Chopin, Carl Czerny, Sigismond Thalberg, Johann Peter Pixis, and Henri Herz.
- The *F-A-E Sonata*, a sonata for violin and piano, written in 1853 as a gift for the violinist Joseph Joachim. The composers were Albert Dietrich (first movement), Robert Schumann (second and fourth movements), and Johannes Brahms (third movement).

3.2 Contemporary examples

3.2.1 Arts

The romanticized notion of a lone, genius artist has existed since the time of Giorgio Vasari's Lives of the Artists, published in 1568. Vasari promulgated the idea that artistic skill was endowed upon chosen individuals by gods, which created an enduring and largely false popular misunderstanding of many artistic processes. Artists have used collaboration to complete large scale works for centuries, but the myth of the lone artist was not questioned by the public consciousness until the 1960s and 1970s.[15]

Collaborative art groups

- Dada (1913)
- Fluxus (1957)

- Situationist International (1957)
- Experiments in Art and Technology (1967)
- Mujeres Muralistas (1973)
- Colab (1977)
- Guerrilla Girls (1985)
- SITO (1993)
- 2 Easy Fashion (2008)

3.2.2 Ballet

Ballet is, almost always, by nature a collaborative art form. Ballet needs music, it needs dancers, it needs costumes, a venue, lighting, etc. Hypothetically, one person could control all of this. But most often, every work of ballet is the by product of collaboration. From the earliest formal works of ballet, to the great 19th century masterpieces of Pyotr Tchaikovsky and Marius Petipa, to the 20th century masterworks of George Balanchine and Igor Stravinsky, to today's ballet companies, such as New York's BalletCollective, feature strong collaborative connections between choreographers, composers and costume designers are essential. Within dance as an art form, there is also the collaboration between choreographer and dancer. The choreographer creates a movement in her/his head and then physically demonstrates the movement to the dancer, which the dancer sees and attempts to either mimic or interpret - two or more people striving for a connected goal.

3.2.3 Business

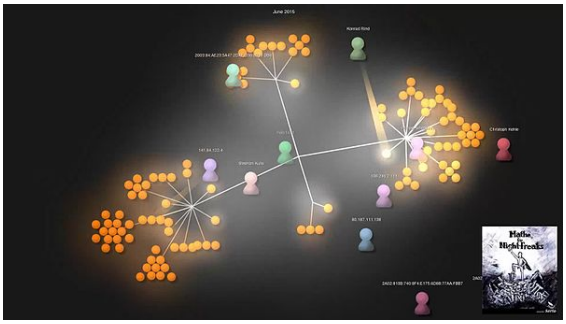
Collaboration in business can be found both inter- and intra-organization[16] and ranges from the simplicity of a partnership and crowd funding to the complexity of a multinational corporation. Inter-organizational collaboration depicts relationship between two or several organizations in which the participating parties agree to invest resources, mutually achieve goals, share information, resources, rewards and responsibilities, as well as jointly make decisions and solve problems.[17] Collaboration between public, private and voluntary sectors can be effective in tackling complex policy problems, but may be handled more effectively by committed boundary-spanning teams and networks than by formal organizational structures.[18] Collaboration between team members allows for better communication within the organization and throughout the supply chains. It is a way of coordinating different ideas from numerous people to generate a wide variety of knowledge. Collaboration with a selected few firms as opposed to collaboration with a large number of different firms has been shown to positively impact firm performance and innovation outcomes.[19] The recent improvement in technology has provided the world with high speed internet, wireless connection, and web-based collaboration tools like blogs, and wikis, and has as such created a "mass collaboration." People from all over the world are efficiently able to communicate and share ideas through the internet, or even conferences, without any geographical barriers. The power of social networks is beginning to permeate into business culture where many collaborative uses are being found including file sharing and knowledge transfer. Evan Rosen, the author of *The Culture of Collaboration*, defines collaboration as "working together to create value while sharing virtual or physical space."[20] According to Rosen, command-and-control organizational structures inhibit collaboration and replacing these obsolete structures allows collaboration to flourish.[21]

See also : Management cybernetics

A plethora of studies have shown that collaboration can be a powerful tool towards higher achievement and increased productivity since collective efficacy can significantly boost groups' aspirations, motivational investment, morale, and resilience to challenges.[22] However, a four-year study of interorganizational collaboration by Fischer and colleagues at the University of Oxford, found that successful collaboration can be rapidly derailed through external policy steering, particularly where it undermines relations built on trust.[23][24]

On a more specific level, coworking spaces are businesses dedicated to providing a space for freelancers to work with others in a collaborative environment. Collaboration is one of the five coworking core values: Collaboration, openness, community, accessibility and sustainability.

3.2.4 Education



Visualization of the collaborative work in the German textbook project Mathe für Nicht-Freaks

In recent years, co-teaching has become one of the most widely used models of collaboration, found in classrooms across all grade levels and content areas.[25] Once only regarded as collaboration between special education and general education teachers, it is now more generally defined as "…two professionals delivering substantive instruction to a diverse group of students in a single physical space."[26]

As classrooms have become increasingly diverse, so too have the challenges for educators. Due to the diverse needs of students with designated special needs, English languages learners (ELL), and students of varied academic levels, teachers have been led to develop new approaches that provide additional support for their students.[27] In practice, this is an inclusive model where students are not removed from the classroom to receive separate instruction, but rather they remain and receive collaborative instruction by both their general teacher and special education teachers.[28]

Societal changes that have taken place over the past few decades allows new ways of conceptualizing collaboration, and to understand the evolution and expansion of these types of relationships. For example, economic changes that have taken place domestically and internationally have resulted in the transformation from an industry-dependent economy to an information-centered economy that is dependent on new technologies and expansion of industries that provide services.[29] From an educational standpoint, such transformations were projected through federal reports, such as A Nation at Risk in 1983 and What Matters Most: Teaching for America's Future in 1996. In these reports, economic success could be assured if students developed the capacity to learn how to "manage teams… and…work together successfully in teams".[30]

The continuing development of Web 2.0 technologies, such as wikis, blogs, multiplayer games, online communities, and Twitter, among others, has changed the manner in which students communicate and collaborate. Teachers are increasingly using collaborative software to establish virtual learning environments (VLEs). This allows them to share learning materials and feedback with both students and in some cases, parents. **See also:**

- Collaborative Partnerships: Business/Industry-Education
- Learning circle
- Collaborative partnerships
- Four Cs of 21st century learning
- 21st century skills

3.2.5 Music

Main article: Classical music written in collaboration

Musical collaboration occurs when musicians in different places or groups work on the same album or song. Typically, in today's music word, multiple parties are involved (singers, songwriters, lyrisits, composers, and producers) come together to create one song. For example, one specific collaboration from recent times (2015) was the song "FourFiveSeconds". This single represents a type of collaboration because it is a form of art that was developed by multiple artists with the inclusion of Rihanna (a recent pop idol), Paul McCartney (former guitarist and vocalist for the Beatles), and Kanye West (a currently popular rapper). Collaboration between musicians, especially with regards to jazz, is often heralded as the epitome of complex collaborative practice. Special websites as well as software have been created to facilitate musical collaboration over the Internet resulting in the emergence of Online Bands.

Several awards exist specifically for collaboration in music:

- Grammy Award for Best Country Collaboration with Vocals—awarded since 1988
- Grammy Award for Best Pop Collaboration with Vocals—awarded since 1995
- Grammy Award for Best Rap/Sung Collaboration—awarded since 2002

Collaboration has been a constant feature of Electroacoustic Music, due to the complexity of the technology. Since the beginning, all laboratories and electronic music studios have involved the presence of different individuals with diverse but intertwined competencies. In particular, the embedding of technological tools into the process of musical creation resulted in the emergence of a new agent with new expertise: the musical assistant, the technician, the tutor, the computer music designer, the music mediator (a profession that has been described and defined in different ways over the years) – who can work in the phase of writing, creating new instruments, recording and/or performance. He or she explains the possibilities of the various instruments and applications, as well as the potential sound effects to the composer (when the latter did not have sufficient knowledge of the programme or a clear idea of what he or she could obtain from it). The musical assistant also explains the most recent results in musical research and translates artistic ideas into programming languages. Finally, he or she transforms those ideas into a score or a computer program and often performs the musical piece during the concerts.[31] Examples of collaboration are numerous: Pierre Boulez and Andrew Gerzso, Alvise Vidolin and Luigi Nono, Jonathan Harvey and Gilbert Nouno, among others.

3.2.6 Entertainment

Collaboration in entertainment is a relatively new phenomenon brought on with the advent of social media, reality TV, and video sharing sites such as YouTube and Vimeo. Collaboration occurs when writers, directors, actors, producers and other individuals or groups work on

the same television show, short film, or feature-length film. A revolutionary system has been developed by Will Wright for the production of the TV series title Bar Karma on CurrentTV. Special web-based software, titled Storymaker, has been written to facilitate plot collaboration over the Internet. Screenwriters' organizations bring together professional and amateur writers and filmmakers in a collaborative manner for entertainment development.

3.2.7 Publishing

Collaboration in publishing can be as simple as dual-authorship or as complex as commons-based peer production. Technological examples include Usenet, e-mail lists, blogs and Wikis while 'brick and mortar' examples include monographs (books) and periodicals such as newspapers, journals and magazines.

See also: Collaborative writing and Collaborative fiction

3.2.8 Science

Though there is no political institution organizing the sciences on an international level, a self-organized, global network had formed in the late 20th century.[3] Observed by the rise in co-authorships in published papers, Wagner and Leydesdorff found international collaborations to have doubled from 1990 to 2005.[3] While collaborative authorships within nations has also risen, this has done so at a slower rate and is not cited as frequently.[3]

See also: Science 2.0

3.2.9 Medicine

In medicine the physician assistant - physician relationship involves a collaborative plan to be on file with each state board of medicine where the PA works. This plan formally delineates the scope of practice approved by the physician.

3.2.10 Technology

Due to the complexity of today's business environment, collaboration in technology encompasses a broad range of tools that enable groups of people to work together including social networking, instant messaging, team spaces, web sharing, audio conferencing, video, and telephony. Broadly defined, any technology that facilitates linking of two or more humans to work together can be considered a collaborative tool. Wikipedia, Blogs, even Twitter are collaborative tools. Many large companies are developing enterprise collaboration strategies and standardizing on a collaboration platform to allow their employees, customers and partners to intelligently connect and interact.

Trilateral agreement between ESO, the National Science Foundation and the National Institutes of Natural Sciences for the operation of ALMA.[32]

Enterprise collaboration tools (see analyst firm Real Story Group's graphic for examples) are centered on attaining collective intelligence and staff collaboration at the organization level, or with partners. These include features such as staff networking, expert recommendations, information sharing, expertise location, peer feedback, and real-time collaboration. At the personal level, this enables employees to enhance social awareness and their profiles and interactions Collaboration encompasses both asynchronous and synchronous methods of communication and serves as an umbrella term for a wide variety of software packages. Perhaps the most commonly associated form of synchronous collaboration is web conferencing using tools such as Cisco TelePresence, Cisco WebEx Meetings, HP Halo Telepresence Solutions, GoToMeeting Web Conferencing, or Microsoft Live Meeting, but the term can easily be applied to IP telephony, instant messaging, and rich video interaction with telepresence, as well. Examples of asynchronous collaboration software include Cisco WebEx Connect, GoToMeeting, Microsoft Sharepoint, eXo Platform, Atlassian Confluence and MediaWiki.

The effectiveness of a collaborative effort is driven by three critical factors: - Communication - Content Management - Workflow control

The Internet The low cost and nearly instantaneous sharing of ideas, knowledge, and skills has made collaborative work dramatically easier. Not only can a group cheaply communicate and test, but the wide reach of the Internet allows such groups to easily form in the first place, even among niche interests. An example of this is the free software movement in software development which produced GNU and Linux from scratch and has taken over development of Mozilla and OpenOffice.org (formerly known as Netscape Communicator and StarOffice).

Commons-based peer production Commons-based

peer production is a term coined by Yale's Law professor Yochai Benkler to describe a new model of economic production in which the creative energy of large numbers of people is coordinated (usually with the aid of the internet) into large, meaningful projects, mostly without traditional hierarchical organization or financial compensation. He compares this to firm production (where a centralized decision process decides what has to be done and by whom) and market-based production (when tagging different prices to different jobs serves as an attractor to anyone interested in doing the job).

Examples of products created by means of commons-based peer production include Linux, a computer operating system; Slashdot, a news and announcements website; Kuro5hin, a discussion site for technology and culture; Wikipedia, an online encyclopedia; and Clickworkers, a collaborative scientific work. Another example is Socialtext which is a software that uses tools such as wikis and weblogs and helps companies to create a collaborative work environment.

Massively distributed collaboration The term massively distributed collaboration was coined by Mitchell Kapor, in a presentation at UC Berkeley on 2005-11-09, to describe an emerging activity of wikis and electronic mailing lists and blogs and other content-creating virtual communities online.

3.3 Wartime collaboration

Main article: Collaborationism

Since World War II the term "collaboration" acquired a negative meaning as referring to persons and groups which help a foreign occupier of their country—due to actual use by people in European countries who worked with and for the Nazi German occupiers. Linguistically, "collaboration" implies more or less equal partners who work together—which was the meaning the Nazi German occupiers were suggesting for ideological reasons but was obviously not the case as one party was an army of occupation and the other were people of the occupied country living under the power of this army. Thus, the term "collaboration" acquired during World War II the additional sense of criminal deeds in the service of the occupying power, including complicity with the occupying power in murder, persecutions, pillage, and economic exploitation as well as participation in a puppet government.

The use of "collaboration" to mean "traitorous cooperation with the enemy," dates from 1940, originally in reference to the Vichy Regime in France, the French civilians who sympathised with Nazi Germany's doctrine, and voluntary troops (LVF) who fought against the Free French and later De Gaulle's French Force. Since then, the words *collaboration* and *collaborateur* may have this very pejorative meaning in French (and the abbreviation *collabo* has only this pejorative and insulting meaning). Nonetheless, *collaboration* and *collaborateur* have kept in French their original positive acceptations –with, for example, *collaborateur* still commonly used in referring to co-workers.

In order to make a distinction, the more specific term Collaborationism is often used for this phenomenon of collaboration with an occupying army. However, there is no water-tight distinction; "Collaboration" and "Collaborator", as well as "Collaborationism" and "Collaborationist", are often used in this pejorative sense—and even more so, the equivalent terms in French and other languages spoken in countries which experienced direct Nazi occupation.

3.4 See also

- Classical music written in collaboration
- Collaborative editing
- Collaborative governance
- Collaborative innovation network
- Collaborative leadership
- Collaborative search engine
- Collaborative software
- Collaborative translation
- Community film
- Conference call
- Critical thinking
- Crowdsourcing
- Design thinking
- Digital Collaboration
- Facilitation
- Intranet portal
- Knowledge management
- Learning circle
- Postpartisan
- Role-based collaboration
- Telepresence
- The Culture of Collaboration

- Unorganisation
- Wikinomics
- Commons-based peer production

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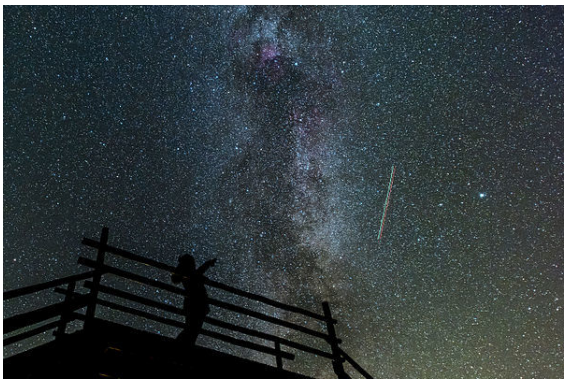
Chapter 4

Observation

"Observations" redirects here. For the travel book, see Observations (Pierre Belon).
For other uses, see Observation (disambiguation).

Observation is the active acquisition of information



Observer is someone who gathers information about observed phenomenon, but does not intervene. Observing the air traffic in Rõuge, Estonia.

from a primary source. In living beings, observation employs the senses. In science, observation can also involve the recording of data via the use of instruments. The term may also refer to any data collected during the scientific activity. Observations can be qualitative, that is, only the absence or presence of a property is noted, or quantitative if a numerical value is attached to the observed phenomenon by counting or measuring.

4.1 Observation in science

The scientific method requires observations of nature to formulate and test hypotheses.[1] It consists of these steps:[2][3]

1. Asking a question about a natural phenomenon
2. Making observations of the phenomenon
3. Hypothesizing an explanation for the phenomenon
4. Predicting logical, observable consequences of the hypothesis that have not yet been investigated
5. Testing the hypothesis' predictions by an experiment, observational study, field study, or simulation
6. Forming a conclusion from data gathered in the experiment, or making a revised/new hypothesis and repeating the process
7. Writing out a description of the method of observation and the results or conclusions reached
8. Review of the results by peers with experience researching the same phenomenon

Observations play a role in the second and fifth steps of the scientific method. However the need for reproducibility requires that observations by different observers can be comparable. Human sense impressions are subjective and qualitative, making them difficult to record or compare. The use of measurement developed to allow recording and comparison of observations made at different times and places, by different people. Measurement consists of using observation to compare the phenomenon being observed to a standard. The standard of comparison can be an artifact, process, or definition which can be duplicated or shared by all observers, if not by direct measurement then by counting the number of aspects or properties of the object that are comparable to the standard. Measurement reduces an observation to a number which can be recorded, and two observations which result in the same number are equal within the resolution of the process.

Senses are limited, and are subject to errors in perception such as optical illusions. Scientific instruments were developed to magnify human powers of observation, such as weighing scales, clocks, telescopes, microscopes, thermometers, cameras, and tape recorders, and also translate into perceptible form events that are unobservable by human senses, such as indicator dyes, voltmeters, spectrometers, infrared cameras, oscilloscopes, interferometers, geiger counters, x-ray machines, and radio receivers.

One problem encountered throughout scientific fields is that the observation may affect the process being observed, resulting in a different outcome than if the process was unobserved. This is called the *observer effect*.

For example, it is not normally possible to check the air pressure in an automobile tire without letting out some of the air, thereby changing the pressure. However, in most fields of science it is possible to reduce the effects of observation to insignificance by using better instruments.

Considered as a physical process itself, all forms of observation (human or instrumental) involve amplification and are thus thermodynamically irreversible processes, increasing entropy.

4.2 Observational paradoxes

In some specific fields of science the results of observation differ depending on factors which are not important in everyday observation. These are usually illustrated with "paradoxes" in which an event appears different when observed from two different points of view, seeming to violate "common sense".

- **Relativity:** In relativistic physics which deals with velocities close to the speed of light, it is found that different observers may observe different values for the length, time rates, mass, and many other properties of an object, depending on the observer's velocity relative to the object. For example, in the twin paradox one twin goes on a trip near the speed of light and comes home younger than the twin who stayed at home. This is not a paradox: time passes at a slower rate when measured from a frame moving with respect to the object. In relativistic physics, an observation must always be qualified by specifying the state of motion of the observer, its reference frame.

- **Quantum mechanics:** In quantum mechanics, which deals with the behavior of very small objects, it is not possible to observe a system without changing the system, and the "observer" must be considered part of the system being observed. In isolation, quantum objects are represented by a wave function which often exists in a superposition or mixture of different states. However, when an observation is made to determine the actual location or state of the object, it always finds the object in a single state, not a "mixture". The interaction of the observation process appears to "collapse" the wave function into a single state. So any interaction between an isolated wave function and the external world that results in this wave function collapse is called an *observation* or *measurement*, whether or not it is part of a deliberate observation process.

4.3 Biases

The human senses do not function like a video camcorder, impartially recording all observations.[4] Human perception occurs by a complex, unconscious process of abstraction, in which certain details of the incoming sense data are noticed and remembered, and the rest forgotten. What is kept and what is thrown away depends on an internal model or representation of the world, called by psychologists a *schema*, that is built up over our entire lives. The data is fitted into this schema. Later when events are remembered, memory gaps may even be filled by "plausible" data the mind makes up to fit the model; this is called *reconstructive memory*. How much attention the various perceived data are given depends on an internal value system, which judges how important it is to the individual. Thus two people can view the same event and come away with entirely different perceptions of it, even disagreeing about simple facts. This is why eyewitness testimony is notoriously unreliable.

Several of the more important ways observations can be affected by human psychology are given below.

4.3.1 Confirmation bias

Human observations are biased toward confirming the observer's conscious and unconscious expectations and view of the world; we "*see what we expect to see*".[5] In psychology, this is called confirmation bias.[5] Since the object of scientific research is the discovery of new phenomena, this bias can and has caused new discoveries to be overlooked. One example is the discovery of x-rays. It can also result in erroneous scientific support for widely held cultural myths, for example the scientific racism that supported ideas of racial superiority in the early 20th century.[6] Correct scientific technique emphasizes careful recording of observations, separating experimental observations from the conclusions drawn from them, and techniques such as blind or double blind experiments, to minimize observational bias.

4.3.2 "Cargo cult" science

Another bias, which has become more prevalent with the advent of "big science" and the large rewards of new discoveries, is bias in favor of the researcher's desired hypothesis or outcome; we "*see what we want to see*". Called pathological science and cargo cult science, this is different from deliberate falsification of results, and can happen to good-faith researchers. Researchers with a great incentive or desire for a given outcome can misinterpret or misjudge results, or even persuade themselves they have seen something they haven't. Possible examples of mistaken discoveries caused by this bias are Martian "canals", N rays, polywater, cold fusion, and perpetual motion machines. Recent decades have seen scientific scandals

caused by researchers playing "fast and loose" with observational methods in order to get their pet theories published. This type of bias is rampant in pseudoscience, where correct scientific techniques are not followed. The main defense against this bias, besides correct research techniques, is peer review and repetition of the experiment, or the observation, by other researchers with no incentive to bias. For example, an emerging practice in the competitive field of biotechnology is to require the physical results of experiments, such as serums and tissue cultures, be made available to competing laboratories for independent testing.

4.3.3 Processing bias

Modern scientific instruments can extensively process "observations" before they are presented to the human senses, and particularly with computerized instruments, there is sometimes a question as to where in the data processing chain "observing" ends and "drawing conclusions" begins. This has recently become an issue with digitally enhanced images published as experimental data in papers in scientific journals. The images are enhanced to bring out features that the researcher wants to emphasize, but this also has the effect of supporting the researcher's conclusions. This is a form of bias that is difficult to quantify. Some scientific journals have begun to set detailed standards for what types of image processing are allowed in research results. Computerized instruments often keep a copy of the "raw data" from sensors before processing, which is the ultimate defense against processing bias, and similarly scientific standards require preservation of the original unenhanced "raw" versions of images used as research data.

4.3.4 Observational bias

An observational bias occurs when researchers only look where they think they will find positive results, or where it is easy to record observations. This is called the "streetlight effect".[7]

4.4 Observations in philosophy

> "Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and to make new ones like them."
> — Meditations. iv. 36. – Marcus Aurelius

Observation in philosophical terms is the process of filtering sensory information through the thought process. Input is received via hearing, sight, smell, taste, or touch and then analyzed through either rational or irrational thought. You *see* a parent beat their child; you *observe* that such an action is either good or bad. Deductions about what behaviors are good or bad may be based in no way on preferences about building relationships, or study of the consequences resulting from the observed behavior. With the passage of time, impressions stored in the consciousness about many related observations, together with the resulting relationships and consequences, permit the individual to build a construct about the moral implications of behavior.

4.5 See also

- Introspection
- List of cognitive biases
- Naturalistic observation
- Observational astronomy
- Observational error
- Observational learning
- Observational study
- Observable quantity
- Observations and Measurements
- Observatory
- Observer effect
    - Uncertainty principle

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Chapter 5

Attention

This article is about the psychological concept of attention. For other uses, see Attention (disambiguation).

Attention is the behavioral and cognitive process of selectively concentrating on a discrete aspect of information, whether deemed subjective or objective, while ignoring other perceivable information. It is the taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought. Focalization, concentration of consciousness are of its essence. Attention has also been referred to as the allocation of limited processing resources.[1]

Focused attention

Attention remains a major area of investigation within education, psychology, neuroscience, cognitive neuroscience, and neuropsychology. Areas of active investigation involve determining the source of the sensory cues and signals that generate attention, the effects of these sensory cues and signals on the tuning properties of sensory neurons, and the relationship between attention and other behavioral and cognitive processes like working memory and vigilance. A relatively new body of research, which expands upon earlier research within neuropsychology, is investigating the diagnostic symptoms associated with traumatic brain injuries and their effects on attention. Attention also varies across cultures.[2]

The relationships between attention and consciousness are complex enough that they have warranted perennial philosophical exploration. Such exploration is both ancient and continually relevant, as it can have effects in fields ranging from mental health and the study of disorders of consciousness to artificial intelligence and its domains of research and development.

5.1 Contemporary definition and research

Prior to the founding of psychology as a scientific discipline, attention was studied in the field of philosophy. Due to this, many of the discoveries in the field of Attention were made by philosophers. Psychologist John Watson cites Juan Luis Vives as the Father of Modern Psychology due to his book *De Anima et Vita* ("*The Soul and Life*") in which Vives was the first to recognize the importance of empirical investigation.[3] In his work on memory, Vives found that the more closely one attends to stimuli, the better they will be retained.

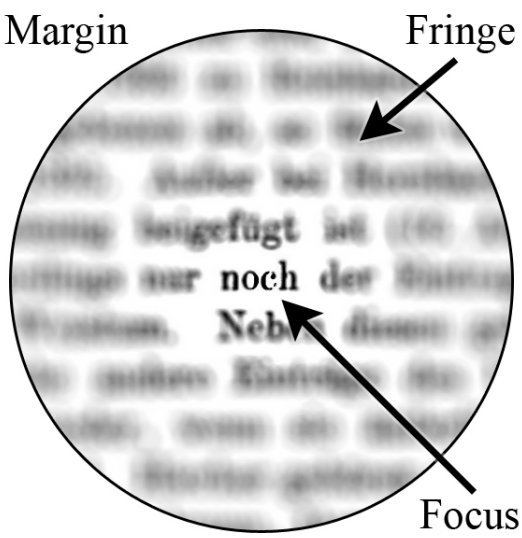
By the 1990s, psychologists began using PET and later fMRI to image the brain while monitoring attention tasks. Because of the highly expensive equipment that was generally only available in hospitals, psychologists sought for cooperation with neurologists. Pioneers of brain imaging studies of selective attention are psychologist Michael Posner (then already renowned for his seminal work on visual selective attention) and neurologist Marcus Raichle.[4] Their results soon sparked interest from the entire neuroscience community in these psychological studies, which had until then focused on monkey brains. With the development of these technological innovations neuroscientists became interested in this type of research that combines sophisticated experimental paradigms from cognitive psychology with these new brain imaging techniques. Although the older technique of EEG had long been used to study the brain activity underlying selective attention by cognitive psychophysiologists, the ability of the newer techniques to actually measure precisely localized activity inside the brain generated renewed interest by a wider community of researchers. The results of these experiments have shown

a broad agreement with the psychological, psychophysiological and the experiments performed on monkeys.

5.2 Selective and visual

See also: Selective auditory attention

In cognitive psychology there are at least two mod-



els which describe how visual attention operates. These models may be considered loosely as metaphors which are used to describe internal processes and to generate hypotheses that are falsifiable. Generally speaking, visual attention is thought to operate as a two-stage process.[5] In the first stage, attention is distributed uniformly over the external visual scene and processing of information is performed in parallel. In the second stage, attention is concentrated to a specific area of the visual scene (i.e., it is focused), and processing is performed in a serial fashion.

The first of these models to appear in the literature is the spotlight model. The term "spotlight" was inspired by the work of William James, who described attention as having a focus, a margin, and a fringe.[6] The focus is an area that extracts information from the visual scene with a high-resolution, the geometric center of which being where visual attention is directed. Surrounding the focus is the fringe of attention, which extracts information in a much more crude fashion (i.e., low-resolution). This fringe extends out to a specified area, and the cut-off is called the margin.

The second model is called the zoom-lens model and was first introduced in 1986.[7] This model inherits all properties of the spotlight model (i.e., the focus, the fringe, and the margin), but it has the added property of changing in size. This size-change mechanism was inspired by the zoom lens one might find on a camera, and any change in size can be described by a trade-off in the efficiency of processing.[8] The zoom-lens of attention can be described in terms of an inverse trade-off between the size of focus and the efficiency of processing: because attentional resources are assumed to be fixed, then it follows that the larger the focus is, the slower processing will be of that region of the visual scene, since this fixed resource will be distributed over a larger area. It is thought that the focus of attention can subtend a minimum of 1° of visual angle,[6][9] however the maximum size has not yet been determined.

A significant debate emerged in the last decade of the 20th century in which Treisman's 1993 Feature Integration Theory (FIT) was compared to Duncan and Humphrey's 1989 attentional engagement theory (AET).[10] FIT posits that "objects are retrieved from scenes by means of selective spatial attention that picks out objects' features, forms feature maps, and integrates those features that are found at the same location into forming objects." Duncan and Humphrey's AET understanding of attention maintained that "there is an initial pre-attentive parallel phase of perceptual segmentation and analysis that encompasses all of the visual items present in a scene. At this phase, descriptions of the objects in a visual scene are generated into structural units; the outcome of this parallel phase is a multiple-spatial-scale structured representation. Selective attention intervenes after this stage to select information that will be entered into visual short-term memory."[10] The contrast of the two theories placed a new emphasis on the separation of visual attention tasks alone and those mediated by supplementary cognitive processes. As Rastophopoulos summarizes the debate: "Against Treisman's FIT, which posits spatial attention as a necessary condition for detection of objects, Humphreys argues that visual elements are encoded and bound together in an initial parallel phase without focal attention, and that attention serves to select among the objects that result from this initial grouping."[11]

5.3 Neuropsychological model

In the twentieth century, the pioneering research of Lev Vygotsky and Alexander Luria led to the three-part model of neuropsychology defining the working brain as being represented by three co-active processes listed as Attention, Memory, and Activation. Attention is identified as one of the three major co-active processes of the working brain. A.R. Luria published his well-known book *The Working Brain* in 1973 as a concise adjunct volume to his previous 1962 book *Higher Cortical Functions in Man*. In this volume, Luria summarized his three-part global theory of the working brain as being composed of three constantly co-active processes which he described as the; (1) Attention system, (2) Mnestic (memory) system, and (3) Cortical activation system. The two books together are considered by Homskaya's account as "among Luria's ma-

jor works in neuropsychology, most fully reflecting all the aspects (theoretical, clinical, experimental) of this new discipline."[12] The product of the combined research of Vygotsky and Luria have determined a large part of the contemporary understanding and definition of attention as it is understood at the start of the 21st-century.

5.4 Multitasking and divided

See also: Human multitasking and Distracted driving

Multitasking can be defined as the attempt to perform two or more tasks simultaneously; however, research shows that when multitasking, people make more mistakes or perform their tasks more slowly.[13] Attention must be divided among all of the component tasks to perform them. In divided attention,individuals attend or give attention to multiple sources of information at once at the same time or perform more than one task.[14]

Older research involved looking at the limits of people performing simultaneous tasks like reading stories, while listening and writing something else,[15] or listening to two separate messages through different ears (i.e., dichotic listening). Generally, classical research into attention investigated the ability of people to learn new information when there were multiple tasks to be performed, or to probe the limits of our perception (c.f. Donald Broadbent). There is also older literature on people's performance on multiple tasks performed simultaneously, such as driving a car while tuning a radio[16] or driving while telephoning.[17]

The vast majority of current research on human multitasking is based on performance of doing two tasks simultaneously,[13] usually that involves driving while performing another task, such as texting, eating, or even speaking to passengers in the vehicle, or with a friend over a cellphone. This research reveals that the human attentional system has limits for what it can process: driving performance is worse while engaged in other tasks; drivers make more mistakes, brake harder and later, get into more accidents, veer into other lanes, and/or are less aware of their surroundings when engaged in the previously discussed tasks.[18][19][20]

There has been little difference found between speaking on a hands-free cell phone or a hand-held cell phone,[21][22] which suggests that it is the strain of attentional system that causes problems, rather than what the driver is doing with his or her hands. While speaking with a passenger is as cognitively demanding as speaking with a friend over the phone,[23] passengers are able to change the conversation based upon the needs of the driver. For example, if traffic intensifies, a passenger may stop talking to allow the driver to navigate the increasingly difficult roadway; a conversation partner over a phone would not be aware of the change in environment.

There have been multiple theories regarding divided attention. One, conceived by Kahneman,[24] explains that there is a single pool of attentional resources that can be freely divided among multiple tasks. This model seems to be too oversimplified, however, due to the different modalities (e.g., visual, auditory, verbal) that are perceived.[25] When the two simultaneous tasks use the same modality, such as listening to a radio station and writing a paper, it is much more difficult to concentrate on both because the tasks are likely to interfere with each other. The specific modality model was theorized by Navon and Gopher in 1979. Although this model is more adequate at explaining divided attention among simple tasks, resource theory is another, more accurate metaphor for explaining divided attention on complex tasks. Resource theory states that as each complex task is automatized, performing that task requires less of the individual's limited-capacity attentional resources.[25]

Other variables play a part in our ability to pay attention to and concentrate on many tasks at once. These include, but are not limited to, anxiety, arousal, task difficulty, and skills.[25]

5.5 Simultaneous

Simultaneous attention is a type of attention, classified by attending to multiple events at the same time. Simultaneous attention is demonstrated by children in Indigenous communities, who learn through this type of attention to their surroundings.[26] Simultaneous attention is present in the ways in which children of indigenous background interact both with their surroundings, and with other individuals. Simultaneous attention requires focus on multiple, simultaneous, activities or occurrences. This differs from multitasking which is characterized by alternating attention and focus between multiple activities; that is, halting one activity before switching to the next.

Simultaneous attention involves uninterrupted attention to several activities occurring at the same time. Another cultural practice that may relate to simultaneous attention strategies is coordination within a group. Indigenous heritage toddlers and caregivers in San Pedro were observed to frequently coordinate their activities with other members of a group in ways parallel to a model of simultaneous attention, whereas middle-class European-descent families in the U.S. would move back and forth between events.[2][27] Research concludes that children with close ties to Indigenous American roots have a high tendency to be especially wide, keen observers.[28] This points to a strong cultural difference in attention management.

5.6 Alternative topics and discussions

5.6.1 Overt and covert orienting

Attention may be differentiated into "overt" versus "covert" orienting.[29]

Overt orienting is the act of selectively attending to an item or location over others by moving the eyes to point in that direction.[30] Overt orienting can be directly observed in the form of eye movements. Although overt eye movements are quite common, there is a distinction that can be made between two types of eye movements; reflexive and controlled. Reflexive movements are commanded by the superior colliculus of the midbrain. These movements are fast and are activated by the sudden appearance of stimuli. In contrast, controlled eye movements are commanded by areas in the frontal lobe. These movements are slow and voluntary.

Covert orienting is the act to mentally shifting one's focus without moving one's eyes.[6][30][31] Simply, it is changes in attention that are not attributable to overt eye movements. Covert orienting has the potential to affect the output of perceptual processes by governing attention to particular items or locations (for example, the activity of a V4 neuron whose receptive field lies on an attended stimuli will be enhanced by covert attention)[32] but does not influence the information that is processed by the senses. Researchers often use "filtering" tasks to study the role of covert attention of selecting information. These tasks often require participants to observe a number of stimuli, but attend to only one.
The current view is that visual covert attention is a mechanism for quickly scanning the field of view for interesting locations. This shift in covert attention is linked to eye movement circuitry that sets up a slower saccade to that location.

There are studies that suggest the mechanisms of overt and covert orienting may not be as separate as previously believed. This is due to the fact that central mechanisms that may control covert orienting, such as the parietal lobe also receive input from subcortical centres involved in overt orienting.[30] General theories of attention actively assume bottom-up (covert) processes and top-down (overt) processes converge on a common neural architecture.[33] For example, if individuals attend to the right hand corner field of view, movement of the eyes in that direction may have to be actively suppressed.

5.6.2 Exogenous and endogenous orienting

Orienting attention is vital and can be controlled through external (exogenous) or internal (endogenous) processes. However, comparing these two processes is challenging because external signals do not operate completely exogenously, but will only summon attention and eye movements if they are important to the subject.[30]

Exogenous (from Greek *exo*, meaning "outside", and *genein*, meaning "to produce") orienting is frequently described as being under control of a stimulus.[34] Exogenous orienting is considered to be reflexive and automatic and is caused by a sudden change in the periphery. This often results in a reflexive saccade. Since exogenous cues are typically presented in the periphery, they are referred to as *peripheral cues*. Exogenous orienting can even be observed when individuals are aware that the cue will not relay reliable, accurate information about where a target is going to occur. This means that the mere presence of an exogenous cue will affect the response to other stimuli that are subsequently presented in the cue's previous location.[35]

Several studies have investigated the influence of valid and invalid cues.[30][36][37][38] They concluded that valid peripheral cues benefit performance, for instance when the peripheral cues are brief flashes at the relevant location before to the onset of a visual stimulus. Posner and Cohen (1984) noted a reversal of this benefit takes place when the interval between the onset of the cue and the onset of the target is longer than about 300 ms.[39] The phenomenon of valid cues producing longer reaction times than invalid cues is called inhibition of return.

Endogenous (from Greek *endo*, meaning "within" or "internally") orienting is the intentional allocation of attentional resources to a predetermined location or space. Simply stated, endogenous orienting occurs when attention is oriented according to an observer's goals or desires, allowing the focus of attention to be manipulated by the demands of a task. In order to have an effect, endogenous cues must be processed by the observer and acted upon purposefully. These cues are frequently referred to as *central cues*. This is because they are typically presented at the center of a display, where an observer's eyes are likely to be fixated. Central cues, such as an arrow or digit presented at fixation, tell observers to attend to a specific location.[40]

When examining differences between exogenous and endogenous orienting, some researchers suggest that there are four differences between the two kinds of cues:

- exogenous orienting is less affected by cognitive load than endogenous orienting;
- observers are able to ignore endogenous cues but not exogenous cues;
- exogenous cues have bigger effects than endogenous cues; and
- expectancies about cue validity and predictive value affects endogenous orienting more than exogenous orienting.[41]

There exist both overlaps and differences in the areas of the brain that are responsible for endogenous and exogenous orientating.[42] Another approach to this discussion has been covered under the topic heading of "bottom-up"

versus "top-down" orientations to attention. Researchers of this school have described two different aspects of how the mind focuses attention to items present in the environment. The first aspect is called bottom-up processing, also known as stimulus-driven attention or exogenous attention. These describe attentional processing which is driven by the properties of the objects themselves. Some processes, such as motion or a sudden loud noise, can attract our attention in a pre-conscious, or non-volitional way. We attend to them whether we want to or not.[43] These aspects of attention are thought to involve parietal and temporal cortices, as well as the brainstem.[44]

The second aspect is called top-down processing, also known as goal-driven, endogenous attention, attentional control or executive attention. This aspect of our attentional orienting is under the control of the person who is attending. It is mediated primarily by the frontal cortex and basal ganglia[44][45] as one of the executive functions.[30][44] Research has shown that it is related to other aspects of the executive functions, such as working memory,[46] and conflict resolution and inhibition.[47]

5.6.3 Influence of processing load

One theory regarding selective attention is the cognitive load theory, which states that there are two mechanisms that affect attention: cognitive and perceptual. The perceptual considers the subject's ability to perceive or ignore stimuli, both task-related and non task-related. Studies show that if there are many stimuli present (especially if they are task-related), it is much easier to ignore the non-task related stimuli, but if there are few stimuli the mind will perceive the irrelevant stimuli as well as the relevant. The cognitive refers to the actual processing of the stimuli, studies regarding this showed that the ability to process stimuli decreased with age, meaning that younger people were able to perceive more stimuli and fully process them, but were likely to process both relevant and irrelevant information, while older people could process fewer stimuli, but usually processed only relevant information.[48]

Some people can process multiple stimuli, e.g. trained morse code operators have been able to copy 100% of a message while carrying on a meaningful conversation. This relies on the reflexive response due to "overlearning" the skill of morse code reception/detection/transcription so that it is an autonomous function requiring no specific attention to perform.

5.6.4 Clinical model

Attention is best described as the sustained focus of cognitive resources on information while filtering or ignoring extraneous information. Attention is a very basic function that often is a precursor to all other neurological/cognitive functions. As is frequently the case, clinical models of attention differ from investigation models. One of the most used models for the evaluation of attention in patients with very different neurologic pathologies is the model of Sohlberg and Mateer.[49] This hierarchic model is based in the recovering of attention processes of brain damage patients after coma. Five different kinds of activities of growing difficulty are described in the model; connecting with the activities those patients could do as their recovering process advanced.

- **Focused attention:** The ability to respond discretely to specific visual, auditory or tactile stimuli.
- **Sustained attention (vigilance and concentration):** The ability to maintain a consistent behavioral response during continuous and repetitive activity.
- **Selective attention:** The ability to maintain a behavioral or cognitive set in the face of distracting or competing stimuli. Therefore, it incorporates the notion of "freedom from distractibility."
- **Alternating attention:** The ability of mental flexibility that allows individuals to shift their focus of attention and move between tasks having different cognitive requirements.
- **Divided attention:** This is the highest level of attention and it refers to the ability to respond simultaneously to multiple tasks or multiple task demands.

This model has been shown to be very useful in evaluating attention in very different pathologies, correlates strongly with daily difficulties and is especially helpful in designing stimulation programs such as attention process training, a rehabilitation program for neurological patients of the same authors.

5.6.5 Neural correlates

Most experiments show that one neural correlate of attention is enhanced firing. If a neuron has a certain response to a stimulus when the animal is not attending to the stimulus, then when the animal does attend to the stimulus, the neuron's response will be enhanced even if the physical characteristics of the stimulus remain the same.

In a 2007 review, Knudsen[50] describes a more general model which identifies four core processes of attention, with working memory at the center:

- Working memory temporarily stores information for detailed analysis.
- Competitive selection is the process that determines which information gains access to working memory.

- Through top-down sensitivity control, higher cognitive processes can regulate signal intensity in information channels that compete for access to working memory, and thus give them an advantage in the process of competitive selection. Through top-down sensitivity control, the momentary content of working memory can influence the selection of new information, and thus mediate voluntary control of attention in a recurrent loop (endogenous attention).[51]

- Bottom-up saliency filters automatically enhance the response to infrequent stimuli, or stimuli of instinctive or learned biological relevance (exogenous attention).[51]

Neurally, at different hierarchical levels spatial maps can enhance or inhibit activity in sensory areas, and induce orienting behaviors like eye movement.

- At the top of the hierarchy, the frontal eye fields (FEF) on the dorsolateral frontal cortex contain a retinocentric spatial map. Microstimulation in the FEF induces monkeys to make a saccade to the relevant location. Stimulation at levels too low to induce a saccade will nonetheless enhance cortical responses to stimuli located in the relevant area.

- At the next lower level, a variety of spatial maps are found in the parietal cortex. In particular, the lateral intraparietal area (LIP) contains a saliency map and is interconnected both with the FEF and with sensory areas.

- Certain automatic responses that influence attention, like orienting to a highly salient stimulus, are mediated subcortically by the superior colliculi.

- At the neural network level, it is thought that processes like lateral inhibition mediate the process of competitive selection.

In many cases attention produces changes in the EEG. Many animals, including humans, produce gamma waves (40–60 Hz) when focusing attention on a particular object or activity.[52][53][54][55]

Another commonly used model for the attention system has been put forth by researchers such as Michael Posner. He divides attention into three functional components: alerting, orienting, and executive attention.[44][56]

- Alerting is the process involved in becoming and staying attentive toward the surroundings. It appears to exist in the frontal and parietal lobes of the right hemisphere, and is modulated by norepinephrine.[57][58]

- Orienting is the directing of attention to a specific stimulus.

- Executive attention is used when there is a conflict between multiple attention cues. It is essentially the same as the central executive in Baddeley's model of working memory. The Eriksen flanker task has shown that the executive control of attention may take place in the anterior cingulate cortex[59]

5.6.6 Cultural variation

Children appear to develop patterns of attention related to the cultural practices of their families, communities, and the institutions in which they participate.[60]

In 1955, Jules Henry suggested that there are societal differences in sensitivity to signals from many ongoing sources that call for the awareness of several levels of attention simultaneously. He tied his speculation to ethnographic observations of communities in which children are involved in a complex social community with multiple relationships.[61]

Many Indigenous children in the Americas predominantly learn by observing and pitching in. There are several studies to support that the use of keen attention towards learning is much more common in Indigenous communities of North and Central America than in a middle-class setting.[62] This is a direct result of the learning by observing and pitching in model.

Keen attention is both a requirement and result of learning by observing and pitching-in. Incorporating the children in the community gives them the opportunity to keenly observe and contribute to activities that were not directed towards them. It can be seen from different Indigenous communities and cultures, such as the Mayans of San Pedro, that children can simultaneously attend to multiple events.[61] Most Maya children have learned to pay attention to several events at once in order to make useful observations.[63]

One example is simultaneous attention which involves uninterrupted attention to several activities occurring at the same time. Another cultural practice that may relate to simultaneous attention strategies is coordination within a group. San Pedro toddlers and caregivers frequently coordinated their activities with other members of a group in multiway engagements rather than in a dyadic fashion.[2][27] Research concludes that children with close ties to Indigenous American roots have a high tendency to be especially keen observers.[28]

This learning by observing and pitching-in model requires active levels of attention management. The child is present while caretakers engage in daily activities and responsibilities such as: weaving, farming, and other skills necessary for survival. Being present allows the child to focus their attention on the actions being performed by their parents, elders, and/or older siblings.[62] In order to learn in this way, keen attention and focus is required. Eventually the child is expected to be able to perform

these skills themselves.

5.6.7 Modelling

In the domain of computer vision, efforts have been made in modelling the mechanism of human attention, especially the bottom-up attentional mechanism.[64]

Generally speaking, there are two kinds of models to mimic the bottom-up saliency mechanism. One way is based on the spatial contrast analysis. For example, a center–surround mechanism has been used to define saliency across scales, inspired by the putative neural mechanism.[65] It has also been hypothesized that some visual inputs are intrinsically salient in certain background contexts and that these are actually task-independent. This model has established itself as the exemplar for saliency detection and consistently used for comparison in the literature;[64] the other way is based on the frequency domain analysis. This method was first proposed by Hou et al.,[66] this method was called SR, and then PQFT method was also introduced. Both SR and PQFT only use the phase information.[64] In 2012, the HFT method was introduced, and both the amplitude and the phase information are made use of.[67]

5.6.8 Hemispatial neglect

Main article: Hemispatial neglect

Hemispatial neglect, also called *unilateral neglect*, often occurs when people have damage to their right hemisphere.[68] This damage often leads to a tendency to ignore the left side of one's body or even the left side of an object that can be seen. Damage to the left side of the brain (the left hemisphere) rarely yields significant neglect of the right side of the body or object in the person's local environments.[69]

The effects of spatial neglect, however, may vary and differ depending on what area of the brain was damaged. Damage to different neural substrates can result in different types of neglect. Attention disorders (lateralized and nonlaterized) may also contribute to the symptoms and effects.[69] Much research has asserted that damage to gray matter within the brain results in spatial neglect.[70]

New technology has yielded more information, such that there is a large, distributed network of frontal, parietal, temporal, and subcortical brain areas that have been tied to neglect.[71] This network can be related to other research as well; the dorsal attention network is tied to spatial orienting.[72] The effect of damage to this network may result in patients neglecting their left side when distracted about their right side or an object on their right side.<rfaulty breaks"Kalat, J. W. 2013"/>

5.6.9 Attention in social contexts

Social attention is one special form of attention that involves the allocation of limited processing resources in a social context. Previous studies on social attention often regard how attention is directed toward socially relevant stimuli such as faces and gaze directions of other individuals.[73] In contrast to attending-to-others, a different line of researches has shown that self-related information such as own face and name automatically captures attention and is preferentially processed comparing to other-related information.[74] These contrasting effects between attending-to-others and attending-to-self prompt a synthetic view in a recent Opinion article [75] proposing that social attention operates at two polarizing states: In one extreme, individual tends to attend to the self and prioritize self-related information over others', and, in the other extreme, attention is allocated to other individuals to infer their intentions and desires. Attending-to-self and attending-to-others mark the two ends of an otherwise continuum spectrum of social attention. For a given behavioral context, the mechanisms underlying these two polarities might interact and compete with each other in order to determine a saliency map of social attention that guides our behaviors.[75] An imbalanced competition between these two behavioral and cognitive processes will cause cognitive disorders and neurological symptoms such as autism spectrum disorders and Williams syndrome.

5.7 History of the study

5.7.1 Philosophical period

Psychologist Daniel E. Berlyne credits the first extended treatment of attention to philosopher Nicolas Malebranche in his work "The Search After Truth". "Malebranche held that we have access to ideas, or mental representations of the external world, but not direct access to the world itself."[3] Thus in order to keep these ideas organized, attention is necessary. Otherwise we will confuse these ideas. Malebranche writes in "The Search After Truth", "because it often happens that the understanding has only confused and imperfect perceptions of things, it is truly a cause of our errors.... It is therefore necessary to look for means to keep our perceptions from being confused and imperfect. And, because, as everyone knows, there is nothing that makes them clearer and more distinct than attentiveness, we must try to find the means to become more attentive than we are".[76] According to Malebranche, attention is crucial to understanding and keeping thoughts organized.

Philosopher Gottfried Wilhelm Leibniz introduced the concept of apperception to this philosophical approach to attention. Apperception refers to "the process by which new experience is assimilated to and transformed by the

residuum of past experience of an individual to form a new whole."[77] Apperception is required for a perceived event to become a conscious event. Leibniz emphasized a reflexive involuntary view of attention known as exogenous orienting. However, there is also endogenous orienting which is voluntary and directed attention. Philosopher Johann Friedrich Herbart agreed with Leibniz's view of apperception however he expounded on it in by saying that new experiences had to be tied to ones already existing in the mind. Herbart was also the first person to stress the importance of applying mathematical modeling to the study of psychology.[3]

It was previously thought in the beginning of the 19th century that people were not able to attend to more than one stimulus at a time. However, with research contributions by Sir William Hamilton, 9th Baronet this view was changed. Hamilton proposed a view of attention that likened its capacity to holding marbles. You can only hold a certain amount of marbles at a time before it starts to spill over. His view states that we can attend to more than one stimulus at once. William Stanley Jevons later expanded this view and stated that we can attend to up to four items at a time .

During this period of attention, various philosophers made significant contributions to the field. They began the research on the extent of attention and how attention is directed.

5.7.2 1860–1909

This period of attention research took the focus from conceptual findings to experimental testing. It also involved psychophysical methods that allowed measurement of the relation between physical stimulus properties and the psychological perceptions of them. This period covers the development of attentional research from the founding of psychology to 1909.

Wilhelm Wundt introduced the study of attention to the field of psychology. Wundt measured mental processing speed by likening it to differences in stargazing measurements. Astronomers in this time would measure the time it took for stars to travel. Among these measurements when astronomers recorded the times, there were personal differences in calculation. These different readings resulted in different reports from each astronomer. To correct for this, a personal equation was developed. Wundt applied this to mental processing speed. Wundt realized that the time it takes to see the stimulus of the star and write down the time was being called an "observation error" but actually was the time it takes to switch voluntarily one's attention from one stimulus to another. Wundt called his school of psychology voluntarism. It was his belief that psychological processes can only be understood in terms of goals and consequences.

Franciscus Donders used mental chronometry to study attention and it was considered a major field of intellectual inquiry by authors such as Sigmund Freud. Donders and his students conducted the first detailed investigations of the speed of mental processes. Donders measured the time required to identify a stimulus and to select a motor response. This was the time difference between stimulus discrimination and response initiation. Donders also formalized the subtractive method which states that the time for a particular process can be estimated by adding that process to a task and taking the difference in reaction time between the two tasks. He also differentiated between three types of reactions: simple reaction, choice reaction, and go/no-go reaction.

Hermann von Helmholtz also contributed to the field of attention relating to the extent of attention. Von Helmholtz stated that it is possible to focus on one stimulus and still perceive or ignore others. An example of this is being able to focus on the letter u in the word house and still perceiving the letters h, o, s, and e.

One major debate in this period was whether it was possible to attend to two things at once (split attention). Walter Benjamin described this experience as "reception in a state of distraction." This disagreement could only be resolved through experimentation.

In 1890, William James, in his textbook *The Principles of Psychology*, remarked:

James differentiated between sensorial attention and intellectual attention. Sensorial attention is when attention is directed to objects of sense, stimuli that are physically present. Intellectual attention is attention directed to ideal or represented objects; stimuli that are not physically present. James also distinguished between immediate or derived attention: attention to the present versus to something not physically present. According to James, attention has five major effects. Attention works to make us perceive, conceive, distinguish, remember, and shorten reactions time.

5.7.3 1910–1949

During this period, research in attention waned and interest in behaviorism flourished, leading some to believe, like Ulric Neisser, that in this period, "There was no research on attention". However, Jersild published very important work on "Mental Set and Shift" in 1927. He stated, "The fact of mental set is primary in all conscious activity. The same stimulus may evoke any one of a large number of responses depending upon the contextual setting in which it is placed".[79] This research found that the time to complete a list was longer for mixed lists than for pure lists. For example, if a list was names of animals versus a list with names of animals, books, makes and models of cars, and types of fruits, it takes longer to process. This is task switching.

In 1931, Telford discovered the psychological refractory period. The stimulation of neurons is followed by a re-

fractory phase during which neurons are less sensitive to stimulation. In 1935 John Ridley Stroop developed the Stroop Task which elicited the Stroop Effect. Stroop's task showed that irrelevant stimulus information can have a major impact on performance. In this task, subjects were to look at a list of colors. This list of colors had each color typed in a color different from the actual text. For example, the word Blue would be typed in Orange, Pink in Black, and so on.

Example: **Blue Purple Red Green Purple Green**

Subjects were then instructed to say the name of the ink color and ignore the text. It took 110 seconds to complete a list of this type compared to 63 seconds to name the colors when presented in the form of solid squares.[3] The naming time nearly doubled in the presence of conflicting color words, an effect known as the Stroop Effect.

5.7.4 1950–1974

In the 1950s, research psychologists renewed their interest in attention when the dominant epistemology shifted from positivism (i.e., behaviorism) to realism during what has come to be known as the "cognitive revolution".[80] The cognitive revolution admitted unobservable cognitive processes like attention as legitimate objects of scientific study.

Modern research on attention began with the analysis of the "cocktail party problem" by Colin Cherry in 1953. At a cocktail party how do people select the conversation that they are listening to and ignore the rest? This problem is at times called "focused attention", as opposed to "divided attention". Cherry performed a number of experiments which became known as dichotic listening and were extended by Donald Broadbent and others.[81] In a typical experiment, subjects would use a set of headphones to listen to two streams of words in different ears and selectively attend to one stream. After the task, the experimenter would question the subjects about the content of the unattended stream.

Broadbent's Filter Model of Attention states that information is held in a pre-attentive temporary store, and only sensory events that have some physical feature in common are selected to pass into the limited capacity processing system. This implies that the meaning of unattended messages is not identified. Also, a significant amount of time is required to shift the filter from one channel to another. Experiments by Gray and Wedderburn and later Anne Treisman pointed out various problems in Broadbent's early model and eventually led to the Deutsch–Norman model in 1968. In this model, no signal is filtered out, but all are processed to the point of activating their stored representations in memory. The point at which attention becomes "selective" is when one of the memory representations is selected for further processing. At any time, only one can be selected, resulting in the *attentional bottleneck*.[82]

This debate became known as the early-selection vs. late-selection models. In the early selection models (first proposed by Donald Broadbent), attention shuts down (in Broadbent's model) or attenuates (in Triesman's refinement) processing in the unattended ear before the mind can analyze its semantic content. In the late selection models (first proposed by J. Anthony Deutsch and Diana Deutsch), the content in both ears is analyzed semantically, but the words in the unattended ear cannot access consciousness.[83] This debate has still not been resolved.

In the 1960s, Robert Wurtz at the National Institutes of Health began recording electrical signals from the brains of macaques who were trained to perform attentional tasks. These experiments showed for the first time that there was a direct neural correlate of a mental process (namely, enhanced firing in the superior colliculus).[84]

5.8 See also

- Attention restoration theory
- Attention seeking
- Attention span
- Attention-deficit hyperactivity disorder
- Attentional control
- Attentional shift
- Binding problem
- Cognitive inhibition
- Crossmodal attention
- Deconcentration of attention
- Focusing
- Informal learning
- Joint attention
- Nonverbal communication
- Observational Learning
- Ovsiankina effect
- Perceptual learning#The role of attention
- Split attention effect
- Vigilance
- Visual search
- Working memory

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Chapter 6

Awareness

Awareness is the ability to directly know and perceive, to feel, or to be cognizant of events. More broadly, it is the state or quality of being conscious of something.

6.1 Concept

Awareness is a relative concept. Awareness may be focused on an internal state, such as a visceral feeling, or on external events by way of sensory perception. Awareness provides the raw material from which animals develop qualia, or subjective ideas about their experience. Insects have awareness that you are trying to swat them or chase after them. But insects do not have consciousness in the usual sense, because they lack the brain capacity for thought and understanding.

6.2 Self-awareness

Main article: Self-awareness

Popular ideas about consciousness suggest the phenomenon describes a condition of being aware of one's awareness or, self-awareness.[1] Efforts to describe consciousness in neurological terms have focused on describing networks in the brain that develop awareness of the qualia developed by other networks.[2]

6.3 Neuroscience

Neural systems that regulate attention serve to attenuate awareness among complex animals whose central and peripheral nervous system provides more information than cognitive areas of the brain can assimilate. Within an attenuated system of awareness, a mind might be aware of much more than is being contemplated in a focused extended consciousness.

6.3.1 Basic awareness

Basic awareness of one's internal and external world depends on the brain stem. Bjorn Merker,[3] an independent neuroscientist in Stockholm, Sweden, argues that the brain stem supports an elementary form of conscious thought in infants with hydranencephaly. "Higher" forms of awareness including self-awareness require cortical contributions, but "primary consciousness" or "basic awareness" as an ability to integrate sensations from the environment with one's immediate goals and feelings in order to guide behavior, springs from the brain stem which human beings share with most of the vertebrates. Psychologist Carroll Izard emphasizes that this form of primary consciousness consists of the capacity to generate emotions and an awareness of one's surroundings, but not an ability to talk about what one has experienced. In the same way, people can become conscious of a feeling that they can't label or describe, a phenomenon that's especially common in pre-verbal infants.

Due to this discovery medical definitions of brain death as a lack of cortical activity face a serious challenge.

6.3.2 Basic interests

Down the brain stem lie interconnected regions that regulate the direction of eye gaze and organize decisions about what to do next, such as reaching for a piece of food or pursuing a potential mate.

6.3.3 Changes in awareness

The ability to consciously detect an image when presented at near-threshold stimulus varies across presentations. One factor is "baseline shifts" due to top down attention that modulates ongoing brain activity in sensory cortex areas that affects the neural processing of subsequent perceptual judgments.[4] Such top down biasing can occur through two distinct processes: an attention driven baseline shift in the alpha waves, and a decision bias reflected in gamma waves.[5]

6.4 Living systems view

Outside of neuroscience biologists, Humberto Maturana and Francisco Varela contributed their Santiago theory of cognition in which they wrote:

> Living systems are cognitive systems, and living as a process is a process of cognition. This statement is valid for all organisms, with or without a nervous system.[6]

This theory contributes a perspective that cognition is a process present at organic levels that we don't usually consider to be aware. Given the possible relationship between awareness and cognition, and consciousness, this theory contributes an interesting perspective in the philosophical and scientific dialogue of awareness and living systems theory.

6.5 Communications and information systems

In cooperative settings, awareness is a term used to denote "knowledge created through the interaction of an agent and its environment — in simple terms 'knowing what is going on'".[7] In this setting, awareness is meant to convey how individuals monitor and perceive the information surrounding their colleagues and the environment they are in. This information is incredibly useful and critical to the performance and success of collaborations.[8][9] Awareness can be further defined by breaking it down into a set of characteristics:[10]

- It is knowledge about the state of some environment
- Environments are continually changing, therefore awareness knowledge must be constantly maintained
- Individuals interact with the environment, and maintenance of awareness is accomplished through this interaction.
- It is generally part of some other activity – generally making it a secondary goal to the primary goal of the activity.

Different categories of awareness have been suggested based on the type of information being obtained or maintained:[11]

- Informal awareness is the sense of who's around and what are they up to. E.g. Information you might know from being collocated with an individual
- Social awareness is the information you maintain about a social or conversational context. This is a subtle awareness maintained through non-verbal cues, such as eye contact, facial express, etc.
- Group-structural awareness is the knowledge of others roles, responsibilities, status in a group. It is an understanding of group dynamics and the relationship another individual has to the group.
- Workspace awareness – this is a focus on the workspace's influence and mediation of awareness information, particularly the location, activity, and changes of elements within the workspace.

These categories are not mutually exclusive, as there can be significant overlap in what a particular type of awareness might be considered. Rather, these categories serve to help understand what knowledge might be conveyed by a particular type of awareness or how that knowledge might be conveyed. Workspace awareness is of particular interest to the CSCW community, due to the transition of workspaces from physical to virtual environments.

While the type of awareness above refers to knowledge a *person* might need in a particular situation, *context awareness* and *location awareness* refer to information a *computer system* might need in a particular situation. These concepts of large importance especially for AAA (authentication, authorization, accounting) applications.

The term of location awareness still is gaining momentum with the growth of ubiquitous computing. First defined with networked work positions (network location awareness), it has been extended to mobile phones and other mobile communicable entities. The term covers a common interest in whereabouts of remote entities, especially individuals and their cohesion in operation. The term of context awareness is a superset including the concept of location awareness. It extends the awareness to context features of an operational target as well as to context of an operational area.

6.6 Covert awareness

See also: Blindsight

Covert awareness is the knowledge of something without knowing it. Some patients with specific brain damage are for example unable to tell if a pencil is horizontal or vertical. They are however able to grab the pencil, using the correct orientation of the hand and wrist. This condition implies that some of the knowledge the mind possesses is delivered through alternate channels than conscious intent.

6.7 Other uses

Awareness forms a basic concept of the theory and practice of Gestalt therapy.

In general, "awareness" may also refer to public or common knowledge or understanding about a social, scientific, or political issue, and hence many movements try to foster "awareness" of a given subject, that is, "raising awareness". Examples include AIDS awareness and Multicultural awareness.

Awareness may refer to anesthesia awareness.

6.8 See also

- Awareness ribbon
- Choiceless awareness
- Consciousness
- Feldenkrais method
- Indefinite monism
- Philosophy of mind
- Raising awareness
- Yoga Nidra
- Legal awareness

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Chapter 7

Organizing Knowledge Cognitively

People store knowledge in many different ways. The main storage types are: Concepts, Schemes and Scripts, and Personal Theories.

7.1 Concepts

A concept is a system of grouping and categorizing our brain uses to sort and store information. Concepts change and adapt as the amount of knowledge about a particular subject changes and grows. For example, as a child we were told that dogs and cats are animals. The concept of an animal might have been something furry with four legs. As school progressed and we learned more about animals the concept changed to incorporate everything from mammals to amphibians to fish.

Limited concepts can lead to two things:

- undergeneralization - too narrow of a view of what or who are included in a concept, like thinking fish are not animals because they have no legs or fur.
- overgeneralization - placing things and ideas in a concept that are, in fact, not related to the concept, like thinking a chair is an animal because it has four legs. There are a few main parts to a concept.

7.2 Feature Lists

Theorists believe that creating a concept includes learning the distinct features and characteristics that are present in all examples of a concept. A good way to know if something is part of a concept is to identify the defining features of the concept and see if the object or event in question shares those defining features. For example, an animal must eat food, a plant must grow, and a vertebrate must have a spine. So, every example of an animal must have the defining feature or eating food, every plant must grow, and every vertebrate must have a spine to be included in the concept.

7.3 Prototypes

Most people have a mental prototype, or mental example of a concept. For example, when referring to the concept of "transportation" you might think of a car, bus, truck, or train, but not typically of a skateboard or a pogo stick. Once the prototype for a concept is found, compare new objects and experiences with that prototype. Objects or events similar to the prototype are readily accepted as instances of the concept. Objects and events that are different are often rejected as instances of the concept when, in fact, they are.

7.4 Exemplars

Exemplars are similar to the prototype except your concept was formed by a mixture of different examples. This helps to limit undergeneralization, a common problem with using the prototype alone. For example, when developing the concept of birds, not only learn about sparrows and pigeons but penguins and ostriches. By learning from a variety of examples, the concept is more complete and less susceptible to error.

7.5 Schemes and Scripts

A scheme is simply an organized set of knowledge about specific items and events. Schemes give a general or common understanding of how things are. Schemes are not only a way to organize information but also influence our perception and interpretation of new things or experiences. A script is a scheme with a particular order or sequence. For example, there is a common scheme and script for driving a car. If I told a story about how a man left his house, got into his car, and went for a drive at night, we would assume that he had turned on his lights between getting in his car and going for a drive even though we are not told so. The general information about driving a car would be the scheme and the sequence of events in driving the car would be the script, or a scheme in a particular order.

7.6 Personal Theories

Ever since birth we have been forming our own personal theories about the world and everything in it. We form personal theories to explain the events and objects in our individual world, such as family and entertainment. Although these theories are based on observation and fact, they are not necessarily 100% correct or complete. Theories grow and change the same way as concepts and schemes. Personal theories are what influence defining features of concepts, thus influence whole concepts. This is an individual process. Personal theories are formed without any outside help. This can often lead to misconceptions or false beliefs. The most correct personal theories are the ones based on the most correct concepts and schemes, or the building blocks of theories.

7.7 External links

Source: Educational Psychology- Developing Learners 4th Edition, Jeanne Ellis Ormrod

Chapter 8

Organizing (management)

Organizing is a systematic process of structuring, integrating, co-ordinating task goals, and activities to resources in order to attain objectives.

8.1 History

The organizing of information could be seen since humans began to write. Prior to that, history was passed down only through song and word. As can be seen with religion, books and spoken word, science (through journals and studies) organizing not only is history, but also supports the communication of history. Recording ideas in a written text, as opposed to verbally communicating with someone, and more specifically cataloging ideas and thoughts, is also an attempt to organize information.

Science books are notable by their organization of a specific subject. Encyclopedias usually organize subjects into a single place, for faster indexing and seeking of meanings.

8.2 Characteristics

The following are the important characteristics of organization.

- **Specialization and division of work.** The entire philosophy of organization is centered on the concepts of specialization and division of work. The division of work is assigning responsibility for each organizational component to a specific individual or group thereof. It becomes specialization when the responsibility for a specific task lies with a designated expert in that field. The efforts of the operatives are coordinated to allow the process at hand to function correctly. Certain operatives occupy positions of management at various points in the process to ensure coordination.
- **Orientation towards goals.** Every organization has its own purposes and objectives. Organizing is the function employed to achieve the overall goals of the organization. Organization harmonizes the individual goals of the employees with overall objectives of the firm.
- **Composition of individuals and groups.** Individuals form a group and the groups form an organization. Thus, organization is the composition of individual and groups. Individuals are grouped into departments and their work is coordinated and directed towards organizational goals.
- **Continuity.** An organization is a group of people with a defined relationship in which they work together to achieve the goals of that organization. This relationship does not come to end after completing each task. Organization is a never ending process.

8.3 Purpose

- **Helps to achieve organizational goal.** Organization is employed to achieve the overall objectives of business firms. Organization focuses attention of individuals objectives towards overall objectives.
- **Optimum use of resources.** To make optimum use of resources such as men, material, money, machine and method, it is necessary to design an organization properly. Work should be divided and right people should be given right jobs to reduce the wastage of resources in an organization.
- **To perform managerial function.** Planning, Organizing, Staffing, Directing and Controlling cannot be implemented without proper organization.
- **Facilitates growth and diversification.** A good organization structure is essential for expanding business activity. Organization structure determines the input resources needed for expansion of a business activity similarly organization is essential for product diversification such as establishing a new product line.
- **Humane treatment of employees.** Organization has to operate for the betterment of employees and must not encourage monotony of work due to higher

degree of specialization. Now, organization has adapted the modern concept of systems approach based on human relations and it discards the traditional productivity and specialization approach.

8.4 Applications

Organizing, in companies point of view, is the management function that usually follows after planning. And it involves the assignment of tasks, the grouping of tasks into departments and the assignment of authority with adequate responsibility and allocation of resources across the organization to achieve common goals.

8.4.1 Structure

The framework in which the organization defines how tasks are divided, resources are deployed, and departments are coordinated.

1. A set of formal tasks assigned to individuals and departments.

2. Formal reporting relationships, including lines of authority, decision responsibility, number of hierarchical levels and span of managers control.

3. The design of systems to ensure effective coordination of employees across departments.

8.4.2 Work specialization

Work specialization (also called division of labour or job specialization) is the degree to which organizational tasks are sub-divided into individual jobs. It may increase the efficiency of workers, but with too much specialization, employees may feel isolated and bored. Many organizations enlarge jobs or rotate assigned tasks to provide greater challenges.

8.4.3 Chain of command

Chain of command is the vertical lines of a command structure that is used for the purposes of overall responsibility and accountability in the achieving of stated goals and objectives through the use of orders one direction and reports of compliance in the other direction. Chain of command differs from horizontal lines in an organization which are basically the communication and coordinating lines of the organization.

8.4.4 Authority, responsibility, and accountability

- **Authority** is a manager's formal and legitimate right to make decisions, issue orders, and allocate resources to achieve organizationally desired outcomes.
- **Responsibility** means an employee's duty to perform assigned task or activities.
- **Accountability** means that those with authority and responsibility must report and justify task outcomes to those above them in the chain of command.

8.4.5 Delegation

Delegation is the process managers use to transfer authority and responsibility to positions below them. Organizations today tend to encourage delegation from highest to lowest possible levels. Delegation can improve flexibility to meet customers' needs and adaptation to competitive environments. Managers often find delegation difficult reasons for delegation(when a manager is advised to carry out delegation) 1 where there is need to carry out more important work that reflect organization's objective 2. where there is need to give more training to his supervisors, juniors,en employees as well 3.if there is need of improvement/acquisition of skills by people in that organization then the manager will find well to delegate authority 4.where there is need to save time, utilize organizational resources then the manager finds is way best to delegate

8.4.6 Types of authority (and responsibility)

Line authority managers have the formal power to direct and control immediate subordinates. The superior issues orders and is responsible for the result and the subordinate obeys and is responsible only for executing the order according to instructions.

Functional authority is where managers have formal power over a specific subset of activities. For instance, the Production Manager may have the line authority to decide whether and when a new machine is needed but the Controller demands that a Capital Expenditure Proposal is submitted first, showing that the investment will have a yield of at least x%; or, a legal department may have functional authority to interfere in any activity that could have legal consequences. This authority would not be functional but it would rather be staff authority if such interference is "advice" rather than "order".

Staff authority is granted to staff specialists in their areas of expertise. It is not a real authority in the sense that a staff manager does not order or instruct but simply advises, recommends, and counsels in the staff specialists'

area of expertise and is responsible only for the quality of the advice (to be in line with the respective professional standards etc.) It is a communication relationship with management. It has an influence that derives indirectly from line authority at a higher level.

Line and Staff Authority is the combination of Line organization and Staff organization. Such organization follows both the principles of scalar chain of command and there is a provision for specialized activities to be performed by staff officers who act in an advisory capacity

8.4.7 Span of management

Categories:

- Direct single relationship.
- Direct group relationships.
- Cross relationship.

Factors influencing larger span of management.

1. Work performed by subordinates is stable and routine.
2. Subordinates perform similar work tasks.
3. Subordinates are concentrated in a single location.
4. Subordinates are highly trained and need little direction in performing tasks.
5. Rules and procedures defining task activities are available.
6. Support systems and personnel are available for the managers.
7. Little time is required in non-supervisory activities such as coordination with other departments or planning.
8. Managers' personal preferences and styles favor a large span.

8.4.8 Tall versus flat structure

- **Tall** - A management structure characterized by an overall narrow span of management and a relatively large number of hierarchical levels. Tight control. Reduced communication overhead.
- **Flat** - A management structure characterized by a wide span of control and relatively few hierarchical levels. Loose control. Facilitates delegation.

8.4.9 Centralization, decentralization, and formalization

- **Centralization** - The location of decision-making authority near top organizational levels.
- **Decentralization** - The location of decision-making authority near lower organizational levels.
- **Formalization** - The written documentation used to direct and control employees.

8.4.10 Departmentalization

Departmentalization is the basis on which individuals are grouped into departments and departments into total organizations. Approach options include:

1. **Functional** - by common skills and work tasks
2. **Divisional** - common product, program or geographical location
3. **Matrix** - combination of Functional and Divisional
4. **Team** - to accomplish specific tasks
5. **Network** - departments are independent providing functions for a central core breaker

8.4.11 Importance of organizing

- Organizations are often troubled by how to organize, particularly when a new strategy is developed
- Changing market conditions or new technology requires change
- Organizations seek efficiencies through improvements in organizing

8.5 See also

- Order theory
- Sorting
- Community organizing
- Union organizer
- Professional organizer
- The organization of the artist

8.6 References

Chapter 9

Goal setting

Goal setting involves the development of an action plan designed to motivate and guide a person or group toward a goal.[1] Goal setting can be guided by goal-setting criteria (or rules) such as SMART criteria. Goal setting is a major component of personal-development and management literature.

Studies by Edwin A. Locke and his colleagues have shown that more specific and ambitious goals lead to more performance improvement than easy or general goals. As long as the person accepts the goal, has the ability to attain it, and does not have conflicting goals, there is a positive linear relationship between goal difficulty and task performance.[2]

9.1 History

Cecil Alec Mace carried out the first empirical studies in 1935.[3]

Edwin A. Locke began to examine goal setting in the mid-1960s and continued researching goal setting for more than 30 years.[2][4][5] Locke derived the idea for goal-setting from Aristotle's form of final causality. Aristotle speculated that purpose can cause action; thus, Locke began researching the impact goals have on human activity. Locke developed and refined his goal-setting theory in the 1960s, publishing his first article on the subject, “Toward a Theory of Task Motivation and Incentives”, in 1968.[6] This article established the positive relationship between clearly identified goals and performance.

9.2 Concept

Goals that are deemed difficult to achieve and specific tend to increase performance more than goals that are not.[7] A goal can become more specific through quantification or enumeration (it should be measurable), such as by demanding "...increase productivity by 50%,” or by defining certain tasks that must be completed.

Setting goals affects outcomes in four ways:[8]

1. Choice: Goals narrow attention and direct efforts to goal-relevant activities, and away from goal-irrelevant actions.
2. Effort: Goals can lead to more effort; for example, if one typically produces 4 widgets an hour, and has the goal of producing 6, one may work more intensely towards the goal than one would otherwise.
3. Persistence: Someone becomes more likely to work through setbacks if pursuing a goal.
4. Cognition: Goals can lead individuals to develop and change their behavior.

9.3 Goal commitment

People perform better when they are committed to achieving certain goals. Through an understanding of the effect of goal setting on individual performance, organizations are able to use goal setting to benefit organizational performance. Locke and Latham (2002) have indicated three moderators that indicate goal setting success:[9]

1. The importance of the expected outcomes of goal attainment, and
2. Self-efficacy—one’s belief that they are able to achieve the goals, and
3. Commitment to others—promises or engagements to others can strongly improve commitment.

Expanding the three from above, the level of commitment is influenced by external factors. Such as the person assigning the goal, setting the standard for the person to achieve/perform. This influences the level of commitment by how compliant the individual is with the one assigning the goal. An external factor can also be the role models of the individual. Say if they strive to be like their favorite athlete, the individual is more likely to put forth more effort to their own work and goals.

Internal factors can derive from their participation level in the work to achieve the goal. What they expect from

themselves can either flourish their success, or destroy it. Also, the individual may want to appear superior to their peers or competitors. They want to achieve the goal the best and be known for it. The self-reward of accomplishing a goal, is usually one of the main keys that keep individuals committed.

9.3.1 Goal–performance relationship

Locke and colleagues (1981) examined the behavioral effects of goal-setting, concluding that 90% of laboratory and field studies involving specific and challenging goals led to higher performance than did easy or no goals.[10]

Locke and Latham (2006) argue that it is not sufficient to urge employees to "do their best". "Doing one's best" has no external referent, which makes it useless in eliciting specific behavior. To elicit some specific form of behavior from another person, it is important that this person has a clear view of what is expected from him/her. A goal is thereby of vital importance because it helps an individual to focus his or her efforts in a specified direction. In other words, goals canalize behavior.[2]

9.3.2 Feedback

Without proper feedback channels it is impossible for employees to adapt or adjust to the required behavior. Managers should keep track of performance to allow employees to see how effective they have been in attaining their goals.[11] Providing feedback on short-term objectives helps to sustain motivation and commitment to the goal and without it, goal setting is unlikely to be successful. Feedback should be provided on the strategies followed to achieve the goals and the final outcomes achieved, as well. Feedback on strategies used to obtain goals is very important, especially for complex work, because challenging goals put focus on outcomes rather than on performance strategies, so they impair performance. Properly delivered feedback is also very essential, and the following hints may help for providing a good feedback:

- Create a positive context for feedback
- Use constructive and positive language
- Focus on behaviors and strategies
- Tailor feedback to the needs of the individual worker
- Make feedback a two-way communication process

Advances in technology can facilitate providing feedback. Systems analysts have designed computer programs that track goals for numerous members of an organization. Such computer systems may maintain every employee's goals, as well as their deadlines. Separate methods may check the employee's progress on a regular basis, and other systems may require perceived slackers to explain how they intend to improve.

More difficult goals require more cognitive strategies and well-developed skills. The more difficult the tasks, the smaller the group of people who possess the necessary skills and strategies. From an organizational perspective, it is thereby more difficult to successfully attain more difficult goals, since resources become more scarce.

9.3.3 Honing goal setting using temporal motivation theory

Locke and Latham (2004) note that goal setting theory lacks "the issue of time perspective".[12] Taking this into consideration, Steel and Konig (2006) utilize their temporal motivation theory (TMT) to account for goal setting's effects, and suggest new hypotheses regarding a pair of its moderators: goal difficulty and proximity.[13] The effectiveness of goal setting can be explained by two aspects of TMT: the principle of diminishing returns and temporal discounting.[13] Similar to the expression "the sum of the parts can be greater than the whole", a division of a project into several, immediate, subgoals appears to take advantage of these two elements.[13]

9.3.4 Employee motivation

See also: Job satisfaction and Motivation

The more employees are motivated, the more they are stimulated and interested in accepting goals. These success factors are interdependent. For example, the expected outcomes of goals are positively influenced when employees are involved in the goal setting process. Not only does participation increase commitment in attaining the goals that are set, participation influences self-efficacy as well. Additionally, feedback is necessary to monitor one's progress. When feedback is not present, an employee might think (s)he is not making enough progress. This can reduce self-efficacy and thereby harm the performance outcomes in the long run.[14]

- Goal-commitment, the most influential moderator, becomes especially important when dealing with difficult or complex goals. If people lack commitment to goals, they lack motivation to reach them. To commit to a goal, one must believe in its importance or significance.
- Attainability: individuals must also believe that they can attain—or at least partially reach—a defined goal. If they think no chance exists of reaching a goal, they may not even try.
- Self-efficacy: the higher someone's self-efficacy regarding a certain task, the more likely they will

set higher goals, and the more persistence they will show in achieving them.[15]

9.4 In business

In business, goal setting encourages participants to put in substantial effort. Also, because every member has defined expectations for their role, little room is left for inadequate, marginal effort to go unnoticed.

Managers cannot constantly drive motivation, or keep track of an employee's work on a continuous basis. Goals are therefore an important tool for managers, since goals have the ability to function as a self-regulatory mechanism that helps employees prioritize tasks.[9][16]

Four mechanisms through which goal setting can affect individual performance are:

1. Goals focus attention toward goal-relevant activities and away from goal-irrelevant activities.

2. Goals serve as an energizer: Higher goals induce greater effort, while low goals induce lesser effort.

3. Goals affect persistence; constraints with regard to resources affect work pace.

4. Goals activate cognitive knowledge and strategies that help employees cope with the situation at hand.

9.5 In personal life

Main article: Personal goal setting

Common personal goals include losing weight, achieving good grades, and saving money. The strategy for goal setting begins with the big picture; taking a look at the big picture before breaking it into smaller components allows one to focus on the primary goal. Once the main goal is set, breaking it up into smaller, more achievable components helps in the planning portion of setting the goal.[17] These smaller, more obtainable objectives promote self-esteem and provide instant feedback to keep the individual on task.[18][19]

Time management is the practice of systematically finishing tasks assigned by superiors or one's self in an efficient and timely manner. Time management steps require identifying the objective and laying out a plan that maximizes efficiency and execution of the objective.[20] There are many useful mobile apps that help with personal goal setting; some of the categories include budgeting, wellness, calendar and productivity apps.[21][22]

9.6 Limitations

Goal-setting theory has limitations. In an organization, a goal of a manager may not align with the goals of the organization as a whole. In such cases, the goals of an individual may come into direct conflict with the employing organization. Without aligning goals between the organization and the individual, performance may suffer.

For complex tasks, goal-setting may actually impair performance. In these situations, an individual may become preoccupied with meeting the goals, rather than performing tasks.[23]

Some evidence suggests that goal-setting can foster unethical behavior when people do not achieve specified goals.[24]

Goal setting may have the drawback of inhibiting implicit learning: goal setting may encourage simple focus on an outcome without openness to exploration, understanding, or growth. A solution to this limitation is to set *learning* goals as well as *performance* goals, so that learning is expected as part of the process of reaching goals.[25][26]

9.7 Developments in theory

9.7.1 Goal choice

Self-efficacy, past performance, and various other social factors influence goal setting.[2] Failure to meet previous goals often leads to setting lower (and more likely achievable) goals.

9.7.2 Learning goals

There are times when having specific goals is not a best option; this is the case when the goal requires new skills or knowledge. Tunnel vision is a consequence of specific goals; if a person is too focused on attaining a specific goal, he or she may ignore the need to learn new skills or acquire new information. In situations like this, the best option is to set a *learning goal*. A learning goal is a generalized goal to achieve knowledge in a certain topic or field, but it can ultimately lead to better performance in specific goals related to the learning goals.[25][26]

Locke and Latham (2006) attribute this response to metacognition. They believe that "a learning goal facilitates or enhances metacognition—namely, planning, monitoring, and evaluating progress toward goal attainment".[2] This is necessary in environments with little or no guidance and structure. Although jobs typically have set goals, individual goals and achievement can benefit from metacognition.

9.7.3 Framing

Framing, or how goals are viewed, influences performance. When one feels threatened and or intimidated by a high goal they perform poorer than those who view the goal as a challenge.[2] The framing of a goal as a gain or a loss influences one's eventual performance.

9.7.4 Affect

Realization of goals has an effect on affect—that is, feelings of success and satisfaction. Achieving goals has a positive effect, and failing to meet goals has negative consequences.[2] However, the effect of goals is not exclusive to one realm. Success in one's job can compensate for feelings of failure in one's personal life.[2]

9.7.5 Group goals

The relationship between group goals and individual goals influences group performance; when goals are compatible there is a positive effect, but when goals are incompatible the effects can be detrimental to the group's performance.[2] There is another factor at work in groups, and that is the sharing factor; a positive correlation exists between sharing information within the group and group performance.[2] In the case of group goals, feedback needs to be related to the group, not individuals, in order for it to improve the group's performance.[2]

9.7.6 Goals and traits

On a basic level, the two types of goals are *learning goals* and *performance goals*; each possesses different traits associated with the selected goal.[2][25]

Learning goals involve tasks where skills and knowledge can be acquired, whereas *performance goals* involve easy-to-accomplish tasks that will make one appear successful (thus tasks where error and judgment may be possible are avoided).

A more complex trait-mediation study is the one conducted by Lee, Sheldon, and Turban (2003),[27] which yielded the following results:

- *Amotivated orientation* (low confidence in one's capabilities) is associated with goal-avoidance motivation, and more generally, associated with lower goals levels and lower performance.
- *Control orientation* (extrinsic motivation) is associated with both avoidance and approach goals. Approach goals are associated with higher goal levels and higher performance.
- *Autonomy goals* (intrinsic motivation) leads to mastery goals, enhanced focus, and therefore enhanced performance.

9.7.7 Macro-level goals

Macro-level goals refer to goal setting that is applied to the company as a whole. Cooperative goals reduce the negative feelings that occur as a result of alliances and the formation of groups.[2] The most common parties involved are the company and its suppliers. The three motivators for macro-level goals are: self-efficacy, growth goals, and organizational vision.[2]

9.7.8 Goals and subconscious priming

The effects of subconscious priming and conscious goals are independent, although a conscious goal has a larger effect.[2] The interaction effect is that priming can enhance the effects of difficult goals, but it has no effect on easy goals.[2] There is also the situation in which priming and conscious goals conflict with one another, and in this situation the conscious goals have a greater effect on performance.[2]

9.7.9 General action and inaction goals

Action goals are believed to promote the sense of action, whereas inaction goals are considered to reduce people's tendency to take actions. Common action goals can be to do something, perform a certain act, or to go someplace, whereas typical inaction goals can take the form of having a rest or to stop doing something.

Goal-regulated overall activity and inactivity tendency result from both biological conditions and social-cultural environment.[28] Recent research revealed that most nations hold more favorable attitude towards action rather than inaction, even though some countries value action and inaction slightly differently than others.[29]

Recent research suggested that people tend to choose inaction goals when they are making decisions among choices where uncertainty could result in negative outcomes, but they prefer action over inaction in their daily behaviors when no deliberation is needed.[30][31] Timothy D. Wilson and colleagues found that many people "preferred to administer electric shocks to themselves instead of being left alone with their thoughts".[32]

9.8 See also

- Big Hairy Audacious Goal
- Goal orientation
- GROW model

- Health coaching
- I-Change Model
- Immunity to change
- Motivational interviewing
- OKR
- Performance measurement
- Positive deviance
- Remuneration
- SMART criteria
- Strategic planning
- Transtheoretical model

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prospective situations. Unlike efficacy (defined as the power to produce an effect—in essence, competence), self-efficacy consists of the belief (whether or not accurate) that one has the power to produce that effect. For example, a person with high self-efficacy may engage in more health-related activity when an illness occurs, whereas a person with low self efficacy may succumb to feelings of hopelessness. (Compare: Sue, David; Sue, Derald Wing; Sue, Stanley; Sue, Diane (2015). *Understanding abnormal behavior* (11th ed.). Belmont, CA: Wadsworth/Cengage Learning. p. 194. ISBN 9781305537606.) Note the distinction between self-esteem and self-efficacy. Self-esteem in this context relates to a person's sense of self-worth, whereas self-efficacy relates to a person's perception of their ability to reach a goal. For example, take the case of an incompetent rock-climber. Though probably afflicted with poor self-efficacy in regard to rock climbing, this hypothetical person could retain their self-esteem unaffected.

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Chapter 10

Personal development

Personal development covers activities that improve awareness and identity, develop talents and potential, build human capital and facilitate employability, enhance the quality of life and contribute to the realization of dreams and aspirations. Personal development takes place over the course of a person's entire life.[1] Not limited to self-help, the concept involves formal and informal activities for developing others in roles such as teacher, guide, counselor, manager, life coach or mentor. When personal development takes place in the context of institutions, it refers to the methods, programs, tools, techniques, and assessment systems that support human development at the individual level in organizations.[2]

10.1 Overview

Inter alia, personal development may include the following activities:

- improving self-awareness
- improving self-knowledge
- improving skills and/or learning new ones
- building or renewing identity/self-esteem
- developing strengths or talents
- improving a career
- identifying or improving potential
- building employability or (alternatively) human capital
- enhancing lifestyle and/or the quality of life and time management
- improving health
- improving wealth or social status
- fulfilling aspirations
- initiating a life enterprise
- defining and executing personal development plans (PDPs)
- improving social relations or emotional intelligence

Personal development can also include developing other people. This may take place through roles such as those of a teacher or mentor, either through a personal competency (such as the skill of certain managers in developing the potential of employees) or through a professional service (such as providing training, assessment or coaching).

Beyond improving oneself and developing others, "personal development" labels a field of practice and research. As a field of practice, it includes personal development methods, learning programs, assessment systems, tools, and techniques.

As a field of research, personal development topics appear in psychology journals, education research, management journals and books, and human development economics.

Any sort of development—whether economic, political, biological, organisational or personal—requires a framework if one wishes to know whether a change has actually occurred.[3] In the case of personal development, an individual often functions as the primary judge of improvement or of regression, but validation of objective improvement requires assessment using standard criteria. Personal-development frameworks may include goals or benchmarks that define the end-points, strategies or plans for reaching goals, measurement, and assessment of progress, levels or stages that define milestones along a development path, and a feedback system to provide information on changes.

10.2 As an industry

Personal development as an industry[4] has several business relationship formats of operating. The main ways are business-to-consumer and business-to-business. However, there are two newer ways increasing in prevalence: consumer-to-business and consumer-to-consumer.

10.2.1 Business-to-consumer market

The business-to-consumer market involves selling books, courses and techniques to individuals, such as:

- newly invented offerings such as:
  - fitness
  - beauty enhancement
  - weight loss
- traditional practices such as:
  - yoga
  - martial arts
  - meditation

Some programs are delivered online and many include tools sold with a program, such as motivational books for self-help, recipes for weight-loss or technical manuals for yoga and martial-arts programs.

A partial list of personal development offerings on the business-to-individual market might include:

- books
- motivational speaking
- e-Learning programs
- workshops
- individual counseling
- life coaching
- Time Management

10.2.2 Business-to-business market

The business-to-business market also involves programs – in this case ones sold to companies and to governments to assess potential, to improve effectiveness, to manage work-life balance or to prepare some entity for a new role in an organization. The goals of these programs are defined with the institution or by the institution and the results are assessed. Universities and business schools also contract programs to external specialist firms or to individuals.

A partial list of business-to-business programs might include:

- marketing and market development
- time management
- courses and assessment systems for higher education organizations for their students
- management services to employees in organizations through:
  - training
  - training and development programs
  - personal-development tools
  - self-assessment
  - feedback
  - business coaching
  - mentoring

Some consulting firms specialize in personal development[5] but as of 2009 generalist firms operating in the fields of human resources, recruitment and organizational strategy have entered what they perceive as a growing market,[6] not to mention smaller firms and self-employed professionals who provide consulting, training and coaching.

Additionally, the International Association for Personal Development Professionals (IAPDP), an international trade group launched in 2013 to support professionals in the self-help industry.

10.3 Origins

Major religions – such as the Abrahamic and Indian religions – as well as New Age philosophies have used practices such as prayer, music, dance, singing, chanting, poetry, writing, sports and martial arts. These practices have various functions, such as health or aesthetic satisfaction, but they may also link to "final goals" of personal development such as discovering the meaning of life or living the good life (compare philosophy).

Michel Foucault describes in *Care of the Self*[7] the techniques of *epimelia* used in ancient Greece and Rome, which included dieting, exercise, sexual abstinence, contemplation, prayer and confession—some of which also became important practices within different branches of Christianity.

In yoga, a discipline originating in India, possibly over 3000 years ago, personal-development techniques include meditation, rhythmic breathing, stretching and postures.

"Yi"Wushu and T'ai chi ch'uan utilise traditional Chinese techniques, including breathing and energy exercises, meditation, martial arts, as well as practices linked to traditional Chinese medicine, such as dieting, massage and acupuncture.

In Islam, which arose almost 1500 years ago in the Middle East, personal-development techniques include ritual prayer, recitation of the Qur'an, pilgrimage, fasting and *tazkiyah* (purification of the soul).

Two individual ancient philosophers: Aristotle and the Western Tradition and Confucius and the Eastern Tradition stand out as major sources [8] of what has become

personal development in the 21st century, representing a Western tradition and an East Asian tradition. Elsewhere anonymous founders of schools of self-development appear endemic – note the traditions of the Indian subcontinent in this regard.

10.3.1 South Asian traditions

Some ancient Indians aspired to "beingness, wisdom and happiness".[9]

10.3.2 Aristotle and the Western tradition

The Greek philosopher Aristotle (384 BCE – 322 BCE) influenced theories of personal development in the West. In his *Nicomachean Ethics*, Aristotle defined personal development as a category of phronesis or practical wisdom, where the practice of virtues (*arête*) leads to *eudaimonia*,[10] commonly translated as "happiness" but more accurately understood as "human flourishing" or "living well".[11] Aristotle continues to influence the Western concept of personal development to this day, particularly in the economics of human development[12] and in positive psychology.[13]

10.3.3 Confucius and the East Asian tradition

In Chinese tradition, Confucius (around 551 BCE – 479 BCE) founded an ongoing philosophy. His ideas continue to influence family values, education and management in China and East Asia. In his *Great Learning* Confucius wrote:

> The ancients who wished to illustrate illustrious virtue throughout the kingdom, first ordered well their own states. Wishing to order well their states, they first regulated their families. Wishing to regulate their families, they first cultivated their persons. Wishing to cultivate their persons, they first rectified their hearts. Wishing to rectify their hearts, they first sought to be sincere in their thoughts. Wishing to be sincere in their thoughts, they first extended to the utmost their knowledge. Such extension of knowledge lay in the investigation of things.[14]

10.4 Contexts

10.4.1 Psychology

Psychology became linked to personal development in the early 20th century starting with Alfred Adler (1870–1937) and Carl Jung (1875–1961).

Adler refused to limit psychology to analysis, making the important point that aspirations look forward and do not limit themselves to unconscious drives or to childhood experiences.[15] He also originated the concepts of lifestyle (1929—he defined "lifestyle" as an individual's characteristic approach to life, in facing problems) and of self image, a concept that influenced management under the heading of work-life balance.

Carl Gustav Jung made contributions to personal development with his concept of individuation, which he saw as the drive of the individual to achieve the wholeness and balance of the Self.[16]

Daniel Levinson (1920–1994) developed Jung's early concept of "life stages" and included a sociological perspective. Levinson proposed that personal development come under the influence—throughout life—of aspirations, which he called "the Dream":

> Whatever the nature of his Dream, a young man has the developmental task of giving it greater definition and finding ways to live it out. It makes a great difference in his growth whether his initial life structure is consonant with and infused by the Dream, or opposed to it. If the Dream remains unconnected to his life it may simply die, and with it his sense of aliveness and purpose.[17]

Levinson's model of seven life-stages has been considerably modified due to sociological changes in the lifecycle.[18]

Research on success in reaching goals, as undertaken by Albert Bandura (born 1925), suggested that self-efficacy[19] best explains why people with the same level of knowledge and skills get very different results. According to Bandura self-confidence functions as a powerful predictor of success because:[20]

1. it makes you expect to succeed
2. it allows you take risks and set challenging goals
3. it helps you keep trying if at first you don't succeed
4. it helps you control emotions and fears when the going gets rough

In 1998 Martin Seligman won election to a one-year term as President of the American Psychological Association and proposed a new focus: on healthy individuals rather than on pathology (he created the "positive psychology" current)

> We have discovered that there is a set of human strengths that are the most likely buffers

> against mental illness: courage, optimism, interpersonal skill, work ethic, hope, honesty and perseverance. Much of the task of prevention will be to create a science of human strength whose mission will be to foster these virtues in young people.[21]

10.4.2 Higher education

Personal development has been at the heart of education in the West in the form of the Greek philosophers; and in the East with Confucius. Some people emphasize personal development as a part of higher education. Wilhelm von Humboldt, who founded the University of Berlin (since 1949: Humboldt University of Berlin) in 1810, made a statement interpretable as referring to personal development: *… if there is one thing more than another which absolutely requires free activity on the part of the individual, it is precisely education, whose object it is to develop the individual.*[22]

During the 1960s a large increase in the number of students on American campuses[23] led to research on the personal development needs of undergraduate students. Arthur Chickering defined seven vectors of personal development[24] for young adults during their undergraduate years:

1. developing competence
2. managing emotions
3. achieving autonomy and interdependence
4. developing mature interpersonal relationships
5. establishing identity
6. developing purpose
7. developing integrity

In the UK, personal development took a central place in university policy in 1997 when the Dearing Report[25] declared that universities should go beyond academic teaching to provide students with personal development. In 2001 a Quality Assessment Agency for UK universities produced guidelines[26] for universities to enhance personal development as:

** a structured and supported process undertaken by an individual to reflect upon their own learning, performance and / or achievement and to plan for their personal, educational and career development;*
** objectives related explicitly to student development; to improve the capacity of students to understand what and how they are learning, and to review, plan and take responsibility for their own learning*

In the 1990s, business schools began to set up specific personal-development programs for leadership and career orientation and in 1998 the European Foundation for Management Development set up the EQUIS accreditation system which specified that personal development must form part of the learning process through internships, working on team projects and going abroad for work or exchange programs.

The first personal development certification required for business school graduation originated in 2002 as a partnership between Metizo,[27] a personal-development consulting firm, and the Euromed Management School[28] in Marseilles: students must not only complete assignments but also demonstrate self-awareness and achievement of personal-development competencies.

As an academic department personal development has become a specific discipline, usually associated with business schools.[29] As an area of research, personal development draws on links to other academic disciplines:

- education for questions of learning and assessment
- psychology for motivation and personality
- sociology for identity and social networks
- economics for human capital and economic value
- philosophy for ethics and self-reflection

10.4.3 The workplace

Abraham Maslow (1908–1970), proposed a hierarchy of needs with self actualization at the top, defined as:[30]

… the desire to become more and more what one is, to become everything that one is capable of becoming.

Since Maslow himself believed that only a small minority of people self-actualize—he estimated one percent[31]—his hierarchy of needs had the consequence that organizations came to regard self-actualization or personal development as occurring at the top of the organizational pyramid, while job security and good working conditions would fulfill the needs of the mass of employees.

As organizations and labor markets became more global, responsibility for development shifted from the company to the individual. In 1999 management thinker Peter Drucker wrote in the *Harvard Business Review*:

> We live in an age of unprecedented opportunity: if you've got ambition and smarts, you can rise to the top of your chosen profession, regardless of where you started out. But with opportunity comes responsibility. Companies today aren't managing their employees' careers; knowledge workers must, effectively, be their own chief executive officers. It's up to you to carve out your place, to know when to change course, and to keep yourself engaged

> and productive during a work life that may span some 50 years.[32]

Management professors Sumantra Ghoshal of the London Business School and Christopher Bartlett of the Harvard Business School wrote in 1997 that companies must manage people individually and establish a new work contract.[33] On the one hand the company must allegedly recognize that personal development creates economic value: “market performance flows not from the omnipotent wisdom of top managers but from the initiative, creativity and skills of all employees”.

On the other hand, employees should recognize that their work includes personal development and "... embrace the invigorating force of continuous learning and personal development”.

The 1997 publication of Ghoshal’s and Bartlett’s *Individualized Corporation* corresponded to a change in career development from a system of predefined paths defined by companies, to a strategy defined by the individual and matched to the needs of organizations in an open landscape of possibilities. Another contribution to the study of career development came with the recognition that women’s careers show specific personal needs and different development paths from men. The 2007 study of women’s careers by Sylvia Ann Hewlett *Off-Ramps and On-Ramps*[34] had a major impact on the way companies view careers. Further work on the career as a personal development process came from study by Herminia Ibarra in her *Working Identity* on the relationship with career change and identity change,[35] indicating that priorities of work and lifestyle continually develop through life.

Personal development programs in companies fall into two categories: the provision of employee benefits and the fostering of development strategies.

Employee benefits have the purpose of improving satisfaction, motivation and loyalty. Employee surveys may help organizations find out personal-development needs, preferences and problems, and they use the results to design benefits programs. Typical programs in this category include:

- work-life balance
- time management
- stress management
- health programs
- counseling

Many such programs resemble programs that some employees might conceivably pay for themselves outside work: yoga, sports, martial arts, money-management, positive psychology, NLP, etc.

As an investment, personal development programs have the goal of increasing human capital or improving productivity, innovation or quality. Proponents actually see such programs not as a cost but as an investment with results linked to an organization’s strategic development goals. Employees gain access to these investment-oriented programs by selection according to the value and future potential of the employee, usually defined in a talent management architecture including populations such as new hires, perceived high-potential employees, perceived key employees, sales staff, research staff and perceived future leaders. Organizations may also offer other (non-investment-oriented) programs to many or even all employees. Typical programs focus on career-development, personal effectiveness, teamwork, and competency-development. Personal development also forms an element in management tools such as personal development planning, assessing one’s level of ability using a competency grid, or getting feedback from a 360 questionnaire filled in by colleagues at different levels in the organization.

10.5 Criticism

Scholars have targeted self-help claims as misleading and incorrect. In 2005, Steve Salerno portrayed the American self-help movement—he uses the acronym *SHAM: The Self-Help and Actualization Movement*—not only as ineffective in achieving its goals, but also as socially harmful. 'Salerno says that 80 percent of self-help and motivational customers are repeat customers and they keep coming back whether the program worked for them or not'. Others similarly point out that with self-help books 'supply increases the demand...The more people read them, the more they think they need them...more like an addiction than an alliance'. Self-help writers have been described as working 'in the area of the ideological, the imagined, the narrativized....although a veneer of scientism permeates the[ir] work, there is also an underlying armature of moralizing'.[36]

10.6 See also

- Coaching
- End-of-history illusion
- Holland Codes
- Know thyself
- Life planning
- Life skills
- Self-actualization
- Self-discovery
- Self-help

- Training and development
- Human Potential Movement
- Micropsychoanalysis

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[2] Bob Aubrey, *Managing Your Aspirations: Developing Personal Enterprise in the Global Workplace* McGraw-Hill 2010 ISBN 978-0-07-131178-6, page 9

[3] Bob Aubrey, *Measure of Man: leading human development* McGraw-Hill 2016 ISBN 978-9-814-66064-8, page 15

[4] Some sources recognize personal development as an "industry": see for example Cullen, John G. (2009). "How to sell your soul and still get into Heaven: Steven Covey's epiphany-inducing technology of effective selfhood". *Human Relations*. SAGE Publications. **62** (8): 1231–1254. doi:10.1177/0018726709334493. ISSN 0018-7267. Retrieved 2010-04-28. The growth of the personal development industry and its gurus continues to be resisted across a number of genres. and Grant, Anthony M.; Blythe O'Hara (November 2006). "The self-presentation of commercial Australian life coaching schools: Cause for concern?" (PDF). *International Coaching Psychology Review*. Leicester: The British Psychological Society. **1** (2): 21–33 [29]. ISSN 1750-2764. Retrieved 2010-04-28. [...] much of the commercial life coaching and personal development industry is grounded more on hyperbole and rhetoric than solid behavioural science (Grant, 2001) [...] and Grant, Anthony M.; Michael J. Cavanagh (December 2007). "Evidence-based coaching: Flourishing or languishing?". *Australian Psychologist*. Australian Psychological Society. **42** (4): 239–254. doi:10.1080/00050060701648175. ISSN 1742-9544. Retrieved 2010-04-28. To flourish, coaching psychology needs to remain clearly differentiated from the frequently sensationalistic and pseudoscientific facets of the personal development industry while at the same time engaging in the development of the wider coaching industry.

[5] Firms such as PDI, DDI, Metizo, and FranklinCovey exemplify international personal-development firms working with companies for consulting, assessment and training.

[6] Human-resources firms such as Hewitt, Mercer, Watson Wyatt Worldwide, the Hay Group; McKinsey and the Boston Consulting Group offer consulting in talent-development, and Korn/Ferry offers executive coaching.

[7] Foucault, Michel, ed. (1986). *Care of the Self*. **2**. Random House. Translated from the French *Le Souci de Soi* editions Gallimard 1984. Part Two of Foucault's book describes the technique of caring for the soul falling in the category of *epimeleia* from the Greek to the classic Roman period and on into the early stages of the age of Christianity.

[8] Jamoukha, Kholoud. "Kholoud Jamoukha Personal Growth".

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[11] Martha Nussbaum, *The Fragility of Goodness*, Cambridge University Press, discusses why the English word happiness does not describe Aristotle's concept of *eudaimonia*, pages 1–6

[12] Nobel Prize winner Amartya Sen identifies economic development with Aristotle's concepts of individual development in his co-authored book written with Aristotle scholar Nussbaum: Nussbaum, Martha; Sen, Amartya, eds. (1993). *The Quality of Life*. Oxford: Clarendon Press. ISBN 0-19-828395-4.; as well as in his general book published a year after receiving the Nobel Prize in Economics in 1998: Sen, Amartya (1999). *Development as Freedom*. Oxford: Oxford University Press.

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[17] Daniel Levinson, Seasons of a Man's Life, Ballantine Press, 1978, page 91-92

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[34] Hewlett, Sylvia Ann (2007), Off-Ramps and On-Ramps, Harvard Business School Press. This book shows how women have started to change the traditional career path and how companies adapt to career/lifestyle issues for men as well as for women.

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Chapter 11

Systems theory

Systems theory or systems science is the interdisciplinary study of systems. A system is an entity with interrelated and interdependent parts, it is defined by its boundaries and it is more than the sum of its parts (subsystem). Change in one part of the system affects other parts and the whole system, they demonstrate predictable pattern of behavior. Positive growth and adaptation of a system depends upon how well the system is adjusted with its environment and Systems often exist to accomplish a common purpose. The goal of systems science is systematically discovering this systems's dynamics, its constraints, conditions and elucidating principles (purpose, measure, methods,tools, etc.) that can be discerned and applied to systems at every level of nesting and in every field of areas for achieving optimized equifinality.

General system theory is about broadly applicable concepts and principles, as opposed to concepts and principles applicable to one domain of knowledge. It is related to systems engineering. Some see it as a specialism of systems thinking; others see systems thinking as the specialism of system theory focused on social systems. System theorists focus on activity systems in which structures/components interact in behaviours/processes and some on passive structures (e.g. a necklace, or the Dewey Decimal System). Others focus on social activity systems in particular.

11.1 Key concepts

- System: An organized entity made up of interrelated and interdependent parts.
- Boundaries: Barriers that define a system and distinguish it from other systems in the environment.
- Homeostasis: The tendency of a system to resist change and maintain status quo.
- Adaptation: The tendency of a system to make the changes needed to protect itself and grow to accomplish its goal.
- Reciprocal Transactions: Circular interactions that systems engage in such that they influence one another.
- Feedback Loop: The process by which systems self-correct based on reactions from other systems in the environment.
- Microsystem: The system closest to the client.
- Mesosystem: Relationships among the systems in an environment.
- Exosystem: A relationship between two systems that has an indirect effect on a third system.
- Macrosystem: A larger system that influences clients, such as policies, administration of entitlement programs, and culture.
- Chronosystem: A system composed of significant life events that can affect adaptation.

11.2 Origin of the term

The term “general system theory” originates from Bertalanffy's general system theory (GST). His ideas were picked by others including Kenneth E. Boulding, William Ross Ashby and Anatol Rapoport working in mathematics, psychology, biology, game theory and social network analysis.

Sociological systems thinking started earlier, in the 19th century. In: Bertrand Badie et al. (eds.), *International Encyclopedia of Political Science*. Sage New York, Stichweh states: "... Since its beginnings the social sciences were an important part of the establishment of systems theory... the two most influential suggestions were the comprehensive sociological versions of systems theory which were proposed by Talcott Parsons since the 1950s and by Niklas Luhmann since the 1970s.” References include Parsons’ action theory[1] and Luhmann’s social systems theory.[2]

11.3 Overview

Contemporary ideas from systems theory have grown with diverse areas, exemplified by the work of biologist Ludwig von Bertalanffy, linguist Béla H. Bánáthy, sociologist Talcott Parsons, ecological systems with Howard T. Odum, Eugene Odum and Fritjof Capra, organizational theory and management with individuals such as Peter Senge, interdisciplinary study with areas like Human Resource Development from the work of Richard A. Swanson, and insights from educators such as Debora Hammond and Alfonso Montuori. As a transdisciplinary, interdisciplinary and multiperspectival domain, the area brings together principles and concepts from ontology, philosophy of science, physics, computer science, biology and engineering as well as geography, sociology, political science, psychotherapy (within family systems therapy) and economics among others. Systems theory thus serves as a bridge for interdisciplinary dialogue between autonomous areas of study as well as within the area of systems science itself.

In this respect, with the possibility of misinterpretations, von Bertalanffy[3] believed a general theory of systems "should be an important regulative device in science", to guard against superficial analogies that "are useless in science and harmful in their practical consequences." Others remain closer to the direct systems concepts developed by the original theorists. For example, Ilya Prigogine, of the Center for Complex Quantum Systems at the University of Texas, Austin, has studied emergent properties, suggesting that they offer analogues for living systems. The theories of autopoiesis of Francisco Varela and Humberto Maturana represent further developments in this field. Important names in contemporary systems science include Russell Ackoff, Béla H. Bánáthy, Anthony Stafford Beer, Peter Checkland, Brian Wilson, Robert L. Flood, Fritjof Capra, Michael C. Jackson, and Edgar Morin among others.

With the modern foundations for a general theory of systems following World War I, Ervin Laszlo, in the preface for Bertalanffy's book: Perspectives on General System Theory, points out that the translation of "general system theory" from German into English has "wrought a certain amount of havoc".[4]

> It (General System Theory) was criticized as pseudoscience and said to be nothing more than an admonishment to attend to things in a holistic way. Such criticisms would have lost their point had it been recognized that von Bertalanffy's general system theory is a perspective or paradigm, and that such basic conceptual frameworks play a key role in the development of exact scientific theory. .. Allgemeine Systemtheorie is not directly consistent with an interpretation often put on 'general system theory,' to wit, that it is a (scientific) "theory of general systems." To criticize it as such is to shoot at straw men. Von Bertalanffy opened up something much broader and of much greater significance than a single theory (which, as we now know, can always be falsified and has usually an ephemeral existence): he created a new paradigm for the development of theories.[5]

"Theorie" (or "Lehre"), just as "Wissenschaft" (translated Scholarship), "has a much broader meaning in German than the closest English words 'theory' and 'science'".[4] These ideas refer to an organized body of knowledge and "any systematically presented set of concepts, whether empirically, axiomatically, or philosophically" represented, while many associate "Lehre" with theory and science in the etymology of general systems, though it also does not translate from the German very well; its "closest equivalent" translates as "teaching", but "sounds dogmatic and off the mark".[4] While the idea of a "general systems theory" might have lost many of its root meanings in the translation, by defining a new way of thinking about science and scientific paradigms, Systems theory became a widespread term used for instance to describe the interdependence of relationships created in organizations.

A system in this frame of reference can contain regularly interacting or interrelating groups of activities. For example, in noting the influence in organizational psychology as the field evolved from "an individually oriented industrial psychology to a systems and developmentally oriented organizational psychology", some theorists recognize that organizations have complex social systems; separating the parts from the whole reduces the overall effectiveness of organizations.[6] This difference, from conventional models that center on individuals, structures, departments and units, separates in part from the whole, instead of recognizing the interdependence between groups of individuals, structures and processes that enable an organization to function. Laszlo[7] explains that the new systems view of organized complexity went "one step beyond the Newtonian view of organized simplicity" which reduced the parts from the whole, or understood the whole without relation to the parts. The relationship between organisations and their environments can be seen as the foremost source of complexity and interdependence. In most cases, the whole has properties that cannot be known from analysis of the constituent elements in isolation. Béla H. Bánáthy, who argued—along with the founders of the systems society—that "the benefit of humankind" is the purpose of science, has made significant and far-reaching contributions to the area of systems theory. For the Primer Group at ISSS, Bánáthy defines a perspective that iterates this view:[8]

> The systems view is a world-view that is based on the discipline of SYSTEM INQUIRY. Central to systems inquiry is the con-

> cept of SYSTEM. In the most general sense, system means a configuration of parts connected and joined together by a web of relationships. The Primer Group defines system as a family of relationships among the members acting as a whole. Von Bertalanffy defined system as "elements in standing relationship."

Similar ideas are found in learning theories that developed from the same fundamental concepts, emphasising how understanding results from knowing concepts both in part and as a whole. In fact, Bertalanffy's organismic psychology paralleled the learning theory of Jean Piaget.[9] Some consider interdisciplinary perspectives critical in breaking away from industrial age models and thinking, wherein history represents history and math represents math, while the arts and sciences specialization remain separate and many treat teaching as behaviorist conditioning.[10] The contemporary work of Peter Senge[11] provides detailed discussion of the commonplace critique of educational systems grounded in conventional assumptions about learning, including the problems with fragmented knowledge and lack of holistic learning from the "machine-age thinking" that became a "model of school separated from daily life". In this way some systems theorists attempt to provide alternatives to, and evolved ideation from orthodox theories which have grounds in classical assumptions, including individuals such as Max Weber and Émile Durkheim in sociology and Frederick Winslow Taylor in scientific management.[12] The theorists sought holistic methods by developing systems concepts that could integrate with different areas.

Some may view the contradiction of reductionism in conventional theory (which has as its subject a single part) as simply an example of changing assumptions. The emphasis with systems theory shifts from parts to the organization of parts, recognizing interactions of the parts as not static and constant but dynamic processes. Some questioned the conventional closed systems with the development of open systems perspectives. The shift originated from absolute and universal authoritative principles and knowledge to relative and general conceptual and perceptual knowledge[13] and still remains in the tradition of theorists that sought to provide means to organize human life. In other words, theorists rethought the preceding history of ideas; they did not lose them. Mechanistic thinking was particularly critiqued, especially the industrial-age mechanistic metaphor for the mind from interpretations of Newtonian mechanics by Enlightenment philosophers and later psychologists that laid the foundations of modern organizational theory and management by the late 19th century.[14]

11.4 Examples of applications

11.4.1 System dynamics

Main article: System dynamics

System dynamics is an approach to understanding the nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, and time delays.[15]

11.4.2 Systems biology

Main article: Systems biology

Systems biology is a movement that draws on several trends in bioscience research. Proponents describe systems biology as a biology-based inter-disciplinary study field that focuses on complex interactions in biological systems, claiming that it uses a new perspective (holism instead of reduction). Particularly from year 2000 onwards, the biosciences use the term widely and in a variety of contexts. An often stated ambition of systems biology is the modelling and discovery of emergent properties which represents properties of a system whose theoretical description requires the only possible useful techniques to fall under the remit of systems biology. It is thought that Ludwig von Bertalanffy may have created the term systems biology in 1928.[16]

11.4.3 Systems ecology

Main article: Systems ecology

Systems ecology is an interdisciplinary field of ecology, a subset of Earth system science, that takes a holistic approach to the study of ecological systems, especially ecosystems.[17][18][19] Systems ecology can be seen as an application of general systems theory to ecology. Central to the systems ecology approach is the idea that an ecosystem is a complex system exhibiting emergent properties. Systems ecology focuses on interactions and transactions within and between biological and ecological systems, and is especially concerned with the way the functioning of ecosystems can be influenced by human interventions. It uses and extends concepts from thermodynamics and develops other macroscopic descriptions of complex systems.

11.4.4 Systems engineering

Main article: Systems engineering

Systems engineering is an interdisciplinary approach and means for enabling the realisation and deployment of successful systems. It can be viewed as the application of engineering techniques to the engineering of systems, as

well as the application of a systems approach to engineering efforts.[20] Systems engineering integrates other disciplines and specialty groups into a team effort, forming a structured development process that proceeds from concept to production to operation and disposal. Systems engineering considers both the business and the technical needs of all customers, with the goal of providing a quality product that meets the user needs.[21]

11.4.5 Systems psychology

Main article: Systems psychology

Systems psychology is a branch of psychology that studies human behaviour and experience in complex systems. It received inspiration from systems theory and systems thinking, as well as the basics of theoretical work from Roger Barker, Gregory Bateson, Humberto Maturana and others. It makes an approach in psychology in which groups and individuals receive consideration as systems in homeostasis. Systems psychology "includes the domain of engineering psychology, but in addition seems more concerned with societal systems and with the study of motivational, affective, cognitive and group behavior that holds the name engineering psychology."[22] In systems psychology, "characteristics of organizational behaviour, for example individual needs, rewards, expectations, and attributes of the people interacting with the systems, considers this process in order to create an effective system".[23]

11.5 History

Whether considering the first systems of written communication with Sumerian cuneiform to Mayan numerals, or the feats of engineering with the Egyptian pyramids, systems thinking can date back to antiquity. Differentiated from Western rationalist traditions of philosophy, C. West Churchman often identified with the I Ching as a systems approach sharing a frame of reference similar to pre-Socratic philosophy and Heraclitus.[25] Von Bertalanffy traced systems concepts to the philosophy of G.W. Leibniz and Nicholas of Cusa's *coincidentia oppositorum*. While modern systems can seem considerably more complicated, today's systems may embed themselves in history.

Figures like James Joule and Sadi Carnot represent an important step to introduce the *systems approach* into the (rationalist) hard sciences of the 19th century, also known as the energy transformation. Then, the thermodynamics of this century, by Rudolf Clausius, Josiah Gibbs and others, established the *system* reference model as a formal scientific object.

The Society for General Systems Research specifically catalyzed systems theory as an area of study, which developed following the World Wars from the work of Ludwig von Bertalanffy, Anatol Rapoport, Kenneth E. Boulding, William Ross Ashby, Margaret Mead, Gregory Bateson, C. West Churchman and others in the 1950s, had specifically catalyzed by collaboration in. Cognizant of advances in science that questioned classical assumptions in the organizational sciences, Bertalanffy's idea to develop a theory of systems began as early as the interwar period, publishing "An Outline for General Systems Theory" in the *British Journal for the Philosophy of Science*, Vol 1, No. 2, by 1950. Where assumptions in Western science from Greek thought with Plato and Aristotle to Newton's *Principia* have historically influenced all areas from the hard to social sciences (see David Easton's seminal development of the "political system" as an analytical construct), the original theorists explored the implications of twentieth century advances in terms of systems.

People have studied subjects like complexity, self-organization, connectionism and adaptive systems in the 1940s and 1950s. In fields like cybernetics, researchers such as Norbert Wiener, William Ross Ashby, John von Neumann and Heinz von Foerster, examined complex systems mathematically. John von Neumann discovered cellular automata and self-reproducing systems, again with only pencil and paper. Aleksandr Lyapunov and Jules Henri Poincaré worked on the foundations of chaos theory without any computer at all. At the same time Howard T. Odum, known as a radiation ecologist, recognized that the study of general systems required a language that could depict energetics, thermodynamics and kinetics at any system scale. Odum developed a general system, or universal language, based on the circuit language of electronics, to fulfill this role, known as the Energy Systems Language. Between 1929-1951, Robert Maynard Hutchins at the University of Chicago had undertaken efforts to encourage innovation and interdisciplinary research in the social sciences, aided by the Ford Foundation with the interdisciplinary Division of the Social Sciences established in 1931.[26] Numerous scholars had actively engaged in these ideas before (Tectology by Alexander Bogdanov, published in 1912-1917, is a remarkable example), but in 1937, von Bertalanffy presented the general theory of systems at a conference at the University of Chicago.

The systems view was based on several fundamental ideas. First, all phenomena can be viewed as a web of relationships among elements, or a system. Second, all systems, whether electrical, biological, or social, have common patterns, behaviors, and properties that the observer can analyze and use to develop greater insight into the behavior of complex phenomena and to move closer toward a unity of the sciences. System philosophy, methodology and application are complementary to this science.[4] By 1956, theorists established the Society for General Systems Research, which they renamed the International Society for Systems Science in 1988. The Cold War affected the research project for systems theory in ways

that sorely disappointed many of the seminal theorists. Some began to recognize that theories defined in association with systems theory had deviated from the initial General Systems Theory (GST) view.[27] The economist Kenneth Boulding, an early researcher in systems theory, had concerns over the manipulation of systems concepts. Boulding concluded from the effects of the Cold War that abuses of power always prove consequential and that systems theory might address such issues.[28] Since the end of the Cold War, a renewed interest in systems theory emerged, combined with efforts to strengthen an ethical[29] view on the subject.

11.6 Developments

11.6.1 General systems research and systems inquiry

Many early systems theorists aimed at finding a general systems theory that could explain all systems in all fields of science. The term goes back to Bertalanffy's book titled "*General System theory: Foundations, Development, Applications*" from 1968.[9] He developed the "allgemeine Systemlehre" (general systems theory) first via lectures beginning in 1937 and then via publications beginning in 1946.[30]

Von Bertalanffy's objective was to bring together under one heading the organismic science he had observed in his work as a biologist. His desire was to use the word *system* for those principles that are common to systems in general. In GST, he writes:

> ...there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relationships or "forces" between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general.
> — Von Bertalanffy[31]

Ervin Laszlo[32] in the preface of von Bertalanffy's book *Perspectives on General System Theory*:[33]

> Thus when von Bertalanffy spoke of Allgemeine Systemtheorie it was consistent with his view that he was proposing a new perspective, a new way of doing science. It was not directly consistent with an interpretation often put on "general system theory", to wit, that it is a (scientific) "theory of general systems." To criticize it as such is to shoot at straw men. Von Bertalanffy opened up something much broader and of much greater significance than a single theory (which, as we now know, can always be falsified and has usually an ephemeral existence): he created a new paradigm for the development of theories.

Ludwig von Bertalanffy outlines systems inquiry into three major domains: Philosophy, Science, and Technology. In his work with the Primer Group, Béla H. Bánáthy generalized the domains into four integratable domains of systemic inquiry:

These operate in a recursive relationship, he explained. Integrating Philosophy and Theory as Knowledge, and Method and Application as action, Systems Inquiry then is knowledgeable action.[34]

11.6.2 Cybernetics

Main article: Cybernetics

Cybernetics is the study of the communication and control of regulatory feedback both in living and lifeless systems (organisms, organizations, machines), and in combinations of those. Its focus is how anything (digital, mechanical or biological) controls its behavior, processes information, reacts to information, and changes or can be changed to better accomplish those three primary tasks.

The terms "systems theory" and "cybernetics" have been widely used as synonyms. Some authors use the term *cybernetic* systems to denote a proper subset of the class of general systems, namely those systems that include feedback loops. However Gordon Pask's differences of eternal interacting actor loops (that produce finite products) makes general systems a proper subset of cybernetics. According to Jackson (2000), von Bertalanffy promoted an embryonic form of general system theory (GST) as early as the 1920s and 1930s but it was not until the early 1950s it became more widely known in scientific circles.

Threads of cybernetics began in the late 1800s that led toward the publishing of seminal works (e.g., Wiener's *Cybernetics* in 1948 and von Bertalanffy's *General Systems Theory* in 1968). Cybernetics arose more from engineering fields and GST from biology. If anything it appears that although the two probably mutually influenced each other, cybernetics had the greater influence. Von Bertalanffy (1969) specifically makes the point of distinguishing between the areas in noting the influence of cybernetics: "Systems theory is frequently identified with cybernetics and control theory. This again is incorrect. Cybernetics as the theory of control mechanisms in technology and nature is founded on the concepts of information and feedback, but as part of a general theory of systems;" then reiterates: "the model is of wide application but should not be identified with 'systems theory' in general", and that "warning is necessary against its incau-

tious expansion to fields for which its concepts are not made." (17-23). Jackson (2000) also claims von Bertalanffy was informed by Alexander Bogdanov's three volume *Tectology* that was published in Russia between 1912 and 1917, and was translated into German in 1928. He also states it is clear to Gorelik (1975) that the "conceptual part" of general system theory (GST) had first been put in place by Bogdanov. The similar position is held by Mattessich (1978) and Capra (1996). Ludwig von Bertalanffy never even mentioned Bogdanov in his works, which Capra (1996) finds "surprising".

Cybernetics, catastrophe theory, chaos theory and complexity theory have the common goal to explain complex systems that consist of a large number of mutually interacting and interrelated parts in terms of those interactions. Cellular automata (CA), neural networks (NN), artificial intelligence (AI), and artificial life (ALife) are related fields, but they do not try to describe general (universal) complex (singular) systems. The best context to compare the different "C"-Theories about complex systems is historical, which emphasizes different tools and methodologies, from pure mathematics in the beginning to pure computer science now. Since the beginning of chaos theory when Edward Lorenz accidentally discovered a strange attractor with his computer, computers have become an indispensable source of information. One could not imagine the study of complex systems without the use of computers today.

11.6.3 Complex adaptive systems

Main article: Complex adaptive system

Complex adaptive systems (CAS) are special cases of complex systems. They are *complex* in that they are diverse and composed of multiple, interconnected elements; they are *adaptive* in that they have the capacity to change and learn from experience. In contrast to control systems in which negative feedback dampens and reverses disequilibria, CAS are often subject to positive feedback, which magnifies and perpetuates changes, converting local irregularities into global features. Another mechanism, Dual-phase evolution arises when connections between elements repeatedly change, shifting the system between phases of variation and selection that reshape the system. Differently from Beer Management Cybernetics, Cultural Agency Theory (CAT) provides a modelling approach to explore predefined contexts and can be adapted to reflect those contexts.

The term *complex adaptive system* was coined at the interdisciplinary Santa Fe Institute (SFI), by John H. Holland, Murray Gell-Mann and others. An alternative conception of complex adaptive (and learning) systems, methodologically at the interface between natural and social science, has been presented by Kristo Ivanov in terms of hypersystems. This concept intends to offer a theoretical basis for understanding and implementing participation of "users", decisions makers, designers and affected actors, in the development or maintenance of self-learning systems.[35]

11.7 See also

- List of types of systems theory
- Autonomous agency theory
- Bibliography of sociology
- Dynamical systems
- Emergence
- Engaged theory
- Glossary of systems theory
- Grey box model
- Meta-systems
- Multidimensional systems
- Open and closed systems in social science
- Social rule system theory
- Sociology and complexity science
- Structure–organization–process
- Systems thinking
- Systemantics
- System identification
- Systematics – study of multi-term systems
- Systemics
- Systemography
- Systems architecture
- Systems ecology
- Systems theory in anthropology
- Systems theory in archaeology
- Systems theory in political science
- User-in-the-loop
- Viable system theory
- Viable systems approach
- World-systems theory

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[4] (Laszlo 1974)

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[6] (Schein 1980: 4-11)

[7] Laslo (1972: 14-15)

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[10] (see Steiss 1967; Buckley, 1967)

[11] Peter Senge (2000: 27-49)

[12] (Bailey 1994: 3-8; see also Owens 2004)

[13] (Bailey 1994: 3-8)

[14] (Bailey 1994; Flood 1997; Checkland 1999; Laszlo 1972)

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[25] (Hammond 2003: 12-13)

[26] Hammond 2003: 5-9

[27] Hull 1970

[28] (Hammond 2003: 229-233)

[29] 1968 Ludwig von Bertalanffy publishes General System theory: Foundations, Development, Applications

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11.10 External links

- Systems theory at Principia Cybernetica Web

Organizations

- International Society for the System Sciences
- New England Complex Systems Institute
- System Dynamics Society
- Institute of Global Dynamic Systems, Canberra, Australia

Chapter 12

Creativity

For other uses, see Creativity (disambiguation).

Creativity is a phenomenon whereby something new and different is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition, or a joke) or a physical object (such as an invention, a literary work, or a painting).

Scholarly interest in creativity involves many definitions and concepts pertaining to a number of disciplines: engineering, psychology, cognitive science, education, philosophy (particularly philosophy of science), technology, theology, sociology, linguistics, business studies, songwriting, and economics, covering the relations between creativity and general intelligence, mental and neurological processes, personality type and creative ability, creativity and mental health; the potential for fostering creativity through education and training, especially as augmented by technology; the maximization of creativity for national economic benefit, and the application of creative resources to improve the effectiveness of teaching and learning.

12.1 Definition

In a summary of scientific research into creativity, Michael Mumford suggested: "Over the course of the last decade, however, we seem to have reached a general agreement that creativity involves the production of novel, useful products" (Mumford, 2003, p. 110),[1] or, in Robert Sternberg's words, the production of "something original and worthwhile".[2] Authors have diverged dramatically in their precise definitions beyond these general commonalities: Peter Meusburger reckons that over a hundred different analyses can be found in the literature.[3] As an illustration, one definition given by Dr. E. Paul Torrance described it as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results."[4]

12.2 Aspects

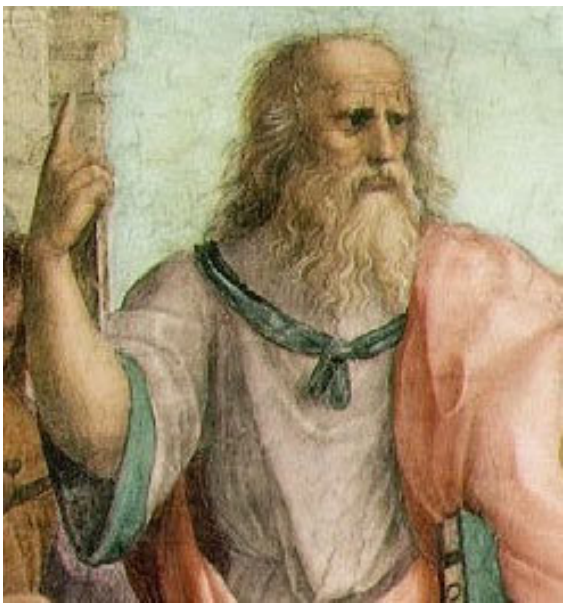
Theories of creativity (particularly investigation of why some people are more creative than others) have focused on a variety of aspects. The dominant factors are usually identified as "the four Ps" — process, product, person, and place (according to Mel Rhodes).[5] A focus on *process* is shown in cognitive approaches that try to describe thought mechanisms and techniques for creative thinking. Theories invoking divergent rather than convergent thinking (such as Guilford), or those describing the staging of the creative process (such as Wallas) are primarily theories of creative process. A focus on creative *product* usually appears in attempts to measure creativity (psychometrics, see below) and in creative ideas framed as successful memes.[6] The psychometric approach to creativity reveals that it also involves the ability to produce more.[7] A focus on the nature of the creative *person* considers more general intellectual habits, such as openness, levels of ideation, autonomy, expertise, exploratory behavior, and so on. A focus on *place* considers the circumstances in which creativity flourishes, such as degrees of autonomy, access to resources, and the nature of gatekeepers. Creative lifestyles are characterized by nonconforming attitudes and behaviors as well as flexibility.[7]

12.3 Etymology

The lexeme in the English word *creativity* comes from the Latin term *creō* "to create, make": its derivational suffixes also come from Latin. The word "create" appeared in English as early as the 14th century, notably in Chaucer, to indicate divine creation[8] (in The Parson's Tale[9]). However, its modern meaning as an act of human creation did not emerge until after the Enlightenment.[8]

12.4 History of the concept

Main article: History of the concept of creativity



Greek philosophers like Plato rejected the concept of creativity, preferring to see art as a form of discovery. Asked in The Republic, *"Will we say, of a painter, that he makes something?", Plato answers, "Certainly not, he merely imitates."*[10]

12.4.1 Ancient views

Most ancient cultures, including thinkers of Ancient Greece,[10] Ancient China, and Ancient India,[11] lacked the concept of creativity, seeing art as a form of discovery and not creation. The ancient Greeks had no terms corresponding to "to create" or "creator" except for the expression "*poiein*" ("to make"), which only applied to *poiesis* (poetry) and to the *poietes* (poet, or "maker") who made it. Plato did not believe in art as a form of creation. Asked in *The Republic*,[12] "Will we say, of a painter, that he makes something?", he answers, "Certainly not, he merely imitates."[10]

It is commonly argued that the notion of "creativity" originated in Western culture through Christianity, as a matter of divine inspiration.[8] According to the historian Daniel J. Boorstin, "the early Western conception of creativity was the Biblical story of creation given in the *Genesis*."[13] However, this is not creativity in the modern sense, which did not arise until the Renaissance. In the Judaeo-Christian tradition, creativity was the sole province of God; humans were not considered to have the ability to create something new except as an expression of God's work.[14] A concept similar to that of Christianity existed in Greek culture, for instance, Muses were seen as mediating inspiration from the Gods.[15] Romans and Greeks invoked the concept of an external creative "daemon" (Greek) or "genius" (Latin), linked to the sacred or the divine. However, none of these views are similar to the modern concept of creativity, and the individual was not seen as the cause of creation until the Renaissance.[16] It was during the Renaissance that creativity was first seen, not as a conduit for the divine, but from the abilities of "great men".[16]

12.4.2 The Enlightenment and after

The rejection of creativity in favor of discovery and the belief that individual creation was a conduit of the divine would dominate the West probably until the Renaissance and even later.[14] The development of the modern concept of creativity begins in the Renaissance, when creation began to be perceived as having originated from the abilities of the individual, and not God. This could be attributed to the leading intellectual movement of the time, aptly named humanism, which developed an intensely human-centric outlook on the world, valuing the intellect and achievement of the individual.[17] From this philosophy arose the Renaissance man (or polymath), an individual who embodies the principals of humanism in their ceaseless courtship with knowledge and creation.[18] One of the most well-known and immensely accomplished examples is Leonardo da Vinci.

However, this shift was gradual and would not become immediately apparent until the Enlightenment.[16] By the 18th century and the Age of Enlightenment, mention of creativity (notably in aesthetics), linked with the concept of imagination, became more frequent.[19] In the writing of Thomas Hobbes, imagination became a key element of human cognition;[8] William Duff was one of the first to identify imagination as a quality of genius, typifying the separation being made between talent (productive, but breaking no new ground) and genius.[15]

As a direct and independent topic of study, creativity effectively received no attention until the 19th century.[15] Runco and Albert argue that creativity as the subject of proper study began seriously to emerge in the late 19th century with the increased interest in individual differences inspired by the arrival of Darwinism. In particular, they refer to the work of Francis Galton, who through his eugenicist outlook took a keen interest in the heritability of intelligence, with creativity taken as an aspect of genius.[8]

In the late 19th and early 20th centuries, leading mathematicians and scientists such as Hermann von Helmholtz (1896) and Henri Poincaré (1908) began to reflect on and publicly discuss their creative processes.

12.4.3 Twentieth century to the present day

The insights of Poincaré and von Helmholtz were built on in early accounts of the creative process by pioneering theorists such as Graham Wallas[20] and Max Wertheimer. In his work *Art of Thought*, published in 1926, Wallas presented one of the first models of the creative process. In the Wallas stage model, creative insights and illuminations may be explained by a process consisting of 5 stages:

> (i) *preparation* (preparatory work on a problem that focuses the individual's mind on the problem and explores the problem's dimensions),
>
> (ii) *incubation* (where the problem is internalized into the unconscious mind and nothing appears externally to be happening),
>
> (iii) *intimation* (the creative person gets a "feeling" that a solution is on its way),
>
> (iv) *illumination* or insight (where the creative idea bursts forth from its preconscious processing into conscious awareness);
>
> (v) *verification* (where the idea is consciously verified, elaborated, and then applied).

Wallas' model is often treated as four stages, with "intimation" seen as a sub-stage.

Wallas considered creativity to be a legacy of the evolutionary process, which allowed humans to quickly adapt to rapidly changing environments. Simonton[21] provides an updated perspective on this view in his book, *Origins of genius: Darwinian perspectives on creativity*.

In 1927, Alfred North Whitehead gave the Gifford Lectures at the University of Edinburgh, later published as *Process and Reality*.[22] He is credited with having coined the term "creativity" to serve as the ultimate category of his metaphysical scheme: "Whitehead actually coined the term – our term, still the preferred currency of exchange among literature, science, and the arts. . . a term that quickly became so popular, so omnipresent, that its invention within living memory, and by Alfred North Whitehead of all people, quickly became occluded".[23]

The formal psychometric measurement of creativity, from the standpoint of orthodox psychological literature, is usually considered to have begun with J. P. Guilford's 1950 address to the American Psychological Association, which helped popularize the topic[24] and focus attention on a scientific approach to conceptualizing creativity. (It should be noted that the London School of Psychology had instigated psychometric studies of creativity as early as 1927 with the work of H. L. Hargreaves into the Faculty of Imagination,[25] but it did not have the same impact.) Statistical analysis led to the recognition of creativity (as measured) as a separate aspect of human cognition to IQ-type intelligence, into which it had previously been subsumed. Guilford's work suggested that above a threshold level of IQ, the relationship between creativity and classically measured intelligence broke down.[26]

12.4.4 "Four C" model

James C. Kaufman and Beghetto introduced a "four C" model of creativity; *mini-c* ("transformative learning" involving "personally meaningful interpretations of experiences, actions, and insights"), *little-c* (everyday problem solving and creative expression), *Pro-C* (exhibited by people who are professionally or vocationally creative though not necessarily eminent) and *Big-C* (creativity considered great in the given field). This model was intended to help accommodate models and theories of creativity that stressed competence as an essential component and the historical transformation of a creative domain as the highest mark of creativity. It also, the authors argued, made a useful framework for analyzing creative processes in individuals.[27]

The contrast of terms "Big C" and "Little c" has been widely used. Kozbelt, Beghetto and Runco use a little-c/Big-C model to review major theories of creativity.[26] Margaret Boden distinguishes between h-creativity (historical) and p-creativity (personal).[28]

Robinson[29] and Anna Craft[30] have focused on creativity in a general population, particularly with respect to education. Craft makes a similar distinction between "high" and "little c" creativity.[30] and cites Ken Robinson as referring to "high" and "democratic" creativity. Mihaly Csikszentmihalyi[31] has defined creativity in terms of those individuals judged to have made significant creative, perhaps domain-changing contributions. Simonton has analysed the career trajectories of eminent creative people in order to map patterns and predictors of creative productivity.[32]

12.5 Theories of creative processes

There has been much empirical study in psychology and cognitive science of the processes through which creativity occurs. Interpretation of the results of these studies has led to several possible explanations of the sources and methods of creativity.

12.5.1 Incubation

Incubation is a temporary break from creative problem solving that can result in insight.[33] There has been some empirical research looking at whether, as the concept of "incubation" in Wallas' model implies, a period of interruption or rest from a problem may aid creative problem-solving. Ward[34] lists various hypotheses that have been advanced to explain why incubation may aid creative

problem-solving, and notes how some empirical evidence is consistent with the hypothesis that incubation aids creative problem-solving in that it enables "forgetting" of misleading clues. Absence of incubation may lead the problem solver to become fixated on inappropriate strategies of solving the problem.[35] This work disputes the earlier hypothesis that creative solutions to problems arise mysteriously from the unconscious mind while the conscious mind is occupied on other tasks.[36] This earlier hypothesis is discussed in Csikszentmihalyi's five phase model of the creative process which describes incubation as a time that your unconscious takes over. This allows for unique connections to be made without your consciousness trying to make logical order out of the problem.[37]

12.5.2 Convergent and divergent thinking

J. P. Guilford[38] drew a distinction between convergent and divergent production (commonly renamed convergent and divergent thinking). Convergent thinking involves aiming for a single, correct solution to a problem, whereas divergent thinking involves creative generation of multiple answers to a set problem. Divergent thinking is sometimes used as a synonym for creativity in psychology literature. Other researchers have occasionally used the terms *flexible* thinking or fluid intelligence, which are roughly similar to (but not synonymous with) creativity.

12.5.3 Creative cognition approach

In 1992, Finke et al. proposed the "Geneplore" model, in which creativity takes place in two phases: a generative phase, where an individual constructs mental representations called preinventive structures, and an exploratory phase where those structures are used to come up with creative ideas. Some evidence shows that when people use their imagination to develop new ideas, those ideas are heavily structured in predictable ways by the properties of existing categories and concepts.[39] Weisberg[40] argued, by contrast, that creativity only involves ordinary cognitive processes yielding extraordinary results.

12.5.4 The Explicit–Implicit Interaction (EII) theory

Helie and Sun[41] recently proposed a unified framework for understanding creativity in problem solving, namely the Explicit–Implicit Interaction (EII) theory of creativity. This new theory constitutes an attempt at providing a more unified explanation of relevant phenomena (in part by reinterpreting/integrating various fragmentary existing theories of incubation and insight).

The EII theory relies mainly on five basic principles, namely:

1. The co-existence of and the difference between explicit and implicit knowledge;
2. The simultaneous involvement of implicit and explicit processes in most tasks;
3. The redundant representation of explicit and implicit knowledge;
4. The integration of the results of explicit and implicit processing;
5. The iterative (and possibly bidirectional) processing.

A computational implementation of the theory was developed based on the CLARION cognitive architecture and used to simulate relevant human data. This work represents an initial step in the development of process-based theories of creativity encompassing incubation, insight, and various other related phenomena.

12.5.5 Conceptual blending

Main article: Conceptual blending

In *The Act of Creation*, Arthur Koestler introduced the concept of *bisociation* — that creativity arises as a result of the intersection of two quite different frames of reference.[42] This idea was later developed into conceptual blending. In the 1990s, various approaches in cognitive science that dealt with metaphor, analogy, and structure mapping have been converging, and a new integrative approach to the study of creativity in science, art and humor has emerged under the label conceptual blending.

12.5.6 Honing theory

Honing theory, developed principally by psychologist Liane Gabora, posits that creativity arises due to the self-organizing, self-mending nature of a worldview. The creative process is a way in which the individual hones (and re-hones) an integrated worldview. Honing theory places emphasis not only on the externally visible creative outcome but also the internal cognitive restructuring and repair of the worldview brought about by the creative process. When faced with a creatively demanding task, there is an interaction between the conception of the task and the worldview. The conception of the task changes through interaction with the worldview, and the worldview changes through interaction with the task. This interaction is reiterated until the task is complete, at which point not only is the task conceived of differently, but the worldview is subtly or drastically transformed as it follows the natural tendency of a worldview to attempt to resolve dissonance and seek internal consistency amongst its components, whether they be ideas, attitudes, or bits of knowledge.

A central feature of honing theory is the notion of a potentiality state.[43] Honing theory posits that creative thought proceeds not by searching through and randomly 'mutating' predefined possibilities, but by drawing upon associations that exist due to overlap in the distributed neural cell assemblies that participate in the encoding of experiences in memory. Midway through the creative process one may have made associations between the current task and previous experiences, but not yet disambiguated which aspects of those previous experiences are relevant to the current task. Thus the creative idea may feel 'half-baked'. It is at that point that it can be said to be in a potentiality state, because how it will actualize depends on the different internally or externally generated contexts it interacts with.

Honing theory is held to explain certain phenomena not dealt with by other theories of creativity, for example, how different works by the same creator are observed in studies to exhibit a recognizable style or 'voice' even through in different creative outlets. This is not predicted by theories of creativity that emphasize chance processes or the accumulation of expertise, but it is predicted by honing theory, according to which personal style reflects the creator's uniquely structured worldview. Another example is in the environmental stimulus for creativity. Creativity is commonly considered to be fostered by a supportive, nurturing, trustworthy environment conducive to self-actualization. However, research shows that creativity is also associated with childhood adversity, which would stimulate honing.

12.5.7 Everyday imaginative thought

In everyday thought, people often spontaneously imagine alternatives to reality when they think "if only...".[44] Their counterfactual thinking is viewed as an example of everyday creative processes.[45] It has been proposed that the creation of counterfactual alternatives to reality depends on similar cognitive processes to rational thought.[46]

12.6 Assessing individual creative ability

12.6.1 Creativity quotient

Several attempts have been made to develop a *creativity quotient* of an individual similar to the intelligence quotient (IQ); however, these have been unsuccessful.[47]

12.6.2 Psychometric approach

J. P. Guilford's group,[38] which pioneered the modern psychometric study of creativity, constructed several tests to measure creativity in 1967:

- Plot Titles, where participants are given the plot of a story and asked to write original titles.
- Quick Responses is a word-association test scored for uncommonness.
- Figure Concepts, where participants were given simple drawings of objects and individuals and asked to find qualities or features that are common by two or more drawings; these were scored for uncommonness.
- Unusual Uses is finding unusual uses for common everyday objects such as bricks.
- Remote Associations, where participants are asked to find a word between two given words (e.g. Hand _____ Call)
- Remote Consequences, where participants are asked to generate a list of consequences of unexpected events (e.g. loss of gravity)

Building on Guilford's work, Torrance[48] developed the Torrance Tests of Creative Thinking in 1966.[49] They involved simple tests of divergent thinking and other problem-solving skills, which were scored on:

- **Fluency** – The total number of interpretable, meaningful, and relevant ideas generated in response to the stimulus.
- **Originality** – The statistical rarity of the responses among the test subjects.
- **Elaboration** – The amount of detail in the responses.

The Creativity Achievement Questionnaire, a self-report test that measures creative achievement across 10 domains, was described in 2005 and shown to be reliable and valid when compared to other measures of creativity and to independent evaluation of creative output.[50]

Such tests, sometimes called *Divergent Thinking (DT)* tests have been both supported[51] and criticized.[52]

Considerable progress has been made in automated scoring of divergent thinking tests using semantic approach. When compared to human raters, NLP techniques were shown to be reliable and valid in scoring the originality (when compared to human raters).[53][54] The reported computer programs were able to achieve a correlation of 0.60 and 0.72 respectively to human graders.

Semantic networks were also used to devise originality scores that yielded significant correlations with socio-personal measures.[55] Most recently, an NSF-funded[56] team of researchers led by James C. Kaufman and Mark A. Runco[57] combined expertise in creativity research,

natural language processing, computational linguistics, and statistical data analysis to devise a scalable system for computerized automated testing (SparcIt Creativity Index Testing system). This system enabled automated scoring of DT tests that is reliable, objective, and scalable, thus addressing most of the issues of DT tests that had been found and reported.[52] The resultant computer system was able to achieve a correlation of 0.73 to human graders.[58]

12.6.3 Social-personality approach

Some researchers have taken a social-personality approach to the measurement of creativity. In these studies, personality traits such as independence of judgement, self-confidence, attraction to complexity, aesthetic orientation, and risk-taking are used as measures of the creativity of individuals.[24] A meta-analysis by Gregory Feist showed that creative people tend to be "more open to new experiences, less conventional and less conscientious, more self-confident, self-accepting, driven, ambitious, dominant, hostile, and impulsive." Openness, conscientiousness, self-acceptance, hostility, and impulsivity had the strongest effects of the traits listed.[59] Within the framework of the Big Five model of personality, some consistent traits have emerged.[60] Openness to experience has been shown to be consistently related to a whole host of different assessments of creativity.[61] Among the other Big Five traits, research has demonstrated subtle differences between different domains of creativity. Compared to non-artists, artists tend to have higher levels of openness to experience and lower levels of conscientiousness, while scientists are more open to experience, conscientious, and higher in the confidence-dominance facets of extraversion compared to non-scientists.[59]

12.7 Creativity and intelligence

The potential relationship between creativity and intelligence has been of interest since the late 1900s, when a multitude of influential studies – from Getzels & Jackson,[62] Barron,[63] Wallach & Kogan,[64] and Guilford[65] – focused not only on creativity, but also on intelligence. This joint focus highlights both the theoretical and practical importance of the relationship: researchers are interested not only if the constructs are related, but also how and why.[66]

There are multiple theories accounting for their relationship, with the 3 main theories as follows:

- Threshold Theory – Intelligence is a necessary, but not sufficient condition for creativity. There is a moderate positive relationship between creativity and intelligence until IQ ~120.[63][65]
- Certification Theory – Creativity is not intrinsically related to intelligence. Instead, individuals are required to meet the requisite level intelligence in order to gain a certain level of education/work, which then in turn offers the opportunity to be creative. Displays of creativity are moderated by intelligence.[67]
- Interference Theory – Extremely high intelligence might interfere with creative ability.[68]

Sternberg and O'Hara[69] proposed a framework of 5 possible relationships between creativity and intelligence:

1. Creativity is a subset of intelligence
2. Intelligence is a subset of creativity
3. Creativity and intelligence are overlapping constructs
4. Creativity and intelligence are part of the same construct (coincident sets)
5. Creativity and intelligence are distinct constructs (disjoint sets)

12.7.1 Creativity as a subset of intelligence

A number of researchers include creativity, either explicitly or implicitly, as a key component of intelligence.

Examples of theories that include creativity as a subset of intelligence

- Gardner's Theory of multiple intelligences (MIT)[70] – implicitly includes creativity as a subset of MIT. To demonstrate this, Gardner cited examples of different famous creators, each of whom differed in their types of intelligences e.g. Picasso (spatial intelligence); Freud (intrapersonal); Einstein (logical-mathematical); and Gandhi (interpersonal).
- Sternberg's Theory of Successful intelligence[68][69][71] (see Triarchic theory of intelligence) includes creativity as a main component, and comprises 3 sub-theories: Componential (Analytic), Contextual (Practical), and Experiential (Creative). Experiential sub-theory – the ability to use pre-existing knowledge and skills to solve new and novel problems – is directly related to creativity.
- The Cattell–Horn–Carroll theory includes creativity as a subset of intelligence. Specifically, it is associated with the broad group factor of long-term storage and retrieval (Glr). Glr narrow abilities relating to creativity include:[72] ideational fluency, associational fluency, and originality/creativity. Silvia et al.[73] conducted a study to look at the relationship between divergent thinking and verbal fluency tests,

and reported that both fluency and originality in divergent thinking were significantly affected by the broad level Glr factor. Martindale[74] extended the CHC-theory in the sense that it was proposed that those individuals who are creative are also selective in their processing speed Martindale argues that in the creative process, larger amounts of information are processed more slowly in the early stages, and as the individual begins to understand the problem, the processing speed is increased.

- The Dual Process Theory of Intelligence[75] posits a two-factor/type model of intelligence. Type 1 is a conscious process, and concerns goal directed thoughts, which are explained by *g*. Type 2 is an unconscious process, and concerns spontaneous cognition, which encompasses daydreaming and implicit learning ability. Kaufman argues that creativity occurs as a result of Type 1 and Type 2 processes working together in combination. The use of each type in the creative process can be used to varying degrees.

12.7.2 Intelligence as a subset of creativity

In this relationship model, intelligence is a key component in the development of creativity.

Theories of creativity that include intelligence as a subset of creativity

- Sternberg & Lubart's Investment Theory.[76][77] Using the metaphor of a stock market, they demonstrate that creative thinkers are like good investors – they buy low and sell high (in their ideas). Like under/low-valued stock, creative individuals generate unique ideas that are initially rejected by other people. The creative individual has to persevere, and convince the others of the ideas value. After convincing the others, and thus increasing the ideas value, the creative individual 'sells high' by leaving the idea with the other people, and moves onto generating another idea. According to this theory, six distinct, but related elements contribute to successful creativity: intelligence, knowledge, thinking styles, personality, motivation, and environment. Intelligence is just one of the six factors that can either solely, or in conjunction with the other five factors, generate creative thoughts.

- Amabile's Componential Model of Creativity.[78][79] In this model, there are 3 within-individual components needed for creativity – domain-relevant skills, creativity-relevant processes, and task motivation – and 1 component external to the individual: their surrounding social environment. Creativity requires a confluence of all components. High creativity will result when an individual is: intrinsically motivated, possesses both a high level of domain-relevant skills and has high skills in creative thinking, and is working in a highly creative environment.

- Amusement Park Theoretical Model.[80] In this 4-step theory, both domain-specific and generalist views are integrated into a model of creativity. The researchers make use of the metaphor of the amusement park to demonstrate that within each of these creative levels, intelligence plays a key role:

  - To get into the amusement park, there are initial requirements (e.g., time/transport to go to the park). Initial requirements (like intelligence) are necessary, but not sufficient for creativity. They are more like prerequisites for creativity, and if an individual does not possess the basic level of the initial requirement (intelligence), then they will not be able to generate creative thoughts/behaviour.
  - Secondly are the subcomponents – general thematic areas – that increase in specificity. Like choosing which type of amusement park to visit (e.g. a zoo or a water park), these areas relate to the areas in which someone could be creative (e.g. poetry).
  - Thirdly, there are specific domains. After choosing the type of park to visit e.g. waterpark, you then have to choose which specific park to go to. Within the poetry domain, there are many different types (e.g. free verse, riddles, sonnet, etc.) that have to be selected from.
  - Lastly, there are micro-domains. These are the specific tasks that reside within each domain e.g. individual lines in a free verse poem / individual rides at the waterpark.

12.7.3 Creativity and intelligence as overlapping yet distinct constructs

This possible relationship concerns creativity and intelligence as distinct, but intersecting constructs.

Theories that include Creativity and Intelligence as Overlapping Yet Distinct Constructs

- Renzulli's Three-Ring Conception of Giftedness.[81] In this conceptualisation, giftedness occurs as a result from the overlap of above average intellectual ability, creativity, and task commitment. Under this view, creativity and intelligence are distinct constructs, but they do overlap under the correct conditions.

- PASS theory of intelligence. In this theory, the planning component – relating to the ability to solve problems, make decisions and take action – strongly overlaps with the concept of creativity.[82]

- Threshold Theory (TT). A number of previous research findings have suggested that a threshold exists in the relationship between creativity and intelligence – both constructs are moderately positively correlated up to an IQ of ~120. Above this threshold of an IQ of 120, if there is a relationship at all, it is small and weak.[62][63][83] TT posits that a moderate level of intelligence is necessary for creativity.

In support of the TT, Barron[63][84] reported finding a non-significant correlation between creativity and intelligence in a gifted sample; and a significant correlation in a non-gifted sample. Yamamoto[85] in a sample of secondary school children, reported a significant correlation between creativity and intelligence of $r = .3$, and reported no significant correlation when the sample consisted of gifted children. Fuchs-Beauchamp et al.[86] in a sample of preschoolers found that creativity and intelligence correlated from $r = .19$ to $r = .49$ in the group of children who had an IQ below the threshold; and in the group above the threshold, the correlations were $r = <.12$. Cho et al.[87] reported a correlation of .40 between creativity and intelligence in the average IQ group of a sample of adolescents and adults; and a correlation of close to $r = .0$ for the high IQ group. Jauk et al.[88] found support for the TT, but only for measures of creative potential; not creative performance.

Much modern day research reports findings against TT. Wai et al.[89] in a study using data from the longitudinal Study of Mathematically Precocious Youth – a cohort of elite students from early adolescence into adulthood – found that differences in SAT scores at age 13 were predictive of creative real-life outcomes 20 years later. Kim's[90] meta-analysis of 21 studies did not find any supporting evidence for TT, and instead negligible correlations were reported between intelligence, creativity, and divergent thinking both below and above IQ's of 120. Preckel et al.,[91] investigating fluid intelligence and creativity, reported small correlations of $r = .3$ to $r = .4$ across all levels of cognitive ability.

12.7.4 Creativity and intelligence as coincident sets

Under this view, researchers posit that there are no differences in the mechanisms underlying creativity in those used in normal problem solving; and in normal problem solving, there is no need for creativity. Thus, creativity and Intelligence (problem solving) are the same thing. Perkins[92] referred to this as the 'nothing-special' view.

Weisberg & Alba[93] examined problem solving by having participants complete the 9-dot problem (see Thinking outside the box#Nine dots puzzle) – where the participants are asked to connect all 9 dots in the 3 rows of 3 dots using 4 straight lines or less, without lifting their pen or tracing the same line twice. The problem can only be solved if the lines go outside the boundaries of the square of dots. Results demonstrated that even when participants were given this insight, they still found it difficult to solve the problem, thus showing that to successfully complete the task it is not just insight (or creativity) that is required.

12.7.5 Creativity and intelligence as disjoint sets

In this view, creativity and intelligence are completely different, unrelated constructs.

Getzels and Jackson[62] administered 5 creativity measures to a group of 449 children from grades 6-12, and compared these test findings to results from previously administered (by the school) IQ tests. They found that the correlation between the creativity measures and IQ was $r = .26$. The high creativity group scored in the top 20% of the overall creativity measures, but were not included in the top 20% of IQ scorers. The high intelligence group scored the opposite: they scored in the top 20% for IQ, but were outside the top 20% scorers for creativity, thus showing that creativity and intelligence are distinct and unrelated.

However, this work has been heavily criticised. Wallach and Kogan[64] highlighted that the creativity measures were not only weakly related to one another (to the extent that they were no more related to one another than they were with IQ), but they seemed to also draw upon non-creative skills. McNemar[94] noted that there were major measurement issues, in that the IQ scores were a mixture from 3 different IQ tests.

Wallach and Kogan[64] administered 5 measures of creativity, each of which resulted in a score for originality and fluency; and 10 measures of general intelligence to 151 5th grade children. These tests were untimed, and given in a game-like manner (aiming to facilitate creativity). Inter-correlations between creativity tests were on average $r = .41$. Inter-correlations between intelligence measures were on average $r = .51$ with each other. Creativity tests and intelligence measures correlated $r = .09$.

12.8 Neuroscience

The neuroscience of creativity looks at the operation of the brain during creative behaviour. It has been addressed[95] in the article "Creative Innovation: Possible Brain Mechanisms." The authors write that "creative innovation might require coactivation and communication between regions of the brain that ordinarily are not strongly connected." Highly creative people who excel at creative innovation tend to differ from others in three ways:

- they have a high level of specialized knowledge,

- they are capable of divergent thinking mediated by the frontal lobe.
- and they are able to modulate neurotransmitters such as norepinephrine in their frontal lobe.

Thus, the frontal lobe appears to be the part of the cortex that is most important for creativity.

This article also explored the links between creativity and sleep, mood and addiction disorders, and depression.

In 2005, Alice Flaherty presented a three-factor model of the creative drive. Drawing from evidence in brain imaging, drug studies and lesion analysis, she described the creative drive as resulting from an interaction of the frontal lobes, the temporal lobes, and dopamine from the limbic system. The frontal lobes can be seen as responsible for idea generation, and the temporal lobes for idea editing and evaluation. Abnormalities in the frontal lobe (such as depression or anxiety) generally decrease creativity, while abnormalities in the temporal lobe often increase creativity. High activity in the temporal lobe typically inhibits activity in the frontal lobe, and vice versa. High dopamine levels increase general arousal and goal directed behaviors and reduce latent inhibition, and all three effects increase the drive to generate ideas.[96] A 2015 study on creativity found that it involves the interaction of multiple neural networks, including those that support associative thinking, along with other default mode network functions.[97]

12.8.1 Working memory and the cerebellum

Vandervert[98] described how the brain's frontal lobes and the cognitive functions of the cerebellum collaborate to produce creativity and innovation. Vandervert's explanation rests on considerable evidence that all processes of working memory (responsible for processing all thought[99]) are adaptively modeled for increased efficiency by the cerebellum.[100] The cerebellum (consisting of 100 billion neurons, which is more than the entirety of the rest of the brain[101]) is also widely known to adaptively model all bodily movement for efficiency. The cerebellum's adaptive models of working memory processing are then fed back to especially frontal lobe working memory control processes[102] where creative and innovative thoughts arise.[103] (Apparently, creative insight or the "aha" experience is then triggered in the temporal lobe.[104])

According to Vandervert, the details of creative adaptation begin in "forward" cerebellar models which are anticipatory/exploratory controls for movement and thought. These cerebellar processing and control architectures have been termed Hierarchical Modular Selection and Identification for Control (HMOSAIC).[105] New, hierarchically arranged levels of the cerebellar control architecture (HMOSAIC) develop as mental mulling in working memory is extended over time. These new levels of the control architecture are fed forward to the frontal lobes. Since the cerebellum adaptively models all movement and all levels of thought and emotion,[106] Vandervert's approach helps explain creativity and innovation in sports, art, music, the design of video games, technology, mathematics, the child prodigy, and thought in general.

Essentially, Vandervert has argued that when a person is confronted with a challenging new situation, visual-spatial working memory and speech-related working memory are decomposed and re-composed (fractionated) by the cerebellum and then blended in the cerebral cortex in an attempt to deal with the new situation. With repeated attempts to deal with challenging situations, the cerebro-cerebellar blending process continues to optimize the efficiency of how working memory deals with the situation or problem.[107] Most recently, he has argued that this is the same process (only involving visual-spatial working memory and pre-language vocalization) that led to the evolution of language in humans.[108] Vandervert and Vandervert-Weathers have pointed out that this blending process, because it continuously optimizes efficiencies, constantly improves prototyping attempts toward the invention or innovation of new ideas, music, art, or technology.[109] Prototyping, they argue, not only produces new products, it trains the cerebro-cerebellar pathways involved to become more efficient at prototyping itself. Further, Vandervert and Vandervert-Weathers believe that this repetitive "mental prototyping" or mental rehearsal involving the cerebellum and the cerebral cortex explains the success of the self-driven, individualized patterning of repetitions initiated by the teaching methods of the Khan Academy. The model proposed by Vandervert has, however, received incisive critique from several authors.[110][111]

12.8.2 REM sleep

Creativity involves the forming of associative elements into new combinations that are useful or meet some requirement. Sleep aids this process.[112] REM rather than NREM sleep appears to be responsible.[113][114] This has been suggested to be due to changes in cholinergic and noradrenergic neuromodulation that occurs during REM sleep.[113] During this period of sleep, high levels of acetylcholine in the hippocampus suppress feedback from the hippocampus to the neocortex, and lower levels of acetylcholine and norepinephrine in the neocortex encourage the spread of associational activity within neocortical areas without control from the hippocampus.[115] This is in contrast to waking consciousness, where higher levels of norepinephrine and acetylcholine inhibit recurrent connections in the neocortex. It is proposed that REM sleep adds creativity by allowing "neocortical structures to reorganize associative hierarchies, in which information from the hippocampus would be reinterpreted in relation to previous semantic representations

or nodes."[113]

12.9 Affect

Some theories suggest that creativity may be particularly susceptible to affective influence. As noted in voting behavior, the term "affect" in this context can refer to liking or disliking key aspects of the subject in question. This work largely follows from findings in psychology regarding the ways in which affective states are involved in human judgment and decision-making.[116]

12.9.1 Positive affect relations

According to Alice Isen, positive affect has three primary effects on cognitive activity:

1. Positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association;
2. Positive affect leads to defocused attention and a more complex cognitive context, increasing the breadth of those elements that are treated as relevant to the problem;
3. Positive affect increases cognitive flexibility, increasing the probability that diverse cognitive elements will in fact become associated. Together, these processes lead positive affect to have a positive influence on creativity.

Barbara Fredrickson in her broaden-and-build model suggests that positive emotions such as joy and love broaden a person's available repertoire of cognitions and actions, thus enhancing creativity.

According to these researchers, positive emotions increase the number of cognitive elements available for association (attention scope) and the number of elements that are relevant to the problem (cognitive scope).

Various meta-analyses, such as Baas et al. (2008) of 66 studies about creativity and affect support the link between creativity and positive affect.[117][118]

12.10 Creativity and artificial intelligence

Jürgen Schmidhuber's formal theory of creativity[119][120] postulates that creativity, curiosity, and interestingness are by-products of a simple computational principle for measuring and optimizing learning progress. Consider an agent able to manipulate its environment and thus its own sensory inputs. The agent can use a black box optimization method such as reinforcement learning to learn (through informed trial and error) sequences of actions that maximize the expected sum of its future reward signals. There are extrinsic reward signals for achieving externally given goals, such as finding food when hungry. But Schmidhuber's objective function to be maximized also includes an additional, intrinsic term to model "wow-effects." This non-standard term motivates purely creative behavior of the agent even when there are no external goals. A wow-effect is formally defined as follows. As the agent is creating and predicting and encoding the continually growing history of actions and sensory inputs, it keeps improving the predictor or encoder, which can be implemented as an artificial neural network or some other machine learning device that can exploit regularities in the data to improve its performance over time. The improvements can be measured precisely, by computing the difference in computational costs (storage size, number of required synapses, errors, time) needed to encode new observations before and after learning. This difference depends on the encoder's present subjective knowledge, which changes over time, but the theory formally takes this into account. The cost difference measures the strength of the present "wow-effect" due to sudden improvements in data compression or computational speed. It becomes an intrinsic reward signal for the action selector. The objective function thus motivates the action optimizer to create action sequences causing more wow-effects. Irregular, random data (or noise) do not permit any wow-effects or learning progress, and thus are "boring" by nature (providing no reward). Already known and predictable regularities also are boring. Temporarily interesting are only the initially unknown, novel, regular patterns in both actions and observations. This motivates the agent to perform continual, open-ended, active, creative exploration.

According to Schmidhuber, his objective function explains the activities of scientists, artists, and comedians.[121][122] For example, physicists are motivated to create experiments leading to observations obeying previously unpublished physical laws permitting better data compression. Likewise, composers receive intrinsic reward for creating non-arbitrary melodies with unexpected but regular harmonies that permit wow-effects through data compression improvements. Similarly, a comedian gets intrinsic reward for "inventing a novel joke with an unexpected punch line, related to the beginning of the story in an initially unexpected but quickly learnable way that also allows for better compression of the perceived data."[123] Schmidhuber argues that ongoing computer hardware advances will greatly scale up rudimentary artificial scientists and artists based on simple implementations of the basic principle since 1990.[124] He used the theory to create low-complexity art[125] and an attractive human face.[126]

12.11 Mental health

Main article: Creativity and mental illness

A study by psychologist J. Philippe Rushton found creativity to correlate with intelligence and psychoticism.[127] Another study found creativity to be greater in schizotypal than in either normal or schizophrenic individuals. While divergent thinking was associated with bilateral activation of the prefrontal cortex, schizotypal individuals were found to have much greater activation of their *right* prefrontal cortex.[128] This study hypothesizes that such individuals are better at accessing both hemispheres, allowing them to make novel associations at a faster rate. In agreement with this hypothesis, ambidexterity is also associated with schizotypal and schizophrenic individuals. Three recent studies by Mark Batey and Adrian Furnham have demonstrated the relationships between schizotypal[129][130] and hypomanic personality[131] and several different measures of creativity.

Particularly strong links have been identified between creativity and mood disorders, particularly manic-depressive disorder (a.k.a. bipolar disorder) and depressive disorder (a.k.a. unipolar disorder). In *Touched with Fire: Manic-Depressive Illness and the Artistic Temperament*, Kay Redfield Jamison summarizes studies of mood-disorder rates in **writers**, **poets**, and **artists**. She also explores research that identifies mood disorders in such famous writers and artists as Ernest Hemingway (who shot himself after electroconvulsive treatment), Virginia Woolf (who drowned herself when she felt a depressive episode coming on), composer Robert Schumann (who died in a mental institution), and even the famed visual artist Michelangelo.

A study looking at 300,000 persons with schizophrenia, bipolar disorder, or unipolar depression, and their relatives, found overrepresentation in creative professions for those with bipolar disorder as well as for undiagnosed siblings of those with schizophrenia or bipolar disorder. There was no overall overrepresentation, but overrepresentation for artistic occupations, among those diagnosed with schizophrenia. There was no association for those with unipolar depression or their relatives.[132]

Another study involving more than one million people, conducted by Swedish researchers at the Karolinska Institute, reported a number of correlations between creative occupations and mental illnesses. Writers had a higher risk of anxiety and bipolar disorders, schizophrenia, unipolar depression, and substance abuse, and were almost twice as likely as the general population to kill themselves. Dancers and photographers were also more likely to have bipolar disorder.[133]

However, as a group, those in the creative professions were no more likely to suffer from psychiatric disorders than other people, although they were more likely to have a close relative with a disorder, including anorexia and, to some extent, autism, the Journal of Psychiatric Research reports.[133]

According to psychologist Robert Epstein, PhD, creativity can be obstructed through stress.[134]

12.12 Creativity and personality

Creativity can be expressed in a number of different forms, depending on unique people and environments. A number of different theorists have suggested models of the creative person. One model suggests that there are kinds to produce growth, innovation, speed, etc. These are referred to as the four "Creativity Profiles" that can help achieve such goals.[135]

(i) *Incubate* (Long-term Development)

(ii) *Imagine* (Breakthrough Ideas)

(iii) *Improve* (Incremental Adjustments)

(iv) *Invest* (Short-term Goals)

Research by Dr Mark Batey of the Psychometrics at Work Research Group at Manchester Business School has suggested that the creative profile can be explained by four primary creativity traits with narrow facets within each

(i) "Idea Generation" (Fluency, Originality, Incubation and Illumination)

(ii) "Personality" (Curiosity and Tolerance for Ambiguity)

(iii) "Motivation" (Intrinsic, Extrinsic and Achievement)

(iv) "Confidence" (Producing, Sharing and Implementing)

This model was developed in a sample of 1000 working adults using the statistical techniques of Exploratory Factor Analysis followed by Confirmatory Factor Analysis by Structural Equation Modelling.[136]

An important aspect of the creativity profiling approach is to account for the tension between predicting the creative profile of an individual, as characterised by the psychometric approach, and the evidence that team creativity is founded on diversity and difference.[137]

One characteristic of creative people, as measured by some psychologists, is what is called *divergent production*. *Divergent production* is the ability of a person to generate a diverse assortment, yet an appropriate amount of responses to a given situation.[138] One way of measuring *divergent production* is by administering the Torrance Tests of Creative Thinking.[139] The Torrance Tests of Creative Thinking assesses the diversity, quantity, and

appropriateness of participants responses to a variety of open-ended questions.

Other researchers of creativity see the difference in creative people as a cognitive process of dedication to problem solving and developing expertise in the field of their creative expression. Hard working people study the work of people before them and within their current area, become experts in their fields, and then have the ability to add to and build upon previous information in innovative and creative ways. In a study of projects by design students, students who had more knowledge on their subject on average had greater creativity within their projects.[140]

The aspect of motivation within a person's personality may predict creativity levels in the person. Motivation stems from two different sources, intrinsic and extrinsic motivation. Intrinsic motivation is an internal drive within a person to participate or invest as a result of personal interest, desires, hopes, goals, etc. Extrinsic motivation is a drive from outside of a person and might take the form of payment, rewards, fame, approval from others, etc. Although extrinsic motivation and intrinsic motivation can both increase creativity in certain cases, strictly extrinsic motivation often impedes creativity in people.[141]

From a personality-traits perspective, there are a number of traits that are associated with creativity in people.[142] Creative people tend to be more open to new experiences, are more self-confident, are more ambitious, self-accepting, impulsive, driven, dominant, and hostile, compared to people with less creativity.

From an evolutionary perspective, creativity may be a result of the outcome of years of generating ideas. As ideas are continuously generated, the need to evolve produces a need for new ideas and developments. As a result, people have been creating and developing new, innovative, and creative ideas to build our progress as a society.[143]

In studying exceptionally creative people in history, some common traits in lifestyle and environment are often found. Creative people in history usually had supportive parents, but rigid and non-nurturing. Most had an interest in their field at an early age, and most had a highly supportive and skilled mentor in their field of interest. Often the field they chose was relatively uncharted, allowing for their creativity to be expressed more in a field with less previous information. Most exceptionally creative people devoted almost all of their time and energy into their craft, and after about a decade had a creative breakthrough of fame. Their lives were marked with extreme dedication and a cycle of hard-work and breakthroughs as a result of their determination.[144]

Another theory of creative people is the *investment theory of creativity*. This approach suggest that there are many individual and environmental factors that must exist in precise ways for extremely high levels of creativity opposed to average levels of creativity. In the *investment* sense, a person with their particular characteristics in their particular environment may see an opportunity to devote their time and energy into something that has been overlooked by others. The creative person develops an undervalued or under-recognised idea to the point that it is established as a new and creative idea. Just like in the financial world, some investments are worth the buy in, while others are less productive and do not build to the extent that the investor expected. This *investment theory of creativity* views creativity in a unique perspective compared to others, by asserting that creativity might rely to some extent on the right investment of effort being added to a field at the right time in the right way.[145]

12.13 Malevolent creativity

Malevolent creativity (MC) focuses on the 'darker side' of creativity.[146] This type of creativity is not typically accepted within society and is defined by the intention to cause harm to others through original and innovative means. MC should be distinguished from negative creativity in that negative creativity may unintentionally cause harm to others, whereas MC is explicitly malevolently motivated. MC is often a key contributor to crime and in its most destructive form can even manifest as terrorism. However, MC can also be observed in ordinary day to day life as lying, cheating and betrayal.[147] Although everyone shows some levels of MC under certain conditions, those that have a higher propensity towards malevolent creativity have increased tendencies to deceive and manipulate others to their own gain. Although levels of MC appear to dramatically increase when an individual is placed under unfair conditions, personality is also a key predictor in anticipating levels of malevolent thinking. Researches Harris and Reiter-Palmon investigated the role of aggression in levels of MC, in particular levels of implicit aggression and the tendency to employ aggressive actions in response to problem solving. The personality traits of physical aggression, conscientiousness, emotional intelligence and implicit aggression all seem to be related with MC.[146] Harris and Reiter-Palmon's research showed that when subjects were presented with a problem that triggered malevolent creativity, participants high in implicit aggression and low in premeditation expressed the largest number of malevolently-themed solutions. When presented with the more benign problem that triggered prosocial motives of helping others and cooperating, those high in implicit aggression, even if they were high in impulsiveness, were far less destructive in their imagined solutions. They concluded premeditation, more than implicit aggression controlled an individual's expression of malevolent creativity.[148]

The current measure for malevolent creativity is the 13 item test Malevolent Creativity Behaviour Scale (MCBS) [147]

12.13.1 Malevolent creativity and crime

Malevolent creativity has strong links with crime. As creativity requires deviating from the conventional, there is a permanent tension between being creative and producing products that go too far and in some cases to the point of breaking the law. Aggression is a key predictor of malevolent creativity, studies have also shown that increased levels of aggression also correlates to a higher likelihood of committing crime.[149]

12.14 Creativity across cultures

Creativity is viewed differently in different countries.[150] For example, cross-cultural research centred on Hong Kong found that Westerners view creativity more in terms of the individual attributes of a creative person, such as their aesthetic taste, while Chinese people view creativity more in terms of the social influence of creative people e.g. what they can contribute to society.[151] Mpofu et al. surveyed 28 African languages and found that 27 had no word which directly translated to 'creativity' (the exception being Arabic).[152] The principle of linguistic relativity, i.e. that language can affect thought, suggests that the lack of an equivalent word for 'creativity' may affect the views of creativity among speakers of such languages. However, more research would be needed to establish this, and there is certainly no suggestion that this linguistic difference makes people any less (or more) creative; Africa has a rich heritage of creative pursuits such as music, art, and storytelling. Nevertheless, it is true that there has been very little research on creativity in Africa,[153] and there has also been very little research on creativity in Latin America.[154] Creativity has been more thoroughly researched in the northern hemisphere, but here again there are cultural differences, even between countries or groups of countries in close proximity. For example, in Scandinavian countries, creativity is seen as an individual attitude which helps in coping with life's challenges,[155] while in Germany, creativity is seen more as a process that can be applied to help solve problems.[156]

12.15 In organizations

It has been the topic of various research studies to establish that organizational effectiveness depends on the creativity of the workforce to a large extent. For any given organization, measures of effectiveness vary, depending upon its mission, environmental context, nature of work, the product or service it produces, and customer demands. Thus, the first step in evaluating organizational effectiveness is to understand the organization itself — how it functions, how it is structured, and what it emphasizes.

Training meeting in an eco-design stainless steel company in Brazil. The leaders among other things wish to cheer and encourage the workers in order to achieve a higher level of creativity.

Amabile[157] argued that to enhance creativity in business, three components were needed:

- Expertise (technical, procedural and intellectual knowledge),
- Creative thinking skills (how flexibly and imaginatively people approach problems),
- and Motivation (especially intrinsic motivation).

There are two types of motivation:

- extrinsic motivation – external factors, for example threats of being fired or money as a reward,
- intrinsic motivation – comes from inside an individual, satisfaction, enjoyment of work, etc.

Six managerial practices to encourage motivation are:

- Challenge – matching people with the right assignments;
- Freedom – giving people autonomy choosing means to achieve goals;
- Resources – such as time, money, space, etc. There must be balance fit among resources and people;
- Work group features – diverse, supportive teams, where members share the excitement, willingness to help, and recognize each other's talents;
- Supervisory encouragement – recognitions, cheering, praising;
- Organizational support – value emphasis, information sharing, collaboration.

Nonaka, who examined several successful Japanese companies, similarly saw creativity and knowledge creation as being important to the success of organizations.[158] In

particular, he emphasized the role that tacit knowledge has to play in the creative process.

In business, originality is not enough. The idea must also be appropriate—useful and actionable.[159][160] Creative competitive intelligence is a new solution to solve this problem. According to Reijo Siltala it links creativity to innovation process and competitive intelligence to creative workers.

Creativity can be encouraged in people and professionals and in the workplace. It is essential for innovation, and is a factor affecting economic growth and businesses. In 2013, the sociologist Silvia Leal Martín, using the Innova 3DX method, suggested measuring the various parameters that encourage creativity and innovation: corporate culture, work environment, leadership and management, creativity, self-esteem and optimism, locus of control and learning orientation, motivation, and fear.[161]

12.16 Economic views of creativity

Economic approaches to creativity have focussed on three aspects — the impact of creativity on economic growth, methods of modelling markets for creativity, and the maximisation of economic creativity (innovation).

In the early 20th century, Joseph Schumpeter introduced the economic theory of *creative destruction*, to describe the way in which old ways of doing things are endogenously destroyed and replaced by the new. Some economists (such as Paul Romer) view creativity as an important element in the recombination of elements to produce new technologies and products and, consequently, economic growth. Creativity leads to capital, and creative products are protected by intellectual property laws.

Mark A. Runco and Daniel Rubenson have tried to describe a "psychoeconomic" model of creativity.[162] In such a model, creativity is the product of endowments and active investments in creativity; the costs and benefits of bringing creative activity to market determine the supply of creativity. Such an approach has been criticised for its view of creativity consumption as always having positive utility, and for the way it analyses the value of future innovations.[163]

The *creative class* is seen by some to be an important driver of modern economies. In his 2002 book, *The Rise of the Creative Class*, economist Richard Florida popularized the notion that regions with “3 T’s of economic development: Technology, Talent and Tolerance” also have high concentrations of creative professionals and tend to have a higher level of economic development.

12.17 Fostering creativity

Main article: Creativity techniques

Daniel Pink, in his 2005 book *A Whole New Mind*, repeating arguments posed throughout the 20th century, argues that we are entering a new age where creativity is becoming increasingly important. In this *conceptual age*, we will need to foster and encourage *right-directed thinking* (representing creativity and emotion) over *left-directed thinking* (representing logical, analytical thought). However, this simplification of 'right' versus 'left' brain thinking is not supported by the research data.[164]

Nickerson[165] provides a summary of the various creativity techniques that have been proposed. These include approaches that have been developed by both academia and industry:

1. Establishing purpose and intention
2. Building basic skills
3. Encouraging acquisitions of domain-specific knowledge
4. Stimulating and rewarding curiosity and exploration
5. Building motivation, especially internal motivation
6. Encouraging confidence and a willingness to take risks
7. Focusing on mastery and self-competition
8. Promoting supportable beliefs about creativity
9. Providing opportunities for choice and discovery
10. Developing self-management (metacognitive skills)
11. Teaching techniques and strategies for facilitating creative performance
12. Providing balance

Some see the conventional system of schooling as “stifling” of creativity and attempt (particularly in the preschool/kindergarten and early school years) to provide a creativity-friendly, rich, imagination-fostering environment for young children.[165][166][167] Researchers have seen this as important because technology is advancing our society at an unprecedented rate and creative problem solving will be needed to cope with these challenges as they arise.[167] In addition to helping with problem solving, creativity also helps students identify problems where others have failed to do so.[165][166][168] See the Waldorf School as an example of an education program that promotes creative thought.

Promoting intrinsic motivation and problem solving are two areas where educators can foster creativity in students. Students are more creative when they see

a task as intrinsically motivating, valued for its own sake.[166][167][169][170] To promote creative thinking, educators need to identify what motivates their students and structure teaching around it. Providing students with a choice of activities to complete allows them to become more intrinsically motivated and therefore creative in completing the tasks.[165][171]

Teaching students to solve problems that do not have well defined answers is another way to foster their creativity. This is accomplished by allowing students to explore problems and redefine them, possibly drawing on knowledge that at first may seem unrelated to the problem in order to solve it.[165][166][167][169]

Several different researchers have proposed methods of increasing the creativity of an individual. Such ideas range from the psychological-cognitive, such as Osborn-Parnes Creative Problem Solving Process, Synectics, science-based creative thinking, Purdue Creative Thinking Program, and Edward de Bono's lateral thinking; to the highly structured, such as TRIZ (the Theory of Inventive Problem-Solving) and its variant Algorithm of Inventive Problem Solving (developed by the Russian scientist Genrich Altshuller), and Computer-Aided morphological analysis.

Creativity has also been identified as one of the key 21st century skills and as one of the Four Cs of 21st century learning by educational leaders and theorists in the United States.

12.18 List of academic journals addressing creativity

- *Creativity Research Journal*
- *Creativity. Theories – Research - Applications*
- *International Journal of Creative Computing*
- *International Journal of Creativity and Problem Solving*
- *Journal of Creative Behavior*
- *Psychology of Aesthetics, Creativity, and the Arts*
- *Thinking Skills and Creativity*
- *Creativity and Innovation Management*
- *Journal of Creativity and Business Innovation*

12.19 See also

- Adaptive performance
- Brainstorming
- Computational creativity
- Confabulation (neural networks)
- E-scape, a technology and approach that looks specifically at the assessment of creativity and collaboration.
- Greatness
- Heroic theory of invention and scientific development
- Innovation
- Invention (such as "artistic invention" in the visual arts)
- Lateral thinking
- Learned industriousness
- Malevolent creativity
- Multiple discovery
- Music therapy
- Musical improvisation
- Management Innovation
- *Why Man Creates* (film)

12.20 Notes

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- John Cleese (2014-08-08) on Fostering Creativity

12.23 External links

Videos

- Raphael DiLuzio (2012-06-28) on 7 Steps of Creative Thinking

Chapter 13

Design

Design is the creation of a plan or convention for the construction of an object, system or measurable human interaction (as in architectural blueprints, engineering drawings, business processes, circuit diagrams, and sewing patterns).[1] Design has different connotations in different fields (see design disciplines below). In some cases, the direct construction of an object (as in pottery, engineering, management, coding, and graphic design) is also considered to use design thinking.

Designing often necessitates considering the aesthetic, functional, economic, and sociopolitical dimensions of both the design object and design process. It may involve considerable research, thought, modeling, interactive adjustment, and re-design. Meanwhile, diverse kinds of objects may be designed, including clothing, graphical user interfaces, skyscrapers, corporate identities, business processes, and even methods or processes of designing.[2]

Thus "design" may be a substantive referring to a categorical abstraction of a created thing or things (the design of something), or a verb for the process of creation as is made clear by grammatical context. It is an act of creativity and innovation.

13.1 Definitions

More formally design has been defined as follows:

> *(noun) a specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to constraints;*
>
> *(verb, transitive) to create a design, in an environment (where the designer operates)*[3]

Another definition for design is *a roadmap or a strategic approach for someone to achieve a unique expectation. It defines the specifications, plans, parameters, costs, activities, processes and how and what to do within legal, political, social, environmental, safety and economic constraints in achieving that objective.*[4]

Here, a "specification" can be manifested as either a plan or a finished product, and "primitives" are the elements from which the design object is composed.

With such a broad denotation, there is no universal language or unifying institution for designers of all disciplines. This allows for many differing philosophies and approaches toward the subject (see Philosophies and studies of design, below).

The person designing is called a *designer*, which is also a term used for people who work professionally in one of the various design areas usually specifying which area is being dealt with (such as a *fashion designer*, *concept designer*, *web designer* or interior designer). A designer's sequence of activities is called a design process while the scientific study of design is called design science.[5][6][7][8]

Another definition of design is planning to manufacture an object, system, component or structure. Thus the word "design" can be used as a noun or a verb. In a broader sense, the design is an applied art and engineering that integrate with technology.

While the definition of design is fairly broad, design has a myriad of specifications that professionals utilize in their fields.

13.2 Design as a process

Substantial disagreement exists concerning how designers in many fields, whether amateur or professional, alone or in teams, produce designs. Kees Dorst and Judith Dijkhuis, both designers themselves, argued that "there are many ways of describing design processes" and discussed "two basic and fundamentally different ways",[9] both of which have several names. The prevailing view has been called "The Rational Model",[10] "Technical Problem Solving"[11] and "The Reason-Centric Perspective".[12] The alternative view has been called "Reflection-in-Action",[11] "Evolutionary Design",[8] "co-evolution",[13] and "The Action-Centric Perspective".[12]

13.2.1 The Rational Model

The Rational Model was independently developed by Herbert A. Simon[14] , an American scientist, and Gerhard Pahl and Wolfgang Beitz, two German engineering design theorists.[15] It posits that:

1. designers attempt to optimize a design candidate for known constraints and objectives,
2. the design process is plan-driven,
3. the design process is understood in terms of a discrete sequence of stages.

The Rational Model is based on a rationalist philosophy[10] and underlies the waterfall model,[16] systems development life cycle,[17] and much of the engineering design literature.[18] According to the rationalist philosophy, design is informed by research and knowledge in a predictable and controlled manner. Technical rationality is at the center of the process.

Example sequence of stages

Typical stages consistent with The Rational Model include the following:

- Pre-production design
  - Design brief or *Parti pris* – an early (often the beginning) statement of design goals
  - Analysis – analysis of current design goals
  - Research – investigating similar design solutions in the field or related topics
  - Specification – specifying requirements of a design solution for a product (product design specification)[19] or service.
  - Problem solving – conceptualizing and documenting design solutions
  - Presentation – presenting design solutions
- Design during production
  - Development – continuation and improvement of a designed solution
  - Testing – *in situ* testing of a designed solution
- Post-production design feedback for future designs
  - Implementation – introducing the designed solution into the environment
  - Evaluation and conclusion – summary of process and results, including constructive criticism and suggestions for future improvements
- Redesign – any or all stages in the design process repeated (with corrections made) at any time before, during, or after production.

Each stage has many associated best practices.[20]

Criticism of the Rational Model

The Rational Model has been widely criticized on two primary grounds:

1. Designers do not work this way – extensive empirical evidence has demonstrated that designers do not act as the rational model suggests.[21]
2. Unrealistic assumptions – goals are often unknown when a design project begins, and the requirements and constraints continue to change.[22]

13.2.2 The Action-Centric Model

The Action-Centric Perspective is a label given to a collection of interrelated concepts, which are antithetical to The Rational Model.[12] It posits that:

1. designers use creativity and emotion to generate design candidates,
2. the design process is improvised,
3. no universal sequence of stages is apparent – analysis, design and implementation are contemporary and inextricably linked[12]

The Action-Centric Perspective is based on an empiricist philosophy and broadly consistent with the Agile approach[23] and amethodical development.[24] Substantial empirical evidence supports the veracity of this perspective in describing the actions of real designers.[21] Like the Rational Model, the Action-Centric model sees design as informed by research and knowledge. However, research and knowledge are brought into the design process through the judgment and common sense of designers – by designers "thinking on their feet" – more than through the predictable and controlled process stipulated by the Rational Model. Designers' context-dependent experience and professional judgment take center stage more than technical rationality.

Descriptions of design activities

At least two views of design activity are consistent with the Action-Centric Perspective. Both involve three basic activities.

In the Reflection-in-Action paradigm, designers alternate between "framing", "making moves", and "evaluate moves." "Framing" refers to conceptualizing the problem, i.e., defining goals and objectives. A "move" is a tentative design decision. The evaluation process may lead to further moves in the design.[11]

In the Sensemaking-Coevolution-Implementation Framework, designers alternate between its three titular activities. Sensemaking includes both framing and

evaluating moves. Implementation is the process of constructing the design object. Coevolution is "the process where the design agent simultaneously refines its mental picture of the design object based on its mental picture of the context, and vice versa."[25]

The concept of the Design Cycle is understood as a circular time structure,[26] which may start with the thinking of an idea, then expressing it by the use of visual and/or verbal means of communication (design tools), the sharing and perceiving of the expressed idea, and finally starting a new cycle with the critical rethinking of the perceived idea. Anderson points out that this concept emphasizes the importance of the means of expression, which at the same time are means of perception of any design ideas.[27]

13.3 Design disciplines

- Army design methodology[28]
- Applied arts
- Architecture
- Automotive design
- Biological design
- Communication design
- Configuration design
- Design management
- Engineering design
- Experience design
- Fashion design
- Game design
- Graphic design
- Information architecture
- Information design
- Industrial design
- Instructional design
- Interaction design
- Interior design
- Jewel design
- Landscape architecture
- Lighting design
- Modular design
- Motion graphic design
- Organization design
- Product design
- Process design
- Service design
- Software design
- Sound design
- Spatial design
- Systems architecture
- Systems design
- Systems modeling
- Urban design
- User experience design
- Visual design
- Web design

13.4 Philosophies and studies of design

There are countless philosophies for guiding design as design values and its accompanying aspects within modern design vary, both between different schools of thought and among practicing designers.[29] Design philosophies are usually for determining design goals. A design goal may range from solving the least significant individual problem of the smallest element, to the most holistic influential utopian goals. Design goals are usually for guiding design. However, conflicts over immediate and minor goals may lead to questioning the purpose of design, perhaps to set better long term or ultimate goals. John Heskett, a 20th-century British writer on design claimed, "Design, stripped to its essence, can be defined as the human nature to shape and make our environment in ways without precedent in nature, to serve our needs and give meaning to our lives."[30]

13.4.1 Philosophies for guiding design

Design philosophies are fundamental guiding principles that dictate how a designer approaches his/her practice. Reflections on material culture and environmental concerns (sustainable design) can guide a design philosophy. One example is the First Things First manifesto which was launched within the graphic design community and states "We propose a reversal of priorities in favor of more useful, lasting and democratic forms of communication – a mindshift away from product marketing and toward the exploration and production of a new kind

of meaning. The scope of debate is shrinking; it must expand. Consumerism is running uncontested; it must be challenged by other perspectives expressed, in part, through the visual languages and resources of design."[31]

In *The Sciences of the Artificial* by polymath Herbert A. Simon, the author asserts design to be a meta-discipline of all professions. "Engineers are not the only professional designers. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state. Design, so construed, is the core of all professional training; it is the principal mark that distinguishes the professions from the sciences. Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design."[32]

13.4.2 Approaches to design

A design approach is a general philosophy that may or may not include a guide for specific methods. Some are to guide the overall goal of the design. Other approaches are to guide the tendencies of the designer. A combination of approaches may be used if they don't conflict.

Some popular approaches include:

- Sociotechnical system design, a philosophy and tools for participative designing of work arrangements and supporting processes - for organizational purpose, quality, safety, economics and customer requirements in core work processes, the quality of peoples experience at work and the needs of society
- KISS principle, (Keep it Simple Stupid), which strives to eliminate unnecessary complications.
- There is more than one way to do it (TIMTOWTDI), a philosophy to allow multiple methods of doing the same thing.
- Use-centered design, which focuses on the goals and tasks associated with the use of the artifact, rather than focusing on the end user.
- User-centered design, which focuses on the needs, wants, and limitations of the end user of the designed artifact.
- Critical design uses designed artifacts as an embodied critique or commentary on existing values, morals, and practices in a culture.
- Service design designing or organizing the experience around a product and the service associated with a product's use.
- Transgenerational design, the practice of making products and environments compatible with those physical and sensory impairments associated with human aging and which limit major activities of daily living.
- Speculative design, the speculative design process doesn't necessarily define a specific problem to solve, but establishes a provocative starting point from which a design process emerges. The result is an evolution of fluctuating iteration and reflection using designed objects to provoke questions and stimulate discussion in academic and research settings.

13.4.3 Methods of designing

Main article: Design methods

Design methods is a broad area that focuses on:

- Exploring possibilities and constraints by focusing critical thinking skills to research and define problem spaces for existing products or services—or the creation of new categories; *(see also Brainstorming)*
- Redefining the specifications of design solutions which can lead to better guidelines for traditional design activities (graphic, industrial, architectural, etc.);
- Managing the process of exploring, defining, creating artifacts continually over time
- Prototyping possible scenarios, or solutions that incrementally or significantly improve the inherited situation
- Trendspotting; understanding the trend process.

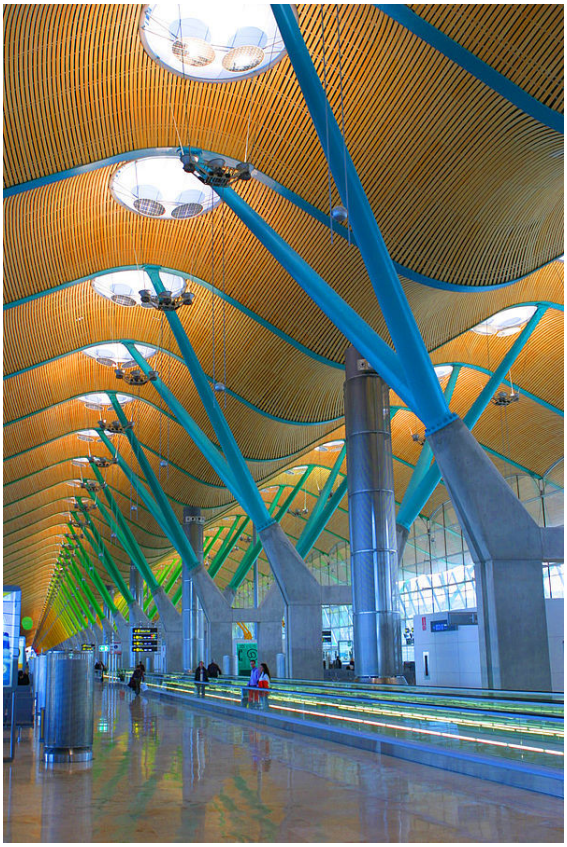
13.5 Terminology

The word "design" is often considered ambiguous, as it is applied in varying contexts.

13.5.1 Design and art

Today, the term design is widely associated with the applied arts as initiated by Raymond Loewy and teachings at the Bauhaus and Ulm School of Design (HfG Ulm) in Germany during the 20th century.

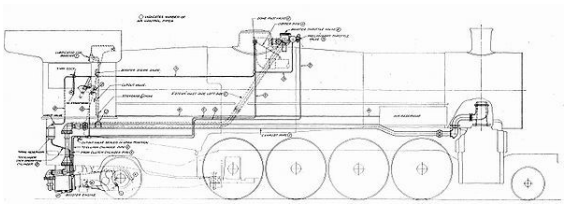
The boundaries between art and design are blurred, largely due to a range of applications both for the term 'art' and the term 'design'. Applied arts has been used as an umbrella term to define fields of industrial design, graphic design, fashion design, etc. The term 'decorative



The new terminal at Barajas airport in Madrid, Spain

arts' is a traditional term used in historical discourses to describe craft objects, and also sits within the umbrella of applied arts. In graphic arts (2D image making that ranges from photography to illustration), the distinction is often made between fine art and commercial art, based on the context within which the work is produced and how it is traded.

To a degree, some methods for creating work, such as employing intuition, are shared across the disciplines within the applied arts and fine art. Mark Getlein, writer, suggests the principles of design are "almost instinctive", "built-in", "natural", and part of "our sense of 'rightness'."[33] However, the intended application and context of the resulting works will vary greatly.



A drawing for a booster engine for steam locomotives. Engineering is applied to design, with emphasis on function and the utilization of mathematics and science.

13.5.2 Design and engineering

In engineering, design is a component of the engineering process. Many overlapping methods and processes can be seen when comparing Product design, Industrial design and Engineering. The American Heritage Dictionary defines design as: *"To conceive or fashion in the mind; invent,"* and *"To formulate a plan"*, and defines engineering as: *"The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems."*.[34][35] Both are forms of problem-solving with a defined distinction being the application of "scientific and mathematical principles". The increasingly scientific focus of engineering in practice, however, has raised the importance of new more "human-centered" fields of design.[36] How much science is applied in a design is a question of what is considered "science". Along with the question of what is considered science, there is social science versus natural science. Scientists at Xerox PARC made the distinction of design versus engineering at "moving minds" versus "moving atoms" (probably in contradiction to the origin of term "engineering - engineer" from Latin "in genio" in meaning of a "genius" what assumes existence of a "mind" not of an "atom").

Jonathan Ive has received several awards for his design of Apple Inc. products like this MacBook. In some design fields, personal computers are also used for both design and production

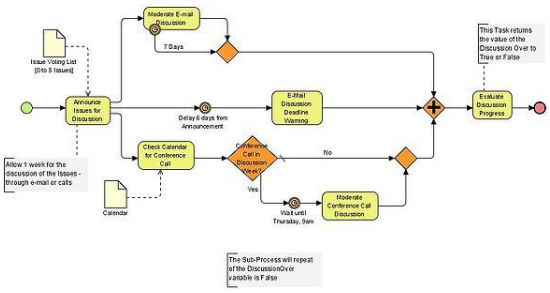
13.5.3 Design and production

The relationship between design and production is one of planning and executing. In theory, the plan should anticipate and compensate for potential problems in the execution process. Design involves problem-solving and creativity. In contrast, production involves a routine or pre-planned process. A design may also be a mere plan that does not include a production or engineering processes although a working knowledge of such processes is usually expected of designers. In some cases, it may be

unnecessary and/or impractical to expect a designer with a broad multidisciplinary knowledge required for such designs to also have a detailed specialized knowledge of how to produce the product.

Design and production are intertwined in many creative professional careers, meaning problem-solving is part of execution and the reverse. As the cost of rearrangement increases, the need for separating design from production increases as well. For example, a high-budget project, such as a skyscraper, requires separating (design) architecture from (production) construction. A Low-budget project, such as a locally printed office party invitation flyer, can be rearranged and printed dozens of times at the low cost of a few sheets of paper, a few drops of ink, and less than one hour's pay of a desktop publisher.

This is not to say that production never involves problem-solving or creativity, nor that design always involves creativity. Designs are rarely perfect and are sometimes repetitive. The imperfection of a design may task a production position (e.g. production artist, construction worker) with utilizing creativity or problem-solving skills to compensate for what was overlooked in the design process. Likewise, a design may be a simple repetition (copy) of a known preexisting solution, requiring minimal, if any, creativity or problem-solving skills from the designer.



An example of a business workflow process using Business Process Modeling Notation.

13.5.4 Process design

See also: Method engineering

"Process design" (in contrast to "design process" mentioned above) refers to the planning of routine steps of a process aside from the expected result. Processes (in general) are treated as a product of design, not the method of design. The term originated with the industrial designing of chemical processes. With the increasing complexities of the information age, consultants and executives have found the term useful to describe the design of business processes as well as manufacturing processes.

13.6 See also

- Design elements and principles
- Design-based learning
- Design thinking

13.7 Footnotes

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Chapter 14

Innovation

For other uses, see Innovation (disambiguation).

Innovation can be defined simply as a "new idea, device or method".[1] However, innovation is often also viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs.[2] This is accomplished through more-effective products, processes, services, technologies, or business models that are readily available to markets, governments and society. The term "innovation" can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society.[3] It is related to, but not the same as, invention.[4] Innovation is often manifested via the engineering process. The opposite of innovation is exnovation.

While a novel device is often described as an innovation, in economics, management science, and other fields of practice and analysis, innovation is generally considered to be the result of a process that brings together various novel ideas in a way that they affect society. In industrial economics, innovations are created and found empirically from services to meet the growing consumer demand.[5][6][7]

14.1 Definition

A 2013 survey of literature on innovation found over 40 definitions. In an industrial survey of how the software industry defined innovation, the following definition given by Crossan and Apaydin was considered to be the most complete, which builds on the Organisation for Economic Co-operation and Development (OECD) manual's definition:[8]

> Innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome.

Two main dimensions of innovation were degree of novelty (patent) i.e. whether an innovation is new to the firm, new to the market, new to the industry, and new to the world and type of innovation, whether it is process or product-service system innovation.[8]

14.2 Inter-disciplinary views

14.2.1 Business and economics

Main article: innovation economics

In business and economics, innovation can be a catalyst to growth. With rapid advancements in transportation and communications over the past few decades, the old world concepts of factor endowments and comparative advantage which focused on an area's unique inputs are outmoded for today's global economy. Economist Joseph Schumpeter, who contributed greatly to the study of innovation economics, argued that industries must incessantly revolutionize the economic structure from within, that is innovate with better or more effective processes and products, as well as market distribution, such as the connection from the craft shop to factory. He famously asserted that "creative destruction is the essential fact about capitalism".[9] In addition, entrepreneurs continuously look for better ways to satisfy their consumer base with improved quality, durability, service, and price which come to fruition in innovation with advanced technologies and organizational strategies.[10]

One prime example was the explosive boom of Silicon Valley startups out of the Stanford Industrial Park. In 1957, dissatisfied employees of Shockley Semiconductor, the company of Nobel laureate and co-inventor of the transistor William Shockley, left to form an independent firm, Fairchild Semiconductor. After several years, Fairchild developed into a formidable presence in the sector. Eventually, these founders left to start their own companies based on their own, unique, latest ideas, and then leading employees started their own firms. Over the next 20 years, this snowball process launched the momentous startup company explosion of information technology firms. Essentially, Silicon Valley began as

65 new enterprises born out of Shockley's eight former employees.[11] Since then, hubs of innovation have sprung up globally with similar metonyms, including Silicon Alley encompassing New York City.

Another example is the Business Incubators - a phenomenon that is nurtured by governments around the world, close to knowledge clusters, mostly research based, like universities or other Government Excellence Centres, while the main goal is to channel the generated knowledge to applied innovation outcomes in order to stimulate regional or national economic growth.[12]

14.2.2 Organizations

In the organizational context, innovation may be linked to positive changes in efficiency, productivity, quality, competitiveness, and market share. However, recent research findings highlight the complementary role of organizational culture in enabling organizations to translate innovative activity into tangible performance improvements.[13] Organizations can also improve profits and performance by providing work groups opportunities and resources to innovate, in addition to employee's core job tasks.[14] Peter Drucker wrote:

> Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, or a new venture started by a lone individual in the family kitchen. It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth. – Drucker[15]

According to Clayton Christensen, disruptive innovation is the key to future success in business.[16] The organisation requires a proper structure in order to retain competitive advantage. It is necessary to create and nurture an environment of innovation. Executives and managers need to break away from traditional ways of thinking and use change to their advantage. It is a time of risk but even greater opportunity.[17] The world of work is changing with the increase in the use of technology and both companies and businesses are becoming increasingly competitive. Companies will have to downsize and re-engineer their operations to remain competitive. This will affect employment as businesses will be forced to reduce the number of people employed while accomplishing the same amount of work if not more.[18]

While disruptive innovation will typically "attack a traditional business model with a lower-cost solution and overtake incumbent firms quickly,"[19] foundational innovation is slower, and typically has the potential to create new foundations for global technology systems over the longer term. Foundational innovation tends to transform business operating models as entirely new business models emerge over many years, with gradual and steady adoption of the innovation leading to waves of technological and institutional change that gain momentum more slowly.[19] The advent of the packet-switched communication protocol TCP/IP—originally introduced in 1972 to support a single use case for United States Department of Defense electronic communication (email), and which gainded widespread adoption only in the mid-1990s with the advent of the World Wide Web—is a foundational technology.[19]

All organizations can innovate, including for example hospitals, universities, and local governments.[20] For instance, former Mayor Martin O'Malley pushed the City of Baltimore to use CitiStat, a performance-measurement data and management system that allows city officials to maintain statistics on crime trends to condition of potholes. This system aids in better evaluation of policies and procedures with accountability and efficiency in terms of time and money. In its first year, CitiStat saved the city $13.2 million.[21] Even mass transit systems have innovated with hybrid bus fleets to real-time tracking at bus stands. In addition, the growing use of mobile data terminals in vehicles, that serve as communication hubs between vehicles and a control center, automatically send data on location, passenger counts, engine performance, mileage and other information. This tool helps to deliver and manage transportation systems.[22]

Still other innovative strategies include hospitals digitizing medical information in electronic medical records. For example, the U.S. Department of Housing and Urban Development's HOPE VI initiatives turned severely distressed public housing in urban areas into revitalized, mixed-income environments; the Harlem Children's Zone used a community-based approach to educate local area children; and the Environmental Protection Agency's brownfield grants facilitates turning over brownfields for environmental protection, green spaces, community and commercial development.

14.2.3 Sources

There are several sources of innovation. It can occur as a result of a focus effort by a range of different agents, by chance, or as a result of a major system failure.

According to Peter F. Drucker, the general sources of innovations are different changes in industry structure, in market structure, in local and global demographics, in human perception, mood and meaning, in the amount of already available scientific knowledge, etc.[15]

In the simplest linear model of innovation the traditionally recognized source is *manufacturer innovation*. This is where an agent (person or business) innovates in order to sell the innovation. Specifically, R&D measurement is the commonly used input for innovation, in particular in the business sector, named Business Expenditure on

Original model of three phases of the process of Technological Change

R&D (BERD) that grew over the years on the expenses of the declining R&D invested by the public sector.[23]

Another source of innovation, only now becoming widely recognized, is *end-user innovation*. This is where an agent (person or company) develops an innovation for their own (personal or in-house) use because existing products do not meet their needs. MIT economist Eric von Hippel has identified end-user innovation as, by far, the most important and critical in his classic book on the subject, *The Sources of Innovation*.[24]

The robotics engineer Joseph F. Engelberger asserts that innovations require only three things:

1. A recognized need,
2. Competent people with relevant technology, and
3. Financial support.[25]

However, innovation processes usually involve: identifying customer needs, macro and meso trends, developing competences, and finding financial support.

The Kline chain-linked model of innovation[26] places emphasis on potential market needs as drivers of the innovation process, and describes the complex and often iterative feedback loops between marketing, design, manufacturing, and R&D.

Innovation by businesses is achieved in many ways, with much attention now given to formal research and development (R&D) for "breakthrough innovations". R&D help spur on patents and other scientific innovations that leads to productive growth in such areas as industry, medicine, engineering, and government.[27] Yet, innovations can be developed by less formal on-the-job modifications of practice, through exchange and combination of professional experience and by many other routes. Investigation of relationship between the concepts of innovation and technology transfer revealed overlap.[28] The more radical and revolutionary innovations tend to emerge from R&D, while more incremental innovations may emerge from practice – but there are many exceptions to each of these trends.

Information technology and changing business processes and management style can produce a work climate favorable to innovation.[29] For example, the software tool company Atlassian conducts quarterly "ShipIt Days" in which employees may work on anything related to the company's products.[30] Google employees work on self-directed projects for 20% of their time (known as Innovation Time Off). Both companies cite these bottom-up processes as major sources for new products and features.

An important innovation factor includes customers buying products or using services. As a result, firms may incorporate users in focus groups (user centred approach), work closely with so called lead users (lead user approach) or users might adapt their products themselves. The lead user method focuses on idea generation based on leading users to develop breakthrough innovations. U-STIR, a project to innovate Europe's surface transportation system, employs such workshops.[31] Regarding this user innovation, a great deal of innovation is done by those actually implementing and using technologies and products as part of their normal activities. In most of the times user innovators have some personal record motivating them. Sometimes user-innovators may become entrepreneurs, selling their product, they may choose to trade their innovation in exchange for other innovations, or they may be adopted by their suppliers. Nowadays, they may also choose to freely reveal their innovations, using methods like open source. In such networks of innovation the users or communities of users can further develop technologies and reinvent their social meaning.[32][33]

14.2.4 Goals and failures

Programs of organizational innovation are typically tightly linked to organizational goals and objectives, to the business plan, and to market competitive positioning. One driver for innovation programs in corporations is to achieve growth objectives. As Davila et al. (2006) notes, "Companies cannot grow through cost reduction and reengineering alone... Innovation is the key element in providing aggressive top-line growth, and for increasing bottom-line results".[34]

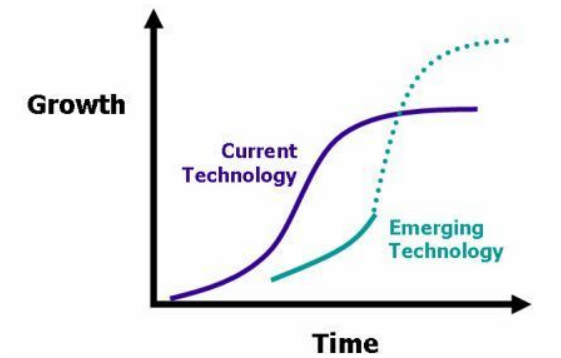
One survey across a large number of manufacturing and services organizations found, ranked in decreasing order of popularity, that systematic programs of organizational innovation are most frequently driven by: Improved quality, Creation of new markets, Extension of the product range, Reduced labor costs, Improved production processes, Reduced materials, Reduced environmental damage, Replacement of products/services, Reduced energy consumption, Conformance to regulations.[34]

These goals vary between improvements to products, processes and services and dispel a popular myth that innovation deals mainly with new product development. Most of the goals could apply to any organisation be it a manufacturing facility, marketing firm, hospital or local government. Whether innovation goals are successfully achieved or otherwise depends greatly on the environment prevailing in the firm.[35]

Conversely, failure can develop in programs of innovations. The causes of failure have been widely researched

and can vary considerably. Some causes will be external to the organization and outside its influence of control. Others will be internal and ultimately within the control of the organization. Internal causes of failure can be divided into causes associated with the cultural infrastructure and causes associated with the innovation process itself. Common causes of failure within the innovation process in most organizations can be distilled into five types: Poor goal definition, Poor alignment of actions to goals, Poor participation in teams, Poor monitoring of results, Poor communication and access to information.[36]

14.3 Diffusion



Main article: Diffusion of innovations

Diffusion of innovation research was first started in 1903 by seminal researcher Gabriel Tarde, who first plotted the S-shaped diffusion curve. Tarde defined the innovation-decision process as a series of steps that includes:[37]

1. First knowledge
2. Forming an attitude
3. A decision to adopt or reject
4. Implementation and use
5. Confirmation of the decision

Once innovation occurs, innovations may be spread from the innovator to other individuals and groups. This process has been proposed that the life cycle of innovations can be described using the 's-curve' or diffusion curve. The s-curve maps growth of revenue or productivity against time. In the early stage of a particular innovation, growth is relatively slow as the new product establishes itself. At some point customers begin to demand and the product growth increases more rapidly. New incremental innovations or changes to the product allow growth to continue. Towards the end of its lifecycle, growth slows and may even begin to decline. In the later stages, no amount of new investment in that product will yield a normal rate of return

The s-curve derives from an assumption that new products are likely to have "product life" – i.e., a start-up phase, a rapid increase in revenue and eventual decline. In fact the great majority of innovations never get off the bottom of the curve, and never produce normal returns.

Innovative companies will typically be working on new innovations that will eventually replace older ones. Successive s-curves will come along to replace older ones and continue to drive growth upwards. In the figure above the first curve shows a current technology. The second shows an emerging technology that currently yields lower growth but will eventually overtake current technology and lead to even greater levels of growth. The length of life will depend on many factors.[38]

14.4 Measures

Edison et al.[8] in their review of literature on innovation management found 232 innovation metrics. They categorized these measures along five dimensions i.e. inputs to the innovation process, output from the innovation process, effect of the innovation output, measures to access the activities in an innovation process and availability of factors that facilitate such a process.[8]

There are two different types of measures for innovation: the organizational level and the political level.

14.4.1 Organizational level

The measure of innovation at the organizational level relates to individuals, team-level assessments, and private companies from the smallest to the largest company. Measure of innovation for organizations can be conducted by surveys, workshops, consultants, or internal benchmarking. There is today no established general way to measure organizational innovation. Corporate measurements are generally structured around balanced scorecards which cover several aspects of innovation such as business measures related to finances, innovation process efficiency, employees' contribution and motivation, as well benefits for customers. Measured values will vary widely between businesses, covering for example new product revenue, spending in R&D, time to market, customer and employee perception & satisfaction, number of patents, additional sales resulting from past innovations.[39]

14.4.2 Political level

For the political level, measures of innovation are more focused on a country or region competitive advantage

through innovation. In this context, organizational capabilities can be evaluated through various evaluation frameworks, such as those of the European Foundation for Quality Management. The OECD Oslo Manual (1995) suggests standard guidelines on measuring technological product and process innovation. Some people consider the Oslo Manual complementary to the Frascati Manual from 1963. The new Oslo manual from 2005 takes a wider perspective to innovation, and includes marketing and organizational innovation. These standards are used for example in the European Community Innovation Surveys.[40]

Other ways of measuring innovation have traditionally been expenditure, for example, investment in R&D (Research and Development) as percentage of GNP (Gross National Product). Whether this is a good measurement of innovation has been widely discussed and the Oslo Manual has incorporated some of the critique against earlier methods of measuring. The traditional methods of measuring still inform many policy decisions. The EU Lisbon Strategy has set as a goal that their average expenditure on R&D should be 3% of GDP.[41]

14.4.3 Indicators

Many scholars claim that there is a great bias towards the "science and technology mode" (S&T-mode or STI-mode), while the "learning by doing, using and interacting mode" (DUI-mode) is ignored and measurements and research about it rarely done. For example, an institution may be high tech with the latest equipment, but lacks crucial doing, using and interacting tasks important for innovation.

A common industry view (unsupported by empirical evidence) is that comparative cost-effectiveness research is a form of price control which reduces returns to industry, and thus limits R&D expenditure, stifles future innovation and compromises new products access to markets.[42] Some academics claim cost-effectiveness research is a valuable value-based measure of innovation which accords "truly significant" therapeutic advances (ie providing "health gain") higher prices than free market mechanisms.[43] Such value-based pricing has been viewed as a means of indicating to industry the type of innovation that should be rewarded from the public purse.[44] Research and Development Expenditure Credit

An Australian academic developed the case that national comparative cost-effectiveness analysis systems should be viewed as measuring "health innovation" as an evidence-based policy concept for valuing innovation distinct from valuing through competitive markets, a method which requires strong anti-trust laws to be effective, on the basis that both methods of assessing pharmaceutical innovations are mentioned in annex 2C.1 of the Australia-United States Free Trade Agreement.[45][46][47]

14.5 Rate

14.5.1 Indices

Several indices attempt to measure innovation and rank entities based on these measures, such as:

- The Bloomberg Innovation Index
- The "Bogota Manual"[48] similar to the Oslo Manual, is focused on Latin America and the Caribbean countries.
- The "Creative Class" developed by Richard Florida
- The EIU Innovation Ranking
- The Global Competitiveness Report
- The Global Innovation Index (GII), by INSEAD[49]
- The Information Technology and Innovation Foundation (ITIF) Index
- The Innovation Capacity Index (ICI) published by a large number of international professors working in a collaborative fashion. The top scorers of ICI 2009–2010 were: 1. Sweden 82.2; 2. Finland 77.8; and 3. United States 77.5.[50]
- The Innovation Index, developed by the Indiana Business Research Center, to measure innovation capacity at the county or regional level in the United States.[51]
- The Innovation Union Scoreboard
- The innovationsindikator for Germany, developed by the Federation of German Industries (Bundesverband der Deutschen Industrie) in 2005[52]
- The INSEAD Innovation Efficacy Index[53]
- The International Innovation Index, produced jointly by The Boston Consulting Group, the National Association of Manufacturers and its nonpartisan research affiliate The Manufacturing Institute, is a worldwide index measuring the level of innovation in a country. NAM describes it as the "largest and most comprehensive global index of its kind".
- The Management Innovation Index - Model for Managing Intangibility of Organizational Creativity: Management Innovation Index[54]
- The NYCEDC Innovation Index, by the New York City Economic Development Corporation, tracks New York City's "transformation into a center for high-tech innovation. It measures innovation in the City's growing science and technology industries and is designed to capture the effect of innovation on the City's economy."[55]

- The Oslo Manual is focused on North America, Europe, and other rich economies.
- The State Technology and Science Index, developed by the Milken Institute, is a U.S.-wide benchmark to measure the science and technology capabilities that furnish high paying jobs based around key components.[56]
- The World Competitiveness Scoreboard[57]

14.5.2 Rankings

Many research studies try to rank countries based on measures of innovation. Common areas of focus include: high-tech companies, manufacturing, patents, post secondary education, research and development, and research personnel. The left ranking of the top 10 countries below is based on the 2016 Bloomberg Innovation Index.[58] However, studies may vary widely; for example the Global Innovation Index 2016 ranks Switzerland as number one wherein countries like South Korea and Japan do not even make the top ten.[59]

14.5.3 Future

In 2005 Jonathan Huebner, a physicist working at the Pentagon's Naval Air Warfare Center, argued on the basis of both U.S. patents and world technological breakthroughs, per capita, that the rate of human technological innovation peaked in 1873 and has been slowing ever since.[60][61] In his article, he asked "Will the level of technology reach a maximum and then decline as in the Dark Ages?"[60] In later comments to *New Scientist* magazine, Huebner clarified that while he believed that we will reach a rate of innovation in 2024 equivalent to that of the Dark Ages, he was not predicting the reoccurrence of the Dark Ages themselves.[62]

John Smart criticized the claim and asserted that technological singularity researcher Ray Kurzweil and others showed a "clear trend of acceleration, not deceleration" when it came to innovations.[63] The foundation replied to Huebner the journal his article was published in, citing Second Life and eHarmony as proof of accelerating innovation; to which Huebner replied.[64] However, Huebner's findings were confirmed in 2010 with U.S. Patent Office data.[65] and in a 2012 paper.[66]

14.5.4 Innovation and international development

The theme of innovation as a tool to disrupting patterns of poverty has gained momentum since the mid-2000s among major international development actors such as DFID,[67] Gates Foundation's use of the Grand Challenge funding model,[68] and USAID's Global Development Lab.[69] Networks have been established to support innovation in development, such as D-Lab at MIT.[70] Investment funds have been established to identify and catalyze innovations in developing countries, such as DFID's Global Innovation Fund,[71] Human Development Innovation Fund,[72] and (in partnership with USAID) the Global Development Innovation Ventures.[73]

14.6 Government policies

Given the noticeable effects on efficiency, quality of life, and productive growth, innovation is a key factor in society and economy. Consequently, policymakers have long worked to develop environments that will foster innovation and its resulting positive benefits, from funding Research and Development to supporting regulatory change, funding the development of innovation clusters, and using public purchasing and standardisation to 'pull' innovation through.

For instance, experts are advocating that the U.S. federal government launch a National Infrastructure Foundation, a nimble, collaborative strategic intervention organization that will house innovations programs from fragmented silos under one entity, inform federal officials on innovation performance metrics, strengthen industry-university partnerships, and support innovation economic development initiatives, especially to strengthen regional clusters. Because clusters are the geographic incubators of innovative products and processes, a cluster development grant program would also be targeted for implementation. By focusing on innovating in such areas as precision manufacturing, information technology, and clean energy, other areas of national concern would be tackled including government debt, carbon footprint, and oil dependence.[27] The U.S. Economic Development Administration understand this reality in their continued Regional Innovation Clusters initiative.[74] In addition, federal grants in R&D, a crucial driver of innovation and productive growth, should be expanded to levels similar to Japan, Finland, South Korea, and Switzerland in order to stay globally competitive. Also, such grants should be better procured to metropolitan areas, the essential engines of the American economy.[27]

Many countries recognize the importance of research and development as well as innovation including Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT);[75] Germany's Federal Ministry of Education and Research;[76] and the Ministry of Science and Technology in the People's Republic of China. Furthermore, Russia's innovation programme is the Medvedev modernisation programme which aims at creating a diversified economy based on high technology and innovation. Also, the Government of Western Australia has established a number of innovation incentives for government departments. Landgate was the first Western Australian government agency to establish its

Innovation Program.[77] The Cairns Region established the Tropical Innovation Awards in 2010 open to all businesses in Australia.[78] The 2011 Awards were extended to include participants from all Tropical Zone Countries.

14.7 Innovators

An innovator, in a general sense, is a person or an organization, who is one of the first to introduce into reality, something better than before. Something that opens up a new area for others, and achieves an innovation.

14.8 See also

- Communities of innovation
- Creative competitive intelligence
- Creative problem solving
- Creativity
- Disruptive innovation
- Theories of technology
- Deployment
- Diffusion (anthropology)
- Ecoinnovation
- List of countries by research and development spending
- List of emerging technologies
- List of Russian inventors
- Hype cycle
- Individual capital
- Induced innovation
- Information revolution
- Ingenuity
- Invention
- Innovation leadership
- Innovation management
- Innovation system
- Global Innovation Index (Boston Consulting Group)
- Global Innovation Index (INSEAD)
- Knowledge economy
- Multiple discovery
- Open Innovation
- Open Innovations (Forum and Technology Show)
- Outcome-Driven Innovation
- Participatory design
- Pro-innovation bias
- Public domain
- Research
- Sustainable Development Goals (Agenda 9)
- Technology Life Cycle
- Technological innovation system
- Timeline of historic inventions
- Toolkits for User Innovation
- Value network
- Virtual product development
- UNDP Innovation Facility

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Chapter 15

Problem solving

"Problem" redirects here. For other uses, see Problem (disambiguation).

Problem solving consists of using generic or *ad hoc* methods, in an orderly manner, for finding solutions to problems. Some of the problem-solving techniques developed and used in artificial intelligence, computer science, engineering, mathematics, or medicine are related to mental problem-solving techniques studied in psychology.

15.1 Definition

The term *problem solving* is used in many disciplines, sometimes with different perspectives, and often with different terminologies. For instance, it is a mental process in psychology and a computerized process in computer science. Problems can also be classified into two different types (ill-defined and well-defined) from which appropriate solutions are to be made. Ill-defined problems are those that do not have clear goals, solution paths, or expected solution. Well-defined problems have specific goals, clearly defined solution paths, and clear expected solutions. These problems also allow for more initial planning than ill-defined problems.[1] Being able to solve problems sometimes involves dealing with pragmatics (logic) and semantics (interpretation of the problem). The ability to understand what the goal of the problem is and what rules could be applied represent the key to solving the problem. Sometimes the problem requires some abstract thinking and coming up with a creative solution.

15.1.1 Psychology

In psychology, problem solving refers to a state of desire for reaching a definite 'goal' from a present condition that either is not directly moving toward the goal, is far from it, or needs more complex logic for finding a missing description of conditions or steps toward the goal.[2] It is the evolutionary drive for living organisms. The nature of human problem solving processes and methods has been studied by psychologists over the past hundred years. Methods of studying problem solving include introspection, behaviorism, simulation, computer modeling, and experiment. Social psychologists also look into the independent and interdependent problem-solving methods.[3] In psychology, problem solving is the concluding part of a larger process that also includes problem finding and problem shaping.

Considered the most complex of all intellectual functions, problem solving has been defined as a higher-order cognitive process that requires the modulation and control of more routine or fundamental skills.[4] Problem solving has two major domains: mathematical problem solving and personal problem solving where, in the second, some difficulty or barrier is encountered.[5]

Interpersonal everyday problem solving is dependent upon the every individual personal motivational and contextual components which require multiple strategies to solve them or reach a specific 'goal'. Often interpersonal problem are fluid and dynamic, it can change constantly over time. Empirical researches show that self-interest and interpersonal skills; collaborative and instrumental problem approach (it helps in reflective and expansive understanding of the problem situation and its preferable outcome); strategy fluency (the number and diversity of strategies) and conceptual clarity that can lead to an action-identification (Vallacher & Wegner, 1987); temporal lifespan perspective that lead to selectivity in strategy (problem focused and emotion focused strategies); self-efficacy and problem familiarity; formation of 'carry over' relationships (egalitarian friendship, romantic ties, cliques, hygge's, etc.) that helps individuals mutually move through life and provide a sense of identity (Antonucci, Birditt, & Ajrouch, 2011); negotiation; type of relationships (obligatory vs. voluntary); gender typing; problem focused and emotion focused strategies as some strategies and factors that influence everyday problem solving. Studies conclude people's strategies cohere with their goals (Hoppmann & Blanchard-Fields, 2010, Berg et al., 1998) and they are stemmed from the natural process of comparing oneself with others (Sonstegard and Bitter, 1998). A practical conclusion of the topic is proscribed with lack of materials that can cover the gaps in understanding problem solving and its correlative fac-

tors.

15.1.2 Clinical psychology

Simple laboratory-based tasks can be useful solving; however, they usually omit the complexity and emotional valence of "real-world" problems. In clinical psychology, researchers have focused on the role of emotions in problem solving (D'Zurilla & Goldfried, 1971; D'Zurilla & Nezu, 1982), demonstrating that poor emotional control can disrupt focus on the target task and impede problem resolution (Rath, Langenbahn, Simon, Sherr, & Diller, 2004). In this conceptualization, human problem solving consists of two related processes: problem orientation, the motivational/attitudinal/affective approach to problematic situations and problem-solving skills. Working with individuals with frontal lobe injuries, neuropsychologists have discovered that deficits in emotional control and reasoning can be remediated, improving the capacity of injured persons to resolve everyday problems successfully (Rath, Simon, Langenbahn, Sherr, & Diller, 2003).

15.1.3 Cognitive sciences

The early experimental work of the Gestaltists in Germany placed the beginning of problem solving study (e.g., Karl Duncker in 1935 with his book *The psychology of productive thinking*[6]). Later this experimental work continued through the 1960s and early 1970s with research conducted on relatively simple (but novel for participants) laboratory tasks of problem solving.[7][8] Choosing simple novel tasks was based on the clearly defined optimal solutions and their short time for solving, which made it possible for the researchers to trace participants' steps in problem-solving process. Researchers' underlying assumption was that simple tasks such as the Tower of Hanoi correspond to the main properties of "real world" problems and thus the characteristic cognitive processes within participants' attempts to solve simple problems are the same for "real world" problems too; simple problems were used for reasons of convenience and with the expectation that thought generalizations to more complex problems would become possible. Perhaps the best-known and most impressive example of this line of research is the work by Allen Newell and Herbert A. Simon.[9] Other experts have shown that the principle of decomposition improves the ability of the problem solver to make good judgment.[10]

15.1.4 Computer science and algorithmics

In computer science and in the part of artificial intelligence that deals with algorithms ("algorithmics"), problem solving encompasses a number of techniques known as algorithms, heuristics, root cause analysis, etc. In these disciplines, problem solving is part of a larger process that encompasses problem determination, de-duplication, analysis, diagnosis, repair, etc.

15.1.5 Engineering

Problem solving is used in when products or processes fail, so corrective action can be taken to prevent further failures. It can also be applied to a product or process prior to an actual fail event, i.e., when a potential problem can be predicted and analyzed, and mitigation applied so the problem never actually occurs. Techniques such as Failure Mode Effects Analysis can be used to proactively reduce the likelihood of problems occurring.

15.1.6 Military science

In military science, problem solving is linked to the concept of "end-states", the desired condition or situation that strategists wish to generate.[11]:xiii, E-2 The ability to solve problems is important at any military rank, but is highly critical at the command and control level, where it is strictly correlated to the deep understanding of qualitative and quantitative scenarios. *Effectiveness* of problem solving is "a criterion used to assess changes in system behavior, capability, or operational environment that is tied to measuring the attainment of an end state, achievement of an objective, or creation of an effect".[11]:IV-24 *Planning* for problem-solving is a "process that determines and describes how to employ 'means' in specific 'ways' to achieve 'ends' (the problem's solution)."[11]:IV-1

15.1.7 Other

Forensic engineering is an important technique of failure analysis that involves tracing product defects and flaws. Corrective action can then be taken to prevent further failures.

Reverse engineering attempts to discover the original problem-solving logic used in developing a product by taking it apart.

Other problem solving tools are linear and nonlinear programming, queuing systems, and simulation.[12]

15.2 Problem-solving strategies

Problem-solving strategies are the steps that one would use to find the problem(s) that are in the way to getting to one's own goal. Firend's Problem Solving Model "PSM" [13] is practical in application and incorporates the conventional 5WH approach, with a systematic process of investigation, implementation and assessment cycle (Firend, 2014). Some would refer to this as the 'problem-solving cycle'. (Bransford & Stein, 1993) In this cycle one

will recognize the problem, define the problem, develop a strategy to fix the problem, organize the knowledge of the problem cycle, figure out the resources at the user's disposal, monitor one's progress, and evaluate the solution for accuracy. The reason it is called a cycle is that once one is completed with a problem another usually will pop up.

Blanchard-Fields (2007) looks at problem solving from one of two facets. The first looking at those problems that only have one solution (like mathematical problems, or fact-based questions) which are grounded in psychometric intelligence. The other that is socioemotional in nature and are unpredictable with answers that are constantly changing (like what's your favorite color or what you should get someone for Christmas).

The following techniques are usually called *problem-solving strategies*[14]

- Abstraction: solving the problem in a model of the system before applying it to the real system
- Analogy: using a solution that solves an analogous problem
- Brainstorming: (especially among groups of people) suggesting a large number of solutions or ideas and combining and developing them until an optimum solution is found
- Divide and conquer: breaking down a large, complex problem into smaller, solvable problems
- Hypothesis testing: assuming a possible explanation to the problem and trying to prove (or, in some contexts, disprove) the assumption
- Lateral thinking: approaching solutions indirectly and creatively
- Means-ends analysis: choosing an action at each step to move closer to the goal
- Method of focal objects: synthesizing seemingly non-matching characteristics of different objects into something new
- Morphological analysis: assessing the output and interactions of an entire system
- Proof: try to prove that the problem cannot be solved. The point where the proof fails will be the starting point for solving it
- Reduction: transforming the problem into another problem for which solutions exist
- Research: employing existing ideas or adapting existing solutions to similar problems
- Root cause analysis: identifying the cause of a problem
- Trial-and-error: testing possible solutions until the right one is found

15.3 Problem-solving methods

- Eight Disciplines Problem Solving
- PSM Model: *The Problem Solving Model, By Firend Al. R.", "Published Model, Journal link")*
- GROW model
- How to Solve It
- OODA loop (observe, orient, decide, and act)
- PDCA (plan–do–check–act)
- Root cause analysis
- RPR problem diagnosis (rapid problem resolution)
- TRIZ (in Russian: *Teoriya Resheniya Izobretatelskikh Zadatch*, "theory of solving inventor's problems")
- A3 problem solving
- System dynamics

15.4 Common barriers to problem solving

Common barriers to problem solving are mental constructs that impede our ability to correctly solve problems. These barriers prevent people from solving problems in the most efficient manner possible. Five of the most common processes and factors that researchers have identified as barriers to problem solving are confirmation bias, mental set, functional fixedness, unnecessary constraints, and irrelevant information.

15.4.1 Confirmation bias

Main article: Confirmation bias

Within the field of science there exists a set of fundamental standards, the scientific method, which outlines the process of discovering facts or truths about the world through unbiased consideration of all pertinent information and through impartial observation of and/or experimentation with that information. According to this method, one is able to most accurately find a solution to a perceived problem by performing the aforementioned steps. The scientific method does not prescribe a process that is limited to scientists, but rather one that all people can practice in their respective fields of work as well as in their personal lives. Confirmation bias can be described as one's unconscious or unintentional corruption of the scientific method. Thus when one demonstrates confirmation bias, one is formally or informally collecting data

and then subsequently observing and experimenting with that data in such a way that favors a preconceived notion that may or may not have *motivation*.[15] Research has found that professionals within scientific fields of study also experience confirmation bias. Andreas Hergovich, Reinhard Schott, and Christoph Burger's experiment conducted online, for instance, suggested that professionals within the field of psychological research are likely to view scientific studies that are congruent with their preconceived understandings more favorably than studies that are incongruent with their established beliefs.[16]

Motivation refers to one's desire to defend or find substantiation for beliefs (e.g., religious beliefs) that are important to one.[17] According to Raymond Nickerson, one can see the consequences of confirmation bias in real-life situations, which range in severity from inefficient government policies to genocide. With respect to the latter and most severe ramification of this cognitive barrier, Nickerson argued that those involved in committing genocide of persons accused of witchcraft, an atrocity that occurred from the 15th to 17th centuries, demonstrated confirmation bias with motivation. Researcher Michael Allen found evidence for confirmation bias with motivation in school children who worked to manipulate their science experiments in such a way that would produce their hoped for results.[18] However, confirmation bias does not necessarily require motivation. In 1960, Peter Cathcart Wason conducted an experiment in which participants first viewed three numbers and then created a hypothesis that proposed a rule that could have been used to create that triplet of numbers. When testing their hypotheses, participants tended to only create additional triplets of numbers that would confirm their hypotheses, and tended not to create triplets that would negate or disprove their hypotheses. Thus research also shows that people can and do work to confirm theories or ideas that do not support or engage personally significant beliefs.[19]

15.4.2 Mental set

Main article: Mental set

Mental set was first articulated by Abraham Luchins in the 1940s and demonstrated in his well-known water jug experiments.[20] In these experiments, participants were asked to fill one jug with a specific amount of water using only other jugs (typically three) with different maximum capacities as tools. After Luchins gave his participants a set of water jug problems that could all be solved by employing a single technique, he would then give them a problem that could either be solved using that same technique or a novel and simpler method. Luchins discovered that his participants tended to use the same technique that they had become accustomed to despite the possibility of using a simpler alternative.[21] Thus mental set describes one's inclination to attempt to solve problems in such a way that has proved successful in previous experiences. However, as Luchins' work revealed, such methods for finding a solution that have worked in the past may not be adequate or optimal for certain new but similar problems. Therefore, it is often necessary for people to move beyond their mental sets in order to find solutions. This was again demonstrated in Norman Maier's 1931 experiment, which challenged participants to solve a problem by using a household object (pliers) in an unconventional manner. Maier observed that participants were often unable to view the object in a way that strayed from its typical use, a phenomenon regarded as a particular form of mental set (more specifically known as functional fixedness, which is the topic of the following section). When people cling rigidly to their mental sets, they are said to be experiencing *fixation*, a seeming obsession or preoccupation with attempted strategies that are repeatedly unsuccessful.[22] In the late 1990s, researcher Jennifer Wiley worked to reveal that expertise can work to create a mental set in persons considered to be experts in certain fields, and she furthermore gained evidence that the mental set created by expertise could lead to the development of fixation.[23]

15.4.3 Functional fixedness

Main article: Functional fixedness

Functional fixedness is a specific form of mental set and fixation, which was alluded to earlier in the Maier experiment, and furthermore it is another way in which cognitive bias can be seen throughout daily life. Tim German and Clark Barrett describe this barrier as the fixed design of an object hindering the individual's ability to see it serving other functions. In more technical terms, these researchers explained that "[s]ubjects become "fixed" on the design function of the objects, and problem solving suffers relative to control conditions in which the object's function is not demonstrated."[24] Functional fixedness is defined as only having that primary function of the object itself hinder the ability of it serving another purpose other than its original function. In research that highlighted the primary reasons that young children are immune to functional fixedness, it was stated that "functional fixedness...[is when]subjects are hindered in reaching the solution to a problem by their knowledge of an object's conventional function."[25] Furthermore, it is important to note that functional fixedness can be easily expressed in commonplace situations. For instance, imagine the following situation: a man sees a bug on the floor that he wants to kill, but the only thing in his hand at the moment is a can of air freshener. If the man starts looking around for something in the house to kill the bug with instead of realizing that the can of air freshener could in fact be used not only as having its main function as to freshen the air, he is said to be experiencing functional fixedness. The man's knowledge of the can being served as purely an air freshener hindered his ability to realize that it too could have been used to serve another purpose, which in

this instance was as an instrument to kill the bug. Functional fixedness can happen on multiple occasions and can cause us to have certain cognitive biases. If we only see an object as serving one primary focus than we fail to realize that the object can be used in various ways other than its intended purpose. This can in turn cause many issues with regards to problem solving. Common sense seems to be a plausible answer to functional fixedness. One could make this argument because it seems rather simple to consider possible alternative uses for an object. Perhaps using common sense to solve this issue could be the most accurate answer within this context. With the previous stated example, it seems as if it would make perfect sense to use the can of air freshener to kill the bug rather than to search for something else to serve that function but, as research shows, this is often not the case.

Functional fixedness limits the ability for people to solve problems accurately by causing one to have a very narrow way of thinking. Functional fixedness can be seen in other types of learning behaviors as well. For instance, research has discovered the presence of functional fixedness in many educational instances. Researchers Furio, Calatayud, Baracenas, and Padilla stated that "... functional fixedness may be found in learning concepts as well as in solving chemistry problems."[26] There was more emphasis on this function being seen in this type of subject and others.

There are several hypotheses in regards to how functional fixedness relates to problem solving.[27] There are also many ways in which a person can run into problems while thinking of a particular object with having this function. If there is one way in which a person usually thinks of something rather than multiple ways then this can lead to a constraint in how the person thinks of that particular object. This can be seen as narrow minded thinking, which is defined as a way in which one is not able to see or accept certain ideas in a particular context. Functional fixedness is very closely related to this as previously mentioned. This can be done intentionally and or unintentionally, but for the most part it seems as if this process to problem solving is done in an unintentional way.

Functional fixedness can affect problem solvers in at least two particular ways. The first is with regards to time, as functional fixedness causes people to use more time than necessary to solve any given problem. Secondly, functional fixedness often causes solvers to make more attempts to solve a problem than they would have made if they were not experiencing this cognitive barrier. In the worst case, functional fixedness can completely prevent a person from realizing a solution to a problem. Functional fixedness is a commonplace occurrence, which affects the lives of many people.

15.4.4 Unnecessary constraints

Unnecessary constraints are another very common barrier that people face while attempting to problem-solve. This particular phenomenon occurs when the subject, trying to solve the problem subconsciously, places boundaries on the task at hand, which in turn forces him or her to strain to be more innovative in their thinking. The solver hits a barrier when they become fixated on only one way to solve their problem, and it becomes increasingly difficult to see anything but the method they have chosen. Typically, the solver experiences this when attempting to use a method they have already experienced success from, and they can not help but try to make it work in the present circumstances as well, even if they see that it is counterproductive.[28]

Groupthink, or taking on the mindset of the rest of the group members, can also act as an unnecessary constraint while trying to solve problems.[29] This is due to the fact that with everybody thinking the same thing, stopping on the same conclusions, and inhibiting themselves to think beyond this. This is very common, but the most well-known example of this barrier making itself present is in the famous example of the dot problem. In this example, there are nine dots lying in a square- three dots across, and three dots running up and down. The solver is then asked to draw no more than four lines, without lifting their pen or pencil from the paper. This series of lines should connect all of the dots on the paper. Then, what typically happens is the subject creates an assumption in their mind that they must connect the dots without letting his or her pen or pencil go outside of the square of dots. Standardized procedures like this can often bring mentally invented constraints of this kind,[30] and researchers have found a 0% correct solution rate in the time allotted for the task to be completed.[31] The imposed constraint inhibits the solver to think beyond the bounds of the dots. It is from this phenomenon that the expression "think outside the box" is derived.[32]

This problem can be quickly solved with a dawning of realization, or *insight*. A few minutes of struggling over a problem can bring these sudden insights, where the solver quickly sees the solution clearly. Problems such as this are most typically solved via insight and can be very difficult for the subject depending on either how they have structured the problem in their minds, how they draw on their past experiences, and how much they juggle this information in their working memories[32] In the case of the nine-dot example, the solver has already been structured incorrectly in their minds because of the constraint that they have placed upon the solution. In addition to this, people experience struggles when they try to compare the problem to their prior knowledge, and they think they must keep their lines within the dots and not go beyond. They do this because trying to envision the dots connected outside of the basic square puts a strain on their working memory.[32]

Luckily, the solution to the problem becomes obvious as insight occurs following incremental movements made toward the solution. These tiny movements happen without the solver knowing. Then when the insight is realized fully, the "aha" moment happens for the subject.[33] These moments of insight can take a long while to manifest or not so long at other times, but the way that the solution is arrived at after toiling over these barriers stays the same.

15.4.5 Irrelevant information

Irrelevant information is information presented within a problem that is unrelated or unimportant to the specific problem.[28] Within the specific context of the problem, irrelevant information would serve no purpose in helping solve that particular problem. Often *irrelevant information* is detrimental to the problem solving process. It is a common barrier that many people have trouble getting through, especially if they are not aware of it. *Irrelevant information* makes solving otherwise relatively simple problems much harder.[34]

For example: "Fifteen percent of the people in Topeka have unlisted telephone numbers. You select 200 names at random from the Topeka phone book. How many of these people have unlisted phone numbers?"[35]

The people that are not listed in the phone book would not be among the 200 names you selected. The individuals looking at this task would have naturally wanted to use the 15% given to them in the problem. They see that there is information present and they immediately think that it needs to be used. This of course is not true. These kinds of questions are often used to test students taking aptitude tests or cognitive evaluations.[36] They aren't meant to be difficult but they are meant to require thinking that is not necessarily common. *Irrelevant Information* is commonly represented in math problems, word problems specifically, where numerical information is put for the purpose of challenging the individual.

One reason irrelevant information is so effective at keeping a person off topic and away from the relevant information, is in how it is represented.[36] The way information is represented can make a vast difference in how difficult the problem is to be overcome. Whether a problem is represented visually, verbally, spatially, or mathematically, irrelevant information can have a profound effect on how long a problem takes to be solved; or if it's even possible. The Buddhist monk problem is a classic example of irrelevant information and how it can be represented in different ways:

> A Buddhist monk begins at dawn one day walking up a mountain, reaches the top at sunset, meditates at the top for several days until one dawn when he begins to walk back to the foot of the mountain, which he reaches at sunset. Making no assumptions about his starting or stopping or about his pace during the trips, prove that there is a place on the path which he occupies at the same hour of the day on the two separate journeys.

This problem is near impossible to solve because of how the information is represented. Because it is written out in a way that represents the information verbally, it causes us to try and create a mental image of the paragraph. This is often very difficult to do especially with all the *irrelevant information* involved in the question. This example is made much easier to understand when the paragraph is represented visually. Now if the same problem was asked, but it was also accompanied by a corresponding graph, it would be far easier to answer this question; *irrelevant information* no longer serves as a road block. By representing the problem visually, there are no difficult words to understand or scenarios to imagine. The visual representation of this problem has removed the difficulty of solving it.

These types of representations are often used to make difficult problems easier.[37] They can be used on tests as a strategy to remove *Irrelevant Information,* which is one of the most common forms of barriers when discussing the issues of problem solving.[28] Identifying crucial information presented in a problem and then being able to correctly identify its usefulness is essential. Being aware of *irrelevant information* is the first step in overcoming this common barrier.

15.5 Cognitive sciences: two schools

In cognitive sciences, researchers' realization that problem-solving processes differ across knowledge domains and across levels of expertise (e.g. Sternberg, 1995) and that, consequently, findings obtained in the laboratory cannot necessarily generalize to problem-solving situations outside the laboratory, has led to an emphasis on real-world problem solving since the 1990s. This emphasis has been expressed quite differently in North America and Europe, however. Whereas North American research has typically concentrated on studying problem solving in separate, natural knowledge domains, much of the European research has focused on novel, complex problems, and has been performed with computerized scenarios (see Funke, 1991, for an overview).

15.5.1 Europe

In Europe, two main approaches have surfaced, one initiated by Donald Broadbent (1977; see Berry & Broadbent, 1995) in the United Kingdom and the other one by Dietrich Dörner (1975, 1985; see Dörner & Wearing, 1995) in Germany. The two approaches share an emphasis on relatively complex, semantically rich, computerized laboratory tasks, constructed to resemble real-life problems. The approaches differ somewhat in their theoretical goals and methodology, however. The tradition initiated by Broadbent emphasizes the distinction between cognitive problem-solving processes that operate under awareness versus outside of awareness, and typically employs mathematically well-defined computerized systems. The tradition initiated by Dörner, on the other hand, has an interest in the interplay of the cognitive, motivational, and social components of problem solving, and utilizes very complex computerized scenarios that contain up to 2,000 highly interconnected variables (e.g., Dörner, Kreuzig, Reither & Stäudel's 1983 LOHHAUSEN project; Ringelband, Misiak & Kluwe, 1990). Buchner (1995) describes the two traditions in detail.

15.5.2 North America

In North America, initiated by the work of Herbert A. Simon on "learning by doing" in semantically rich domains (e.g. Anzai & Simon, 1979; Bhaskar & Simon, 1977), researchers began to investigate problem solving separately in different natural knowledge domains – such as physics, writing, or chess playing – thus relinquishing their attempts to extract a global theory of problem solving (e.g. Sternberg & Frensch, 1991). Instead, these researchers have frequently focused on the development of problem solving within a certain domain, that is on the development of expertise (e.g. Anderson, Boyle & Reiser, 1985; Chase & Simon, 1973; Chi, Feltovich & Glaser, 1981).

Areas that have attracted rather intensive attention in North America include:

- Reading (Stanovich & Cunningham, 1991)
- Writing (Bryson, Bereiter, Scardamalia & Joram, 1991)
- Calculation (Sokol & McCloskey, 1991)
- Political decision making (Voss, Wolfe, Lawrence & Engle, 1991)
- Managerial problem solving (Wagner, 1991)
- Lawyers' reasoning (Amsel, Langer & Loutzenhiser, 1991)
- Mechanical problem solving (Hegarty, 1991)
- Problem solving in electronics (Lesgold & Lajoie, 1991)
- Computer skills (Kay, 1991)
- Game playing (Frensch & Sternberg, 1991)
- Personal problem solving (Heppner & Krauskopf, 1987)
- Mathematical problem solving (Pólya, 1945; Schoenfeld, 1985)
- Social problem solving (D'Zurilla & Goldfreid, 1971; D'Zurilla & Nezu, 1982)
- Problem solving for innovations and inventions: TRIZ (Altshuller, 1994)

15.6 Characteristics of complex problems

As elucidated by Dietrich Dörner and later expanded upon by Joachim Funke, complex problems have some typical characteristics that can be summarized as follows:

- Complexity (large numbers of items, interrelations and decisions)
  - enumerability
  - heterogeneity
  - connectivity (hierarchy relation, communication relation, allocation relation)
- Dynamics (time considerations)
  - temporal constraints
  - temporal sensitivity
  - phase effects
  - dynamic unpredictability
- Intransparency (lack of clarity of the situation)
  - commencement opacity
  - continuation opacity
- Polytely (multiple goals)
  - inexpressiveness
  - opposition
  - transience

15.7 Collective problem solving

See also: Collective action, Collaborative intelligence, Mass collaboration, Collective wisdom, The Wisdom of Crowds, Distributed knowledge, Online participation, and Group decision-making

Problem solving is applied on many different levels – from the individual to the civilizational. Collective problem solving refers to problem solving performed collectively.

Social issues and global issues can typically only be solved collectively.

It has been noted that the complexity of contemporary problems has exceeded the cognitive capacity of any individual and requires different but complementary expertise and collective problem solving ability.[38]

Collective intelligence is shared or group intelligence that emerges from the collaboration, collective efforts, and competition of many individuals.

In a 1962 research report, Douglas Engelbart linked collective intelligence to organizational effectiveness, and predicted that pro-actively 'augmenting human intellect' would yield a multiplier effect in group problem solving: “Three people working together in this augmented mode [would] seem to be more than three times as effective in solving a complex problem as is one augmented person working alone”.[39]

Henry Jenkins, a key theorist of new media and media convergence draws on the theory that collective intelligence can be attributed to media convergence and participatory culture.[40] He criticizes contemporary education for failing to incorporate online trends of collective problem solving into the classroom, stating “whereas a collective intelligence community encourages ownership of work as a group, schools grade individuals”. Jenkins argues that interaction within a knowledge community builds vital skills for young people, and teamwork through collective intelligence communities contribute to the development of such skills.[41]

Collective impact is the commitment of a group of actors from different sectors to a common agenda for solving a specific social problem, using a structured form of collaboration.

After World War II the UN, the Bretton Woods organization and the WTO were created and collective problem solving on the international level crystallized since the 1980s around these 3 types of organizations. As these global institutions remain state-like or state-centric it has been called unsurprising that these continue state-like or state-centric approaches to collective problem-solving rather than alternative ones.[42]

It has been observed that models of liberal democracy provide neither adequate designs for collective problem solving nor handling the substantive challenges in society such as crime, war, economic decline, illness and environmental degradation to produce satisfying outcomes.[43]

Crowdsourcing is a process of accumulating the ideas, thoughts or information from many independent participants, with aim to find the best solution for a given challenge. Modern information technologies allow for massive number of subjects to be involved as well as systems of managing these suggestions that provide good results.[44] With the Internet a new capacity for collective, including planetary-scale, problem solving was created.[45]

15.8 See also

- Analytical skill
- Creative problem-solving
- Collective intelligence
- Divergent thinking
- Grey problem
- Innovation
- Instrumentalism
- Problem statement
- Problem structuring methods
- Psychedelics in problem-solving experiment
- Structural fix
- Subgoal labeling
- Troubleshooting
- Wicked problem

15.9 Notes

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[2] “In each case “where you want to be” is an imagined (or written) state in which you would like to be. We might use the term 'Problem Identification' or analysis in order to figure out exactly what the problem is. After we have found a problem we need to define what the problem is. In other words, a distinguished feature of a problem is that there is a *goal* to be reached and how you get there is not immediately obvious.”, What is a problem? in S. Ian Robertson, Problem solving, Psychology Press, 2001, p. 2.

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Chapter 16

Communication

Communication (from Latin *commūnicāre*, meaning "to share"[1]) is the act of conveying intended meanings from one entity or group to another through the use of mutually understood signs and semiotic rules.

The main steps inherent to all communication are: [2]

1. The forming of communicative motivation or reason.
2. Message composition (further internal or technical elaboration on what exactly to express).
3. Message encoding (for example, into digital data, written text, speech, pictures, gestures and so on).
4. Transmission of the encoded message as a sequence of signals using a specific channel or medium.
5. Noise sources such as natural forces and in some cases human activity (both intentional and accidental) begin influencing the quality of signals propagating from the sender to one or more receivers.
6. Reception of signals and reassemblying of the encoded message from a sequence of received signals.
7. Decoding of the reassembled encoded message.
8. Interpretation and making sense of the presumed original message.

The scientific study of communication can be divided into:

- Information theory which studies the quantification, storage, and communication of information in general;
- Communication studies which concerns human communication;
- Biosemiotics which examines communication in and between living organisms in general.

The channel of communication can be visual, auditory, tactile (such as in Braille) and haptic, olfactory, electromagnetic, or biochemical.

Human communication is unique for its extensive use of abstract language. Development of civilization has been closely linked with progress in telecommunication.

16.1 Non-verbal

Main article: Nonverbal communication

Nonverbal communication describes the process of conveying information in the form of non-linguistic representations. Examples of nonverbal communication include haptic communication, chronemic communication, gestures, body language, facial expressions, eye contact, and how one dresses. Nonverbal communication also relates to intent of a message. Examples of intent are voluntary, intentional movements like shaking a hand or winking, as well as involuntary, such as sweating.[3] Speech also contains nonverbal elements known as paralanguage, e.g. rhythm, intonation, tempo, and stress. It affects communication most at the subconscious level and establishes trust. Likewise, written texts include nonverbal elements such as handwriting style, spatial arrangement of words and the use of emoticons to convey emotion.

Nonverbal communication demonstrates one of Wazlawick's laws: you cannot not communicate. Once proximity has formed awareness, living creatures begin interpreting any signals received.[4] Some of the functions of nonverbal communication in humans are to complement and illustrate, to reinforce and emphasize, to replace and substitute, to control and regulate, and to contradict the denovative message.

Nonverbal cues are heavily relied on to express communication and to interpret others' communication and can replace or substitute verbal messages. However, non-verbal communication is ambiguous. When verbal messages contradict non-verbal messages, observation of non-verbal behaviour is relied on to judge another's attitudes and feelings, rather than assuming the truth of the verbal message alone.

There are several reasons as to why non-verbal communication plays a vital role in communication:

"Non-verbal communication is omnipresent." [5] They are

included in every single communication act. To have total communication, all non-verbal channels such as the body, face, voice, appearance, touch, distance, timing, and other environmental forces must be engaged during face-to-face interaction. Written communication can also have non-verbal attributes. E-mails and web chats allow individual's the option to change text font colours, stationary, emoticons, and capitalization in order to capture non-verbal cues into a verbal medium.

"Non-verbal behaviours are multifunctional." [6] Many different non-verbal channels are engaged at the same time in communication acts, and allow the chance for simultaneous messages to be sent and received.

"Non-verbal behaviours may form a universal language system." [7] Smiling, crying, pointing, caressing, and glaring are non-verbal behaviours that are used and understood by people regardless of nationality. Such non-verbal signals allow the most basic form of communication when verbal communication is not effective due to language barriers.

16.2 Verbal

Verbal communication is the spoken or written conveyance of a message. Human language can be defined as a system of symbols (sometimes known as lexemes) and the grammars (rules) by which the symbols are manipulated. The word "language" also refers to common properties of languages. Language learning normally occurs most intensively during human childhood. Most of the thousands of human languages use patterns of sound or gesture for symbols which enable communication with others around them. Languages tend to share certain properties, although there are exceptions. There is no defined line between a language and a dialect. Constructed languages such as Esperanto, programming languages, and various mathematical formalism is not necessarily restricted to the properties shared by human languages.

As previously mentioned, language can be characterized as symbolic. Charles Ogden and I.A Richards developed The Triangle of Meaning model to explain the symbol (the relationship between a word), the referent (the thing it describes), and the meaning (the thought associated with the word and the thing)

The properties of language are governed by rules. Language follows phonological rules (sounds that appear in a language), syntactic rules (arrangement of words and punctuation in a sentence), semantic rules (the agreed upon meaning of words), and pragmatic rules (meaning derived upon context).

The meanings that are attached to words can be literal; or otherwise known as denotative, which relates to the topic being discussed, or, the meanings take context and relationships into account, otherwise known as connotative; relating to the feelings, history, and power dynamics of the communicators.[8]

16.3 Written communication and its historical development

Over time the forms of and ideas about communication have evolved through the continuing progression of technology. Advances include communications psychology and media psychology, an emerging field of study.

The progression of written communication can be divided into three "information communication revolutions":[9]

1. Written communication first emerged through the use of pictographs. The pictograms were made in stone, hence written communication was not yet mobile. Pictograms began to develop standardized and simplified forms.
2. The next step occurred when writing began to appear on paper, papyrus, clay, wax, and other media with common shared writing systems, leading to adaptable alphabets. Communication became mobile.
3. The final stage is characterized by the transfer of information through controlled waves of electromagnetic radiation (i.e., radio, microwave, infrared) and other electronic signals.

Communication is thus a process by which meaning is assigned and conveyed in an attempt to create shared understanding. Gregory Bateson called it "the replication of tautologies in the universe.[10] This process, which requires a vast repertoire of skills in interpersonal processing, listening, observing, speaking, questioning, analyzing, gestures, and evaluating enables collaboration and cooperation.[11]

16.4 Business

Main article: Business communication

Business communication is used for a wide variety of activities including, but not limited to: strategic communications planning, media relations, public relations (which can include social media, broadcast and written communications, and more), brand management, reputation management, speech-writing, customer-client relations, and internal/employee communications.

Companies with limited resources may choose to engage in only a few of these activities, while larger organizations may employ a full spectrum of communications. Since it is difficult to develop such a broad range of skills, communications professionals often specialize in one or two

of these areas but usually have at least a working knowledge of most of them. By far, the most important qualifications communications professionals can possess are excellent writing ability, good 'people' skills, and the capacity to think critically and strategically.

16.5 Political

Communication is one of the most relevant tools in political strategies, including persuasion and propaganda. In mass media research and online media research, the effort of strategist is that of getting a precise decoding, avoiding “message reactance”, that is, message refusal. The reaction to a message is referred also in terms of approach to a message, as follows:

- In “radical reading” the audience rejects the meanings, values, and viewpoints built into the text by its makers. Effect: message refusal.
- In “dominant reading”, the audience accepts the meanings, values, and viewpoints built into the text by its makers. Effect: message acceptance.
- In “subordinate reading” the audience accepts, by and large, the meanings, values, and worldview built into the text by its makers. Effect: obey to the message.[12]

Holistic approaches are used by communication campaign leaders and communication strategists in order to examine all the options, “actors” and channels that can generate change in the semiotic landscape, that is, change in perceptions, change in credibility, change in the "memetic background”, change in the image of movements, of candidates, players and managers as perceived by key influencers that can have a role in generating the desired “end-state”.

The modern political communication field is highly influenced by the framework and practices of “information operations” doctrines that derive their nature from strategic and military studies. According to this view, what is really relevant is the concept of acting on the Information Environment. The information environment is the aggregate of individuals, organizations, and systems that collect, process, disseminate, or act on information. This environment consist s of three interrelated dimensions, which continuously interact with individuals, organizations, and systems. These dimensions are known as physical, informational, and cognitive.[13]

16.6 Family

Family communication is the study of the communication perspective in a broadly defined family, with intimacy and trusting relationship.[14] The main goal of family communication is to understand the interactions of family and the pattern of behaviors of family members in different circumstances. Open and honest communication creates an atmosphere that allows family members to express their differences as well as love and admiration for one another. It also helps to understand the feelings of one another.

Family communication study looks at topics such as family rules, family roles or family dialectics and how those factors could affect the communication between family members. Researchers develop theories to understand communication behaviors. Family communication study also digs deep into certain time periods of family life such as marriage, parenthood or divorce and how communication stands in those situations. It is important for family members to understand communication as a trusted way which leads to a well constructed family.

16.7 Interpersonal

In simple terms, interpersonal communication is the communication between one person and another (or others). It is often referred to as face-to-face communication between two (or more) people. Both verbal and nonverbal communication, or body language, play a part in how one person understands another. In verbal interpersonal communication there are two types of messages being sent: a content message and a relational message. Content messages are messages about the topic at hand and relational messages are messages about the relationship itself.[15] This means that relational messages come across in *how* one says something and it demonstrates a person’s feelings, whether positive or negative, towards the individual they are talking to, indicating not only how they feel about the topic at hand, but also how they feel about their relationship with the other individual.[15]

There are many different aspects to interpersonal communication including;

- Audiovisual Perception of Communication Problems [16]

- The concept follows the idea that our words change what form they take based on the stress level or urgency of the situation.
- It also explores the concept that stuttering during speech shows the audience that there is a problem or that the situation is more stressful.

- The Attachment Theory [17]

- This is the combined work of John Bowlby and Mary Ainsworth (Ainsworth & Bowlby, 1991)
- This theory follows the relationships that builds between a mother and child, and the impact it has on their relationships with others.

- Emotional Intelligence and Triggers [18]

- Emotional Intelligence focuses on the ability to monitor ones own emotions as well as those of others.
- Emotional Triggers focus on events or people that tend to set off intense, emotional reactions within individuals.

- Attribution Theory [19]

- This is the study of how individuals explain what causes different events and behaviors.

- The Power of Words (Verbal communications) [20]

- Verbal communication focuses heavily on the power of words, and how those words are said.
- It takes into consideration tone, volume, and choice of words.

- Nonverbal Communication

- Focuses heavily on the setting that the words are conveyed in.
- As well as the physical tone of the words.

- Ethics in Personal Relations [21]

- It is about a space of mutual responsibility between two individuals, it's about giving and receiving in a relationship.
- This theory is explored by Dawn J. Lipthrott in the article What IS Relationship? What is Ethical Partnership?

- Deception in Communication [22]

- This concept goes into that everyone lies, and how this can impact relationships.
- This theory is explored by James Hearn in his article Interpersonal Deception Theory: Ten Lessons for Negotiators

- Conflict in Couples [23]

- This focuses on the impact that social media has on relationships.
- As well as how to communicate through conflict.
- This theory is explored by Amanda Lenhart and Maeve Duggan in their paper Couples, the Internet, and Social Media

16.8 Barriers to effectiveness

Barriers to effective communication can retard or distort the message and intention of the message being conveyed which may result in failure of the communication process or an effect that is undesirable. These include filtering, selective perception, information overload, emotions, language, silence, communication apprehension, gender differences and political correctness[24]

This also includes a lack of expressing "knowledge-appropriate" communication, which occurs when a person uses ambiguous or complex legal words, medical jargon, or descriptions of a situation or environment that is not understood by the recipient.

- **Physical barriers-** Physical barriers are often due to the nature of the environment. An example of this is the natural barrier which exists if staff are located in different buildings or on different sites. Likewise, poor or outdated equipment, particularly the failure of management to introduce new technology, may also cause problems. Staff shortages are another factor which frequently causes communication difficulties for an organization.
- **System design-** System design faults refer to problems with the structures or systems in place in an organization. Examples might include an organizational structure which is unclear and therefore makes it confusing to know whom to communicate with. Other examples could be inefficient or inappropriate information systems, a lack of supervision or training, and a lack of clarity in roles and responsibilities which can lead to staff being uncertain about what is expected of them.
- **Attitudinal barriers-** Attitudinal barriers come about as a result of problems with staff in an organization. These may be brought about, for example, by such factors as poor management, lack of consultation with employees, personality conflicts which can result in people delaying or refusing to communicate, the personal attitudes of individual employees which may be due to lack of motivation or dissatisfaction at work, brought about by insufficient training to enable them to carry out particular tasks, or simply resistance to change due to entrenched attitudes and ideas.
- **Ambiguity of words/phrases-** Words sounding the same but having different meaning can convey a different meaning altogether. Hence the communicator must ensure that the receiver receives the same meaning. It is better if such words are avoided by using alternatives whenever possible.
- **Individual linguistic ability-** The use of jargon, difficult or inappropriate words in communication can prevent the recipients from understanding the

message. Poorly explained or misunderstood messages can also result in confusion. However, research in communication has shown that confusion can lend legitimacy to research when persuasion fails.[25][26]

- **Physiological barriers-** These may result from individuals' personal discomfort, caused—for example—by ill health, poor eyesight or hearing difficulties.

- **Bypassing-**These happens when the communicators (sender and the receiver) do not attach the same symbolic meanings to their words. It is when the sender is expressing a thought or a word but the receiver take it in a different meaning. For example-ASAP, Rest room

- **Technological multi-tasking and absorbency-** With a rapid increase in technologically-driven communication in the past several decades, individuals are increasingly faced with condensed communication in the form of e-mail, text, and social updates. This has, in turn, led to a notable change in the way younger generations communicate and perceive their own self-efficacy to communicate and connect with others. With the ever-constant presence of another "world" in one's pocket, individuals are multitasking both physically and cognitively as constant reminders of something else happening somewhere else bombard them. Though perhaps too new of an advancement to yet see long-term effects, this is a notion currently explored by such figures as Sherry Turkle.[27]

- **Fear of being criticized-**This is a major factor that prevents good communication. If we exercise simple practices to improve our communication skill, we can become effective communicators. For example, read an article from the newspaper or collect some news from the television and present it in front of the mirror. This will not only boost your confidence, but also improve your language and vocabulary.

- **Gender barriers-** Most communicators whether aware or not, often have a set agenda. This is very notable among the different genders. For example, many women are found to be more critical in addressing conflict. It's also been noted that men are more than likely to withdraw from conflict when in comparison to women.[28] This breakdown and comparison not only shows that there are many factors to communication between two specific genders, but also room for improvement as well as established guidelines for all.

16.8.1 Cultural aspects

Cultural differences exist within countries (tribal/regional differences, dialects etc.), between religious groups and in organisations or at an organisational level - where companies, teams and units may have different expectations, norms and idiolects. Families and family groups may also experience the effect of cultural barriers to communication within and between different family members or groups. For example: words, colours and symbols have different meanings in different cultures. In most parts of the world, nodding your head means agreement, shaking your head means no, except in some parts of the world.[29]

Communication to a great extent is influenced by culture and cultural variables.[30][31][32][33] Understanding *cultural aspects of communication* refers to having knowledge of different cultures in order to communicate effectively with cross culture people. Cultural aspects of communication are of great relevance in today's world which is now a global village, thanks to globalisation. Cultural aspects of communication are the cultural differences which influences communication across borders. Impact of cultural differences on communication components are explained below:

1) Verbal communication refers to form of communication which uses spoken and written words for expressing and transferring views and ideas. Language is the most important tool of verbal communication and it is the area where cultural difference play its role. All countries have different languages and to have a better understanding of different culture it is required to have knowledge of languages of different countries.

2) Non verbal communication is a very wide concept and it includes all the other forms of communication which do not uses written or spoken words. Non verbal communication takes following forms:

- Paralinguistics are the voice involved in communication other than actual language and involves tones, pitch, vocal cues etc. It also include sounds from throat and all these are greatly influenced by cultural differences across borders.

- Proxemics deals with the concept of space element in communication. Proxemics explains four zones of spaces namely intimate personal, social and public. This concept differs with different culture as the permissible space vary in different countries.

- Artifactics studies about the non verbal signals or communication which emerges from personal accessories such as dresses or fashion accessories worn and it varies with culture as people of different countries follow different dressing codes.

- Chronemics deal with the time aspects of communication and also include importance given to the time.

Some issues explaining this concept are pauses, silences and response lag during an interaction. This aspect of communication is also influenced by cultural differences as it is well known that there is a great difference in the value given by different cultures to time.

- Kinesics mainly deals with the body languages such as postures, gestures, head nods, leg movements etc. In different countries, the same gestures and postures are used to convey different messages. Sometimes even a particular kinesic indicating something good in a country may have a negative meaning in any other culture.

So in order to have an effective communication across world it is desirable to have a knowledge of cultural variables effecting communication.

According to Michael Walsh and Ghil'ad Zuckermann, Western conversational interaction is typically "dyadic", between two particular people, where eye contact is important and the speaker controls the interaction; and "contained" in a relatively short, defined time frame. However, traditional Aboriginal conversational interaction is "communal", broadcast to many people, eye contact is not important, the listener controls the interaction; and "continuous", spread over a longer, indefinite time frame.[34][35]

16.9 Nonhuman

See also: Biocommunication (science), Interspecies communication, and Biosemiotics

Every information exchange between living organisms — i.e. transmission of signals that involve a living sender and receiver can be considered a form of communication; and even primitive creatures such as corals are competent to communicate. Nonhuman communication also include cell signaling, cellular communication, and chemical transmissions between primitive organisms like bacteria and within the plant and fungal kingdoms.

16.9.1 Animals

The broad field of animal communication encompasses most of the issues in ethology. Animal communication can be defined as any behavior of one animal that affects the current or future behavior of another animal. The study of animal communication, called *zoo semiotics* (distinguishable from anthroposemiotics, the study of human communication) has played an important part in the development of ethology, sociobiology, and the study of animal cognition. Animal communication, and indeed the understanding of the animal world in general, is a rapidly growing field, and even in the 21st century so far, a great share of prior understanding related to diverse fields such as personal symbolic name use, animal emotions, animal culture and learning, and even sexual conduct, long thought to be well understood, has been revolutionized. A special field of animal communication has been investigated in more detail such as vibrational communication.[36]

16.9.2 Plants and fungi

Communication is observed within the plant organism, i.e. within plant cells and between plant cells, between plants of the same or related species, and between plants and non-plant organisms, especially in the root zone. Plant roots communicate with rhizome bacteria, fungi, and insects within the soil. These interactions are governed by syntactic, pragmatic, and semantic rules, and are possible because of the decentralized "nervous system" of plants. The original meaning of the word "neuron" in Greek is "vegetable fiber" and recent research has shown that most of the microorganism plant communication processes are neuron-like.[37] Plants also communicate via volatiles when exposed to herbivory attack behavior, thus warning neighboring plants.[38] In parallel they produce other volatiles to attract parasites which attack these herbivores. In stress situations plants can overwrite the genomes they inherited from their parents and revert to that of their grand- or great-grandparents.

Fungi communicate to coordinate and organize their growth and development such as the formation of Marcelia and fruiting bodies. Fungi communicate with their own and related species as well as with non fungal organisms in a great variety of symbiotic interactions, especially with bacteria, unicellular eukaryote, plants and insects through biochemicals of biotic origin. The biochemicals trigger the fungal organism to react in a specific manner, while if the same chemical molecules are not part of biotic messages, they do not trigger the fungal organism to react. This implies that fungal organisms can differentiate between molecules taking part in biotic messages and similar molecules being irrelevant in the situation. So far five different primary signalling molecules are known to coordinate different behavioral patterns such as filamentation, mating, growth, and pathogenicity. Behavioral coordination and production of signaling substances is achieved through interpretation processes that enables the organism to differ between self or non-self, a biotic indicator, biotic message from similar, related, or non-related species, and even filter out "noise", i.e. similar molecules without biotic content.[39]

16.9.3 Bacteria quorum sensing

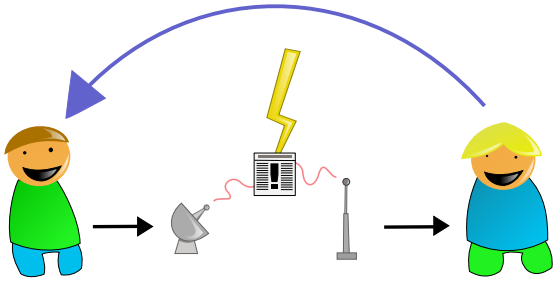
Communication is not a tool used only by humans, plants and animals, but it is also used by microorganisms like

bacteria. The process is called quorum sensing. Through quorum sensing, bacteria are able to sense the density of cells, and regulate gene expression accordingly. This can be seen in both gram positive and gram negative bacteria. This was first observed by Fuqua *et al.* in marine microorganisms like *V. harveyi* and *V. fischeri*.[40]

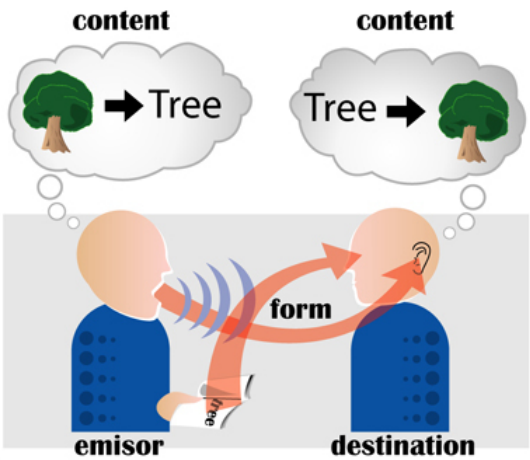
16.10 Models

Main article: Models of communication

The first major model for communication was introduced by Claude Shannon and Warren Weaver for Bell Laboratories in 1949[41] The original model was designed to mirror the functioning of radio and telephone technologies. Their initial model consisted of three primary parts: sender, channel, and receiver. The sender was the part of a telephone a person spoke into, the channel was the telephone itself, and the receiver was the part of the phone where one could hear the other person. Shannon and Weaver also recognized that often there is static that interferes with one listening to a telephone conversation, which they deemed noise.



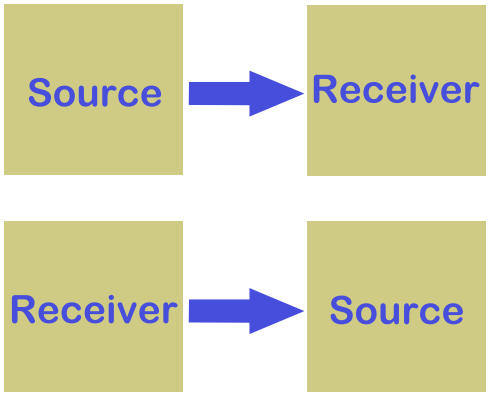
Shannon and Weaver Model of Communication



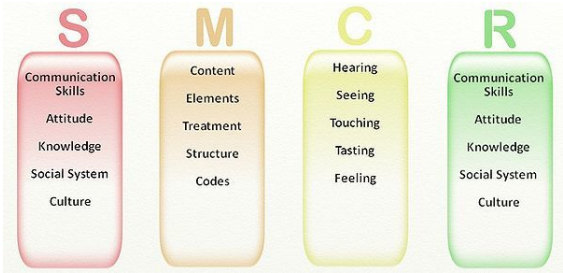
Communication major dimensions scheme

In a simple model, often referred to as the transmission model or standard view of communication, information or content (e.g. a message in natural language) is sent in some form (as spoken language) from an emisor/ sender/ encoder to a destination/ receiver/ decoder. This common conception of communication simply views communication as a means of sending and receiving information. The strengths of this model are simplicity, generality, and quantifiability. Claude Shannon and Warren Weaver structured this model based on the following elements:

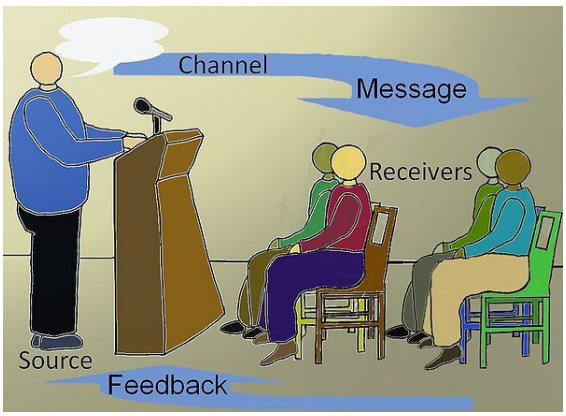
1. An information source, which produces a message.
2. A transmitter, which encodes the message into sig-



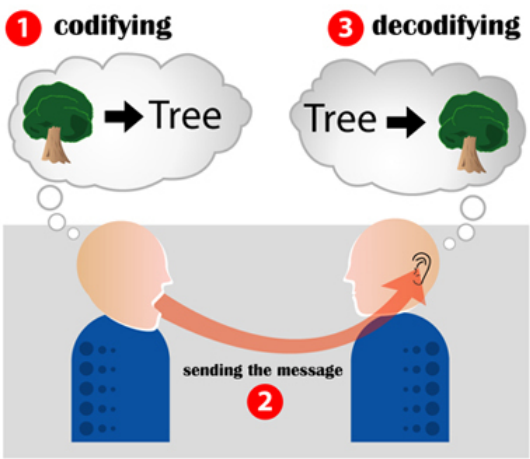
Interactional Model of Communication



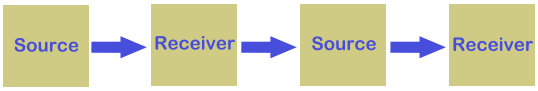
Berlo's Sender-Message-Channel-Receiver Model of Communication



Transactional model of communication



Communication code scheme



Linear Communication Model

nals

3. A channel, to which signals are adapted for transmission
4. A noise source, which distorts the signal while it propagates through the channel
5. A receiver, which 'decodes' (reconstructs) the message from the signal.
6. A destination, where the message arrives.

Shannon and Weaver argued that there were three levels of problems for communication within this theory.

> The technical problem: how accurately can the message be transmitted?
>
> The semantic problem: how precisely is the meaning 'conveyed'?
>
> The effectiveness problem: how effectively does the received meaning affect behavior?

Daniel Chandler[42] critiques the transmission model by stating:

> It assumes communicators are isolated individuals.
>
> No allowance for differing purposes.
>
> No allowance for differing interpretations.
>
> No allowance for unequal power relations.
>
> No allowance for situational contexts.

In 1960, David Berlo expanded on Shannon and Weaver's (1949) linear model of communication and created the SMCR Model of Communication.[43] The Sender-Message-Channel-Receiver Model of communication separated the model into clear parts and has been expanded upon by other scholars.

Communication is usually described along a few major dimensions: Message (what type of things are communicated), source / emisor / sender / encoder (by whom), form (in which form), channel (through which medium), destination / receiver / target / decoder (to whom), and Receiver. Wilbur Schram (1954) also indicated that we should also examine the impact that a message has (both desired and undesired) on the target of the message.[44] Between parties, communication includes acts that confer knowledge and experiences, give advice and commands, and ask questions. These acts may take many forms, in one of the various manners of communication. The form depends on the abilities of the group communicating. Together, communication content and form make messages that are sent towards a destination. The target can be oneself, another person or being, another entity (such as a corporation or group of beings).

Communication can be seen as processes of information transmission with three levels of semiotic rules:

1. Pragmatic (concerned with the relations between signs/expressions and their users)
2. Semantic (study of relationships between signs and symbols and what they represent) and
3. Syntactic (formal properties of signs and symbols).

Therefore, communication is social interaction where at least two interacting agents share a common set of signs and a common set of semiotic rules. This commonly held rule in some sense ignores autocommunication, including intrapersonal communication via diaries or self-talk, both secondary phenomena that followed the primary acquisition of communicative competences within social interactions.

In light of these weaknesses, Barnlund (2008) proposed a transactional model of communication.[45] The basic premise of the transactional model of communication is that individuals are simultaneously engaging in the sending and receiving of messages.

In a slightly more complex form a sender and a receiver are linked reciprocally. This second attitude of communication, referred to as the constitutive model or constructionist view, focuses on how an individual communicates as the determining factor of the way the message will be interpreted. Communication is viewed as a conduit; a passage in which information travels from one individual to another and this information becomes separate from the communication itself. A particular instance of communication is called a speech act. The sender's personal

filters and the receiver's personal filters may vary depending upon different regional traditions, cultures, or gender; which may alter the intended meaning of message contents. In the presence of "communication noise" on the transmission channel (air, in this case), reception and decoding of content may be faulty, and thus the speech act may not achieve the desired effect. One problem with this encode-transmit-receive-decode model is that the processes of encoding and decoding imply that the sender and receiver each possess something that functions as a codebook, and that these two code books are, at the very least, similar if not identical. Although something like code books is implied by the model, they are nowhere represented in the model, which creates many conceptual difficulties.

Theories of coregulation describe communication as a creative and dynamic continuous process, rather than a discrete exchange of information. Canadian media scholar Harold Innis had the theory that people use different types of media to communicate and which one they choose to use will offer different possibilities for the shape and durability of society (Wark, McKenzie 1997). His famous example of this is using ancient Egypt and looking at the ways they built themselves out of media with very different properties stone and papyrus. Papyrus is what he called 'Space Binding'. it made possible the transmission of written orders across space, empires and enables the waging of distant military campaigns and colonial administration. The other is stone and 'Time Binding', through the construction of temples and the pyramids can sustain their authority generation to generation, through this media they can change and shape communication in their society (Wark, McKenzie 1997).

16.11 Noise

In any communication model, noise is interference with the decoding of messages sent over a channel by an encoder. There are many examples of noise:

- **Environmental noise.** Noise that physically disrupts communication, such as standing next to loud speakers at a party, or the noise from a construction site next to a classroom making it difficult to hear the professor.
- **Physiological-impairment noise.** Physical maladies that prevent effective communication, such as actual deafness or blindness preventing messages from being received as they were intended.
- **Semantic noise.** Different interpretations of the meanings of certain words. For example, the word "weed" can be interpreted as an undesirable plant in a yard, or as a euphemism for marijuana.
- **Syntactical noise.** Mistakes in grammar can disrupt communication, such as abrupt changes in verb tense during a sentence.
- **Organizational noise.** Poorly structured communication can prevent the receiver from accurate interpretation. For example, unclear and badly stated directions can make the receiver even more lost.
- **Cultural noise.** Stereotypical assumptions can cause misunderstandings, such as unintentionally offending a non-Christian person by wishing them a "Merry Christmas".
- **Psychological noise.** Certain attitudes can also make communication difficult. For instance, great anger or sadness may cause someone to lose focus on the present moment. Disorders such as autism may also severely hamper effective communication.[46]

To face communication noise, redundancy and acknowledgement must often be used. Acknowledgements are messages from the addressee informing the originator that his/her communication has been received and is understood.[47] Message repetition and feedback about message received are necessary in the presence of noise to reduce the probability of misunderstanding.

16.12 As academic discipline

Main article: Communication studies

16.13 See also

- Advice
- Augmentative and alternative communication
- Communication rights
- Data communication
- Four Cs of 21st century learning
- Human communication
- *Inter Mirifica*
- Intercultural communication
- Ishin-denshin
- Proactive communications
- Sign system
- Small talk
- SPEAKING
- Telecommunication

- Telepathy
- Understanding
- 21st century skills
- Assertion Theory

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16.15 Further reading

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Chapter 17

Information theory

Not to be confused with information science.

Information theory studies the quantification, storage, and communication of information. It was originally proposed by Claude E. Shannon in 1948 to find fundamental limits on signal processing and communication operations such as data compression, in a landmark paper entitled "A Mathematical Theory of Communication". Now this theory has found applications in many other areas, including statistical inference, natural language processing, cryptography, neurobiology,[1] the evolution[2] and function[3] of molecular codes, model selection in ecology,[4] thermal physics,[5] quantum computing, linguistics, plagiarism detection,[6] pattern recognition, and anomaly detection.[7]

A key measure in information theory is "entropy". Entropy quantifies the amount of uncertainty involved in the value of a random variable or the outcome of a random process. For example, identifying the outcome of a fair coin flip (with two equally likely outcomes) provides less information (lower entropy) than specifying the outcome from a roll of a die (with six equally likely outcomes). Some other important measures in information theory are mutual information, channel capacity, error exponents, and relative entropy.

Applications of fundamental topics of information theory include lossless data compression (e.g. ZIP files), lossy data compression (e.g. MP3s and JPEGs), and channel coding (e.g. for Digital Subscriber Line (DSL)).

The field is at the intersection of mathematics, statistics, computer science, physics, neurobiology, and electrical engineering. Its impact has been crucial to the success of the Voyager missions to deep space, the invention of the compact disc, the feasibility of mobile phones, the development of the Internet, the study of linguistics and of human perception, the understanding of black holes, and numerous other fields. Important sub-fields of information theory include source coding, channel coding, algorithmic complexity theory, algorithmic information theory, information-theoretic security, and measures of information.

17.1 Overview

Information theory studies the transmission, processing, utilization, and extraction of information. Abstractly, information can be thought of as the resolution of uncertainty. In the case of communication of information over a noisy channel, this abstract concept was made concrete in 1948 by Claude Shannon in his paper "A Mathematical Theory of Communication", in which “information” is thought of as a set of possible messages, where the goal is to send these messages over a noisy channel, and then to have the receiver reconstruct the message with low probability of error, in spite of the channel noise. Shannon’s main result, the noisy-channel coding theorem showed that, in the limit of many channel uses, the rate of information that is asymptotically achievable is equal to the channel capacity, a quantity dependent merely on the statistics of the channel over which the messages are sent.[1]

Information theory is closely associated with a collection of pure and applied disciplines that have been investigated and reduced to engineering practice under a variety of rubrics throughout the world over the past half century or more: adaptive systems, anticipatory systems, artificial intelligence, complex systems, complexity science, cybernetics, informatics, machine learning, along with systems sciences of many descriptions. Information theory is a broad and deep mathematical theory, with equally broad and deep applications, amongst which is the vital field of coding theory.

Coding theory is concerned with finding explicit methods, called *codes*, for increasing the efficiency and reducing the error rate of data communication over noisy channels to near the Channel capacity. These codes can be roughly subdivided into data compression (source coding) and error-correction (channel coding) techniques. In the latter case, it took many years to find the methods Shannon’s work proved were possible. A third class of information theory codes are cryptographic algorithms (both codes and ciphers). Concepts, methods and results from coding theory and information theory are widely used in cryptography and cryptanalysis. *See the article ban (unit) for a historical application.*

Information theory is also used in information retrieval, intelligence gathering, gambling, statistics, and even in musical composition.

17.2 Historical background

Main article: History of information theory

The landmark event that *established* the discipline of information theory and brought it to immediate worldwide attention was the publication of Claude E. Shannon's classic paper "A Mathematical Theory of Communication" in the *Bell System Technical Journal* in July and October 1948.

Prior to this paper, limited information-theoretic ideas had been developed at Bell Labs, all implicitly assuming events of equal probability. Harry Nyquist's 1924 paper, *Certain Factors Affecting Telegraph Speed*, contains a theoretical section quantifying "intelligence" and the "line speed" at which it can be transmitted by a communication system, giving the relation $W = K \log m$ (recalling Boltzmann's constant), where W is the speed of transmission of intelligence, m is the number of different voltage levels to choose from at each time step, and K is a constant. Ralph Hartley's 1928 paper, *Transmission of Information*, uses the word *information* as a measurable quantity, reflecting the receiver's ability to distinguish one sequence of symbols from any other, thus quantifying information as $H = \log S^n = n \log S$, where S was the number of possible symbols, and n the number of symbols in a transmission. The unit of information was therefore the decimal digit, much later renamed the hartley in his honour as a unit or scale or measure of information. Alan Turing in 1940 used similar ideas as part of the statistical analysis of the breaking of the German second world war Enigma ciphers.

Much of the mathematics behind information theory with events of different probabilities were developed for the field of thermodynamics by Ludwig Boltzmann and J. Willard Gibbs. Connections between information-theoretic entropy and thermodynamic entropy, including the important contributions by Rolf Landauer in the 1960s, are explored in *Entropy in thermodynamics and information theory*.

In Shannon's revolutionary and groundbreaking paper, the work for which had been substantially completed at Bell Labs by the end of 1944, Shannon for the first time introduced the qualitative and quantitative model of communication as a statistical process underlying information theory, opening with the assertion that

> "The fundamental problem of communication is that of reproducing at one point, either exactly or approximately, a message selected at another point."

With it came the ideas of

- the information entropy and redundancy of a source, and its relevance through the source coding theorem;
- the mutual information, and the channel capacity of a noisy channel, including the promise of perfect loss-free communication given by the noisy-channel coding theorem;
- the practical result of the Shannon–Hartley law for the channel capacity of a Gaussian channel; as well as
- the bit—a new way of seeing the most fundamental unit of information.

17.3 Quantities of information

Main article: Quantities of information

Information theory is based on probability theory and statistics. Information theory often concerns itself with measures of information of the distributions associated with random variables. Important quantities of information are entropy, a measure of information in a single random variable, and mutual information, a measure of information in common between two random variables. The former quantity is a property of the probability distribution of a random variable and gives a limit on the rate at which data generated by independent samples with the given distribution can be reliably compressed. The latter is a property of the joint distribution of two random variables, and is the maximum rate of reliable communication across a noisy channel in the limit of long block lengths, when the channel statistics are determined by the joint distribution.

The choice of logarithmic base in the following formulae determines the unit of information entropy that is used. A common unit of information is the bit, based on the binary logarithm. Other units include the nat, which is based on the natural logarithm, and the hartley, which is based on the common logarithm.

In what follows, an expression of the form $p \log p$ is considered by convention to be equal to zero whenever $p = 0$. This is justified because $\lim_{p \to 0+} p \log p = 0$ for any logarithmic base.

17.3.1 Entropy of an information source

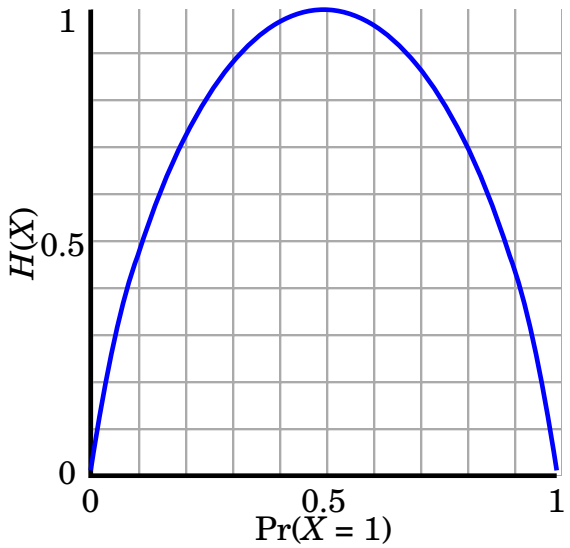
Based on the probability mass function of each source symbol to be communicated, the Shannon entropy H, in units of bits (per symbol), is given by

$$H = -\sum_i p_i \log_2(p_i)$$

where *pi* is the probability of occurrence of the *i*-th possible value of the source symbol. This equation gives the entropy in the units of "bits" (per symbol) because it uses a logarithm of base 2, and this base-2 measure of entropy has sometimes been called the "shannon" in his honor. Entropy is also commonly computed using the natural logarithm (base e, where e is Euler's number), which produces a measurement of entropy in "nats" per symbol and sometimes simplifies the analysis by avoiding the need to include extra constants in the formulas. Other bases are also possible, but less commonly used. For example, a logarithm of base $2^8 = 256$ will produce a measurement in bytes per symbol, and a logarithm of base 10 will produce a measurement in decimal digits (or hartleys) per symbol.

Intuitively, the entropy *HX* of a discrete random variable *X* is a measure of the amount of *uncertainty* associated with the value of *X* when only its distribution is known.

The entropy of a source that emits a sequence of *N* symbols that are independent and identically distributed (iid) is *N·H* bits (per message of *N* symbols). If the source data symbols are identically distributed but not independent, the entropy of a message of length *N* will be less than *N·H*.



The entropy of a Bernoulli trial as a function of success probability, often called the ***binary entropy function****,* Hb(p)*. The entropy is maximized at 1 bit per trial when the two possible outcomes are equally probable, as in an unbiased coin toss.*

Suppose one transmits 1000 bits (0s and 1s). If the value of each of these bits is known to the receiver (has a specific value with certainty) ahead of transmission, it is clear that no information is transmitted. If, however, each bit is independently equally likely to be 0 or 1, 1000 shannons of information (more often called bits) have been transmitted. Between these two extremes, information can be quantified as follows. If $\mathbb{X}$ is the set of all messages $\{x_1, \ldots, xn\}$ that *X* could be, and *p*(*x*) is the probability of some $x \in \mathbb{X}$, then the entropy, *H*, of *X* is defined:[8]

$$H(X) = \mathbb{E}_X[I(x)] = -\sum_{x\in\mathbb{X}} p(x) \log p(x).$$

(Here, *I*(*x*) is the self-information, which is the entropy contribution of an individual message, and $\mathbb{E}X$ is the expected value.) A property of entropy is that it is maximized when all the messages in the message space are equiprobable *p*(*x*) = 1/*n*; i.e., most unpredictable, in which case *H*(*X*) = log *n*.

The special case of information entropy for a random variable with two outcomes is the **binary entropy function**, usually taken to the logarithmic base 2, thus having the shannon (Sh) as unit:

$$H_{\mathrm{b}}(p) = -p \log_2 p - (1-p) \log_2 (1-p).$$

17.3.2 Joint entropy

The **joint entropy** of two discrete random variables *X* and *Y* is merely the entropy of their pairing: (*X*, *Y*). This implies that if *X* and *Y* are independent, then their joint entropy is the sum of their individual entropies.

For example, if (*X*, *Y*) represents the position of a chess piece — *X* the row and *Y* the column, then the joint entropy of the row of the piece and the column of the piece will be the entropy of the position of the piece.

$$H(X,Y) = \mathbb{E}_{X,Y}[-\log p(x,y)] = -\sum_{x,y} p(x,y) \log p(x,y)$$

Despite similar notation, joint entropy should not be confused with **cross entropy**.

17.3.3 Conditional entropy (equivocation)

The **conditional entropy** or **conditional uncertainty** of *X* given random variable *Y* (also called the **equivocation** of *X* about *Y*) is the average conditional entropy over *Y*:[9]

$$H(X|Y) = \mathbb{E}_Y[H(X|y)] = -\sum_{y\in Y} p(y) \sum_{x\in X} p(x|y) \log p(x|y) = -\sum_{x,y} p$$

Because entropy can be conditioned on a random variable or on that random variable being a certain value, care should be taken not to confuse these two definitions of conditional entropy, the former of which is in more common use. A basic property of this form of conditional entropy is that:

$$H(X|Y) = H(X,Y) - H(Y).$$

17.3.4 Mutual information (transinformation)

Mutual information measures the amount of information that can be obtained about one random variable by observing another. It is important in communication where it can be used to maximize the amount of information shared between sent and received signals. The mutual information of *X* relative to *Y* is given by:

$$I(X;Y) = \mathbb{E}_{X,Y}[SI(x,y)] = \sum_{x,y} p(x,y) \log \frac{p(x,y)}{p(x)\,p(y)}$$

where SI (*S*pecific mutual *I*nformation) is the pointwise mutual information.

A basic property of the mutual information is that

$$I(X;Y) = H(X) - H(X|Y).$$

That is, knowing *Y*, we can save an average of *I*(*X*; *Y*) bits in encoding *X* compared to not knowing *Y*.

Mutual information is symmetric:

$$I(X;Y) = I(Y;X) = H(X) + H(Y) - H(X,Y).$$

Mutual information can be expressed as the average Kullback–Leibler divergence (information gain) between the posterior probability distribution of *X* given the value of *Y* and the prior distribution on *X*:

$$I(X;Y) = \mathbb{E}_{p(y)}[D_{\mathrm{KL}}(p(X|Y=y)\|p(X))].$$

In other words, this is a measure of how much, on the average, the probability distribution on *X* will change if we are given the value of *Y*. This is often recalculated as the divergence from the product of the marginal distributions to the actual joint distribution:

$$I(X;Y) = D_{\mathrm{KL}}(p(X,Y)\|p(X)p(Y)).$$

Mutual information is closely related to the log-likelihood ratio test in the context of contingency tables and the multinomial distribution and to Pearson's χ^2 test: mutual information can be considered a statistic for assessing independence between a pair of variables, and has a well-specified asymptotic distribution.

17.3.5 Kullback–Leibler divergence (information gain)

The **Kullback–Leibler divergence** (or **information divergence**, **information gain**, or **relative entropy**) is a way of comparing two distributions: a "true" probability distribution *p(X)*, and an arbitrary probability distribution *q(X)*. If we compress data in a manner that assumes *q(X)* is the distribution underlying some data, when, in reality, *p(X)* is the correct distribution, the Kullback–Leibler divergence is the number of average additional bits per datum necessary for compression. It is thus defined

$$D_{\mathrm{KL}}(p(X)\|q(X)) = \sum_{x\in X} -p(x)\log q(x) - \sum_{x\in X} -p(x)\log p(x) = \sum_{x\in X} p$$

Although it is sometimes used as a 'distance metric', KL divergence is not a true metric since it is not symmetric and does not satisfy the triangle inequality (making it a semi-quasimetric).

Another interpretation of the KL divergence is the "unnecessary surprise" introduced by a prior from the truth: suppose a number *X* is about to be drawn randomly from a discrete set with probability distribution *p(x)*. If Alice knows the true distribution *p(x)*, while Bob believes (has a prior) that the distribution is *q(x)*, then Bob will be more surprised than Alice, on average, upon seeing the value of *X*. The KL divergence is the (objective) expected value of Bob's (subjective) surprisal minus Alice's surprisal, measured in bits if the *log* is in base 2. In this way, the extent to which Bob's prior is "wrong" can be quantified in terms of how "unnecessarily surprised" it's expected to make him.

17.3.6 Other quantities

Other important information theoretic quantities include Rényi entropy (a generalization of entropy), differential entropy (a generalization of quantities of information to continuous distributions), and the conditional mutual information.

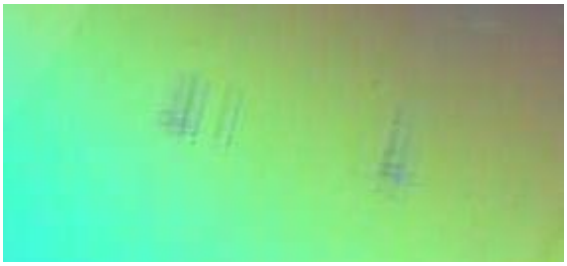
17.4 Coding theory

Main article: Coding theory

Coding theory is one of the most important and direct applications of information theory. It can be subdivided into source coding theory and channel coding theory. Using a statistical description for data, information theory quantifies the number of bits needed to describe the data, which is the information entropy of the source.

- Data compression (source coding): There are two formulations for the compression problem:

1. lossless data compression: the data must be reconstructed exactly;
2. lossy data compression: allocates bits needed to reconstruct the data, within a specified fidelity level



A picture showing scratches on the readable surface of a CD-R. Music and data CDs are coded using error correcting codes and thus can still be read even if they have minor scratches using error detection and correction.

measured by a distortion function. This subset of Information theory is called rate–distortion theory.

- Error-correcting codes (channel coding): While data compression removes as much redundancy as possible, an error correcting code adds just the right kind of redundancy (i.e., error correction) needed to transmit the data efficiently and faithfully across a noisy channel.

This division of coding theory into compression and transmission is justified by the information transmission theorems, or source–channel separation theorems that justify the use of bits as the universal currency for information in many contexts. However, these theorems only hold in the situation where one transmitting user wishes to communicate to one receiving user. In scenarios with more than one transmitter (the multiple-access channel), more than one receiver (the broadcast channel) or intermediary "helpers" (the relay channel), or more general networks, compression followed by transmission may no longer be optimal. Network information theory refers to these multi-agent communication models.

17.4.1 Source theory

Any process that generates successive messages can be considered a **source** of information. A memoryless source is one in which each message is an independent identically distributed random variable, whereas the properties of ergodicity and stationarity impose less restrictive constraints. All such sources are stochastic. These terms are well studied in their own right outside information theory.

Rate

Information **rate** is the average entropy per symbol. For memoryless sources, this is merely the entropy of each symbol, while, in the case of a stationary stochastic process, it is

$$r = \lim_{n\to\infty} H(X_n|X_{n-1}, X_{n-2}, X_{n-3}, \ldots);$$

that is, the conditional entropy of a symbol given all the previous symbols generated. For the more general case of a process that is not necessarily stationary, the *average rate* is

$$r = \lim_{n\to\infty} \frac{1}{n} H(X_1, X_2, \ldots X_n);$$

that is, the limit of the joint entropy per symbol. For stationary sources, these two expressions give the same result.[10]

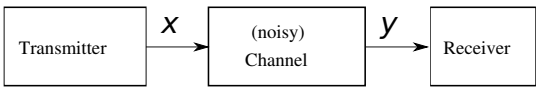
It is common in information theory to speak of the "rate" or "entropy" of a language. This is appropriate, for example, when the source of information is English prose. The rate of a source of information is related to its redundancy and how well it can be compressed, the subject of **source coding**.

17.4.2 Channel capacity

Main article: Channel capacity

Communications over a channel—such as an ethernet cable—is the primary motivation of information theory. As anyone who's ever used a telephone (mobile or landline) knows, however, such channels often fail to produce exact reconstruction of a signal; noise, periods of silence, and other forms of signal corruption often degrade quality. How much information can one hope to communicate over a noisy (or otherwise imperfect) channel?

Consider the communications process over a discrete channel. A simple model of the process is shown below:



Here X represents the space of messages transmitted, and Y the space of messages received during a unit time over our channel. Let $p(y|x)$ be the conditional probability distribution function of Y given X. We will consider $p(y|x)$ to be an inherent fixed property of our communications channel (representing the nature of the **noise** of our channel). Then the joint distribution of X and Y is completely determined by our channel and by our choice of $f(x)$, the marginal distribution of messages we choose to send over the channel. Under these constraints, we would like to maximize the rate of information, or the **signal**, we can communicate over the channel. The appropriate measure for this is the mutual information, and this maximum mutual information is called the **channel capacity** and is given by:

$$C = \max_f I(X;Y).$$

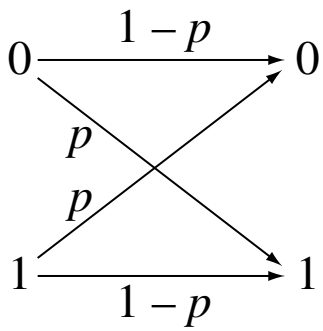
This capacity has the following property related to communicating at information rate R (where R is usually bits per symbol). For any information rate $R < C$ and coding error $\varepsilon > 0$, for large enough N, there exists a code of length N and rate ≥ R and a decoding algorithm, such that the maximal probability of block error is ≤ ε; that is, it is always possible to transmit with arbitrarily small block error. In addition, for any rate $R > C$, it is impossible to transmit with arbitrarily small block error.

Channel coding is concerned with finding such nearly optimal codes that can be used to transmit data over a noisy channel with a small coding error at a rate near the channel capacity.

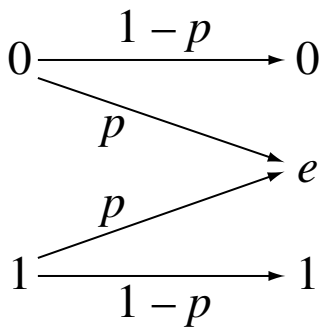
Capacity of particular channel models

- A continuous-time analog communications channel subject to Gaussian noise — see Shannon–Hartley theorem.

- A binary symmetric channel (BSC) with crossover probability p is a binary input, binary output channel that flips the input bit with probability p. The BSC has a capacity of $1 - H_b(p)$ bits per channel use, where H_b is the binary entropy function to the base 2 logarithm:



- A binary erasure channel (BEC) with erasure probability p is a binary input, ternary output channel. The possible channel outputs are *0*, *1*, and a third symbol 'e' called an erasure. The erasure represents complete loss of information about an input bit. The capacity of the BEC is *1* - *p* bits per channel use.



17.5 Applications to other fields

17.5.1 Intelligence uses and secrecy applications

Information theoretic concepts apply to cryptography and cryptanalysis. Turing's information unit, the ban, was used in the Ultra project, breaking the German Enigma machine code and hastening the end of World War II in Europe. Shannon himself defined an important concept now called the unicity distance. Based on the redundancy of the plaintext, it attempts to give a minimum amount of ciphertext necessary to ensure unique decipherability.

Information theory leads us to believe it is much more difficult to keep secrets than it might first appear. A brute force attack can break systems based on asymmetric key algorithms or on most commonly used methods of symmetric key algorithms (sometimes called secret key algorithms), such as block ciphers. The security of all such methods currently comes from the assumption that no known attack can break them in a practical amount of time.

Information theoretic security refers to methods such as the one-time pad that are not vulnerable to such brute force attacks. In such cases, the positive conditional mutual information between the plaintext and ciphertext (conditioned on the key) can ensure proper transmission, while the unconditional mutual information between the plaintext and ciphertext remains zero, resulting in absolutely secure communications. In other words, an eavesdropper would not be able to improve his or her guess of the plaintext by gaining knowledge of the ciphertext but not of the key. However, as in any other cryptographic system, care must be used to correctly apply even information-theoretically secure methods; the Venona project was able to crack the one-time pads of the Soviet Union due to their improper reuse of key material.

17.5.2 Pseudorandom number generation

Pseudorandom number generators are widely available in computer language libraries and application pro-

grams. They are, almost universally, unsuited to cryptographic use as they do not evade the deterministic nature of modern computer equipment and software. A class of improved random number generators is termed cryptographically secure pseudorandom number generators, but even they require random seeds external to the software to work as intended. These can be obtained via extractors, if done carefully. The measure of sufficient randomness in extractors is min-entropy, a value related to Shannon entropy through Rényi entropy; Rényi entropy is also used in evaluating randomness in cryptographic systems. Although related, the distinctions among these measures mean that a random variable with high Shannon entropy is not necessarily satisfactory for use in an extractor and so for cryptography uses.

17.5.3 Seismic exploration

One early commercial application of information theory was in the field of seismic oil exploration. Work in this field made it possible to strip off and separate the unwanted noise from the desired seismic signal. Information theory and digital signal processing offer a major improvement of resolution and image clarity over previous analog methods.[11]

17.5.4 Semiotics

Concepts from information theory such as redundancy and code control have been used by semioticians such as Umberto Eco and Ferruccio Rossi-Landi to explain ideology as a form of message transmission whereby a dominant social class emits its message by using signs that exhibit a high degree of redundancy such that only one message is decoded among a selection of competing ones.[12]

17.5.5 Miscellaneous applications

Information theory also has applications in gambling and investing, black holes, and bioinformatics.

17.6 See also

- Algorithmic probability
- Algorithmic information theory
- Bayesian inference
- Communication theory
- Constructor theory - a generalization of information theory that includes quantum information
- Inductive probability
- Minimum message length
- Minimum description length
- List of important publications
- Philosophy of information

17.6.1 Applications

- Active networking
- Cryptanalysis
- Cryptography
- Cybernetics
- Entropy in thermodynamics and information theory
- Gambling
- Intelligence (information gathering)
- Seismic exploration

17.6.2 History

- Hartley, R.V.L.
- History of information theory
- Shannon, C.E.
- Timeline of information theory
- Yockey, H.P.

17.6.3 Theory

- Coding theory
- Detection theory
- Estimation theory
- Fisher information
- Information algebra
- Information asymmetry
- Information field theory
- Information geometry
- Information theory and measure theory
- Kolmogorov complexity
- Logic of information
- Network coding
- Philosophy of Information
- Quantum information science
- Semiotic information theory
- Source coding
- Unsolved Problems

17.6.4 Concepts

- Ban (unit)
- Channel capacity
- Channel (communications)
- Communication source
- Conditional entropy
- Covert channel
- Decoder
- Differential entropy
- Encoder
- Information entropy
- Joint entropy
- Kullback–Leibler divergence
- Mutual information
- Pointwise mutual information (PMI)
- Receiver (information theory)
- Redundancy
- Rényi entropy
- Self-information
- Unicity distance
- Variety
- Hamming distance

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Marek69, John254, Bobblehead, Maximilian Schönherr, Tellyaddict, BauerPower, Pkapitola, Siggis, Escarbot, Mentifisto, Porqin, AntiVandalBot, BokicaK, Luna Santin, Seaphoto, CZmarlin, Goodmansasha, Antique Rose, Expligatory, DeepJR, Smartse, Jacqke, Alexthurleyratcliff, Dylan Lake, PseudoChron, Jenny Wong, Jaredroberts, MikeLynch, JAnDbot, DuncanHill, MER-C, The Transhumanist, JonBernstein, Charanhere, Acroterion, Rose455, Pablothegreat85, Freedomlinux, .snoopy., Hayduke lives, Bongwarrior, VoABot II, Usereed, JamesBWatson, D1doherty, Autie 808, Swpb, Ling.Nut, Bwhack, I JethroBT, Champvirgomartin, Animum, Cgingold, Ciaccona, Hazukisan, Cpl Syx, Spellmaster, Vssun, DerHexer, JaGa, Edward321, Khalid Mahmood, Oicumayberight, 0612, MartinBot, Yrrah, Management Culture, Rettetast, Anaxial, CommonsDelinker, AlexiusHoratius, Jarhed, EdBever, Mausy5043, Erkan Yilmaz, J.delanoy, Pharaoh of the Wizards, Trusilver, Petreg, Adavidb, Hanteng, Silverxxx, Wtimrock, MistyMorn, Maurice Carbonaro, Extransit, Amanda Renee, Cdamama, Athalia~enwiki, Joe fob, Aqwis, Elkost, Katalaveno, Allanhgilbertson, McSly, Bryantnorland, Lovely seungmi, Brolsma, Babochka18, Gemena, The Transhumanist (AWB), NewEnglandYankee, Arun0070, Johnabolarin, Jorfer, EyeRmonkey, Cometstyles, Warlordwolf, Treisijs, Sjwk, Kvdveer, Pdcook, Ja 62, Inwind, S (usurped also), DASonnenfeld, KGV, Funandtrvl, Black Kite, Deor, VolkovBot, Jeff G., MaxwellBliss, Nburden, Tomer T, Aesopos, Philip Trueman, Tcaruso2, TXiKiBoT, AllanManangan, Yupi666, Anne1024, NPrice, Anonymous Dissident, Nl74, GcSwRhIc, Qxz, Anna Lincoln, Brainresearch, Corvus cornix, Don4of4, C7796E2C, DieBuche, Butterscotch, Andy Dingley, Lova Falk, Chuthuy20262, Enviroboy, Xsamanthaxwoodsx, Cnilep, Dpleibovitz, Brianga, Rlanigan, DennisRivers, Raenico, Kalivd, Irishdunn, FlyingLeopard2014, Anon The Nitpicker, EJF, SieBot, John.n-irl, Danielden, Jauerback, Fantastic fred, Dawn Bard, Viskonsas, RJaguar3, Triwbe, Lucasbfrbot, Yintan, Keilana, Hebisddave, Bentogoa, Breawycker, Happysailor, Flyer22 Reborn, MaynardClark, Oda Mari, JetLover, SPACKlick, Yerpo, Wombatcat, Tmorin, Sbowers3, Ayudante, Doctorfluffy, Oxymoron83, OKBot, Nancy, Svick, Reneeholle, Capitalismojo, WikiLaurent, Aalucas, Asikhi, Denisarona, Sasha Callahan, Linforest, Atif.t2, Loren.wilton, Martarius, ClueBot, Thedosmann, Avenged Eightfold, GorillaWarfare, Snigbrook, The Thing That Should Not Be, EoGuy, Shujaat Ali Rahi, Jacob F. 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Scot, Ronhjones, Cr0, Fieldday-sunday, Moosehadley, Ynaztiw, Fluffernutter, Ccnc, MrOllie, Download, CarsracBot, Facilitation Author, 5 albert square, Tassedethe, Numbo3-bot, Tide rolls, OlEnglish, Krano, Luckas Blade, Gail, MuZemike, Jarble, טבעת-זרם, Albeiror24, Legobot, Luckas-bot, Postalprimesmock, Yobot, Senator Palpatine, Fraggle81, TaBOT-zerem, Thescimitar, AmaraBot, Timir Saxa, Eric-Wester, Tempodivalse, SD93981, Rpf 81, AnomieBOT, DemocraticLuntz, Quangbao, Hairhorn, Rubinbot, ThaddeusB, Sonia, Jim1138, IRP, Galoubet, Piano non troppo, AdjustShift, Drdac, Kingpin13, Justme89, NickK, Flewis, Materialscientist, ArdWar, Citation bot, Nifky?, LilHelpa, Grey ghost, MauritsBot, Xqbot, Brown tabel, Sketchmoose, Sionus, Khodeirmas229, Melmann, JimVC3, Capricorn42, Mankapr, Wingroad2, Meewam, Millahnna, Nasnema, Batesmas214, Venkaat, Ched, GrandKokla, MiniBill, Anna Frodesiak, Wazofski, Dr Oldekop, Cat1project, Tdjewell, Frosted14, Omnipaedista, Charismatic Verma, Frankie0607, 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