

Creativity

• Parameshwar Hegde

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VIDYANIDHI PRAKASHANA
GADAG



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SIRSI



VIDYANIDHI PRAKASHANA GADAG

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PREFACE

Creativity is a mental process involving the discovery of new ideas or concepts, or new associations of the existing ideas or concepts, fueled by the process of either conscious or unconscious insight.

From a scientific point of view, the products of creative thought (sometimes referred to as divergent thought) are usually considered to have both originality and appropriateness.

Although intuitively a simple phenomenon, it is in fact quite complex. It has been studied from the perspectives of behavioural psychology, social psychology, psychometrics, cognitive science, artificial intelligence, philosophy, aesthetics, history, economics, design research, business, and management, among others. The studies have covered everyday creativity, exceptional creativity and even artificial creativity. Unlike many phenomena in science, there is no single, authoritative perspective or definition of creativity. And unlike many phenomena in psychology, there is no standardized measurement technique.

Creativity has been attributed variously to divine intervention, cognitive processes, the social environment, personality traits, and chance ("accident", "serendipity"). It has been associated with genius, mental illness, humour and REM sleep. Some say it is a trait we are born with; others say it can be taught with the application of simple techniques. Creativity has also been viewed as a beneficence of a muse or Muses.

Although popularly associated with art and literature, it is also an essential part of innovation and invention and is important in professions such as business, economics, architecture, industrial design, graphic design, advertising, mathematics, music, science and engineering, and teaching.

Despite, or perhaps because of, the ambiguity and multi-dimensional nature of creativity, entire industries have been spawned from the pursuit of creative ideas and the development of creativity techniques.

Some students of creativity have emphasized an element of chance in the creative process. Linus Pauling, asked at a public lecture how one creates scientific theories, replied that one must endeavor to come up with *many* ideas — then discard the useless ones.

Another adequate definition of creativity, according to Otto Rank, is that it is an "assumptions-breaking process." Creative ideas are often generated when one discards preconceived assumptions and attempts a new approach or method that might seem to others unthinkable.

The ways in which societies have perceived the concept of creativity have changed throughout history, as has the term itself. The ancient Greek concept of art (in Greek, "*techne*" — the root of "technique" and "technology"), with the exception of poetry, involved not freedom of action but subjection to *rules*. In Rome, this Greek concept was partly shaken, and visual artists were viewed as sharing, with poets, imagination and inspiration.

Although neither the Greeks nor the Romans had a word that directly corresponded to the word "creativity," their art, architecture, music, inventions and discoveries provide numerous examples of what today would be described as creative works. The Greek scientist of Syracuse, Archimedes experienced the creative moment in his Eureka experience, finding the answer to a problem he had been wrestling with for a long time. At the time, the concept of "genius" probably came closest to describing the creative talents that brought forth such works.

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Suggestions for the further improvement of the book will be highly appreciated.

SIRSI
13th June, 2010

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CREATIVITY

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INTRODUCTION

Creativity is a mental process involving the discovery of new ideas or concepts, or new associations of the existing ideas or concepts, fueled by the process of either conscious or unconscious insight.

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Although intuitively a simple phenomenon, it is in fact quite complex. It has been studied from the perspectives of behavioural psychology, social psychology, psychometrics, cognitive science, artificial intelligence, philosophy, aesthetics, history, economics, design research, business, and management, among others. The studies have covered everyday creativity, exceptional creativity and even artificial creativity. Unlike many phenomena in science, there is no single, authoritative perspective or definition of creativity. And unlike many phenomena in psychology, there is no standardized measurement technique.

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architecture, industrial design, graphic design, advertising, mathematics, music, science and engineering, and teaching.

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Another adequate definition of creativity, according to Otto Rank, is that it is an “assumptions-breaking process.” Creative ideas are often generated when one discards preconceived assumptions and attempts a new approach or method that might seem to others unthinkable.

Distinguishing between creativity and innovation

It is often useful to explicitly distinguish between *creativity* and *innovation*.

Creativity is typically used to refer to the act of producing new ideas, approaches or actions, while innovation is the process of both generating *and applying* such creative ideas in some specific context.

In the context of an organization, therefore, the term *innovation* is often used to refer to the entire process by which an organization generates creative new ideas and converts them into novel, useful and viable commercial products, services, and business practices, while the term *creativity* is reserved to apply specifically to the generation of novel ideas by individuals or groups, as a necessary step within the innovation process.

For example, Amabile and Shermaine Montefalco et al. (1996) suggest that while innovation “begins with creative ideas,”

"...creativity by individuals and teams is a starting point for innovation; the first is a necessary but not sufficient condition for the second."

Although the two words are novel, they go hand in hand. In order to be innovative, employees have to be creative to stay competitive.

History of the term and the concept

The ways in which societies have perceived the concept of creativity have changed throughout history, as has the term itself. The ancient Greek concept of art (in Greek, "*techne*"—the root of "technique" and "technology"), with the exception of poetry, involved not freedom of action but subjection to *rules*. In Rome, this Greek concept was partly shaken, and visual artists were viewed as sharing, with poets, imagination and inspiration.

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A fundamental change came in the Christian period: "*creatio*" came to designate God's act of "creation from nothing". "*Creatio*" thus took on a different meaning than "*facere*" ("to make") and ceased to apply to human functions. The ancient view that art is not a domain of creativity persisted in this period.

A shift occurred in modern times. Renaissance men had a sense of their own independence, freedom and creativity, and sought to give voice to this sense. The first to actually apply the word "creativity" was the Polish poet Maciej Kazimierz Sarbiewski, who applied it exclusively to poetry. For over a century and a half, the idea of *human* creativity met with

resistance, due to the fact that the term "creation" was reserved for creation "from nothing." Baltasar Gracián (1601–58) would only venture to write: "Art is the completion of nature, as if it were a *second Creator...*"

By the 18th century and the Age of Enlightenment, the concept of creativity was appearing more often in art theory, and was linked with the concept of imagination.

The Western view of creativity can be contrasted with the Eastern view. For Hindus, Confucianists, Taoists and Buddhists, creation was at most a kind of discovery or mimicry, and the idea of creation "from nothing" had no place in these philosophies and religions.

In the West, by the 19th century, not only had art come to be regarded as creativity, but *it alone* was so regarded. When later, at the turn of the 20th century, there began to be discussion of creativity in the sciences (e.g., Jan Lukasiewicz, 1878–1956) and in nature (e.g., Henri Bergson), this was generally taken as the transference, to the sciences, of concepts that were proper to art.

In the late nineteenth and early twentieth 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, and these insights were built on in early accounts of the creative process by pioneering theorists such as Graham Wallas (1926) and Max Wertheimer (1945).

However, the formal starting point for the scientific study of creativity, from the standpoint of orthodox psychological literature, is generally considered to have been J. P. Guilford's 1950 address to the American Psychological Association, which helped popularize the topic and focus attention on a scientific approach to conceptualizing creativity and measuring it psychometrically.

In parallel with these developments, other investigators have taken a more pragmatic approach, teaching practical creativity techniques. Three of the best-known are:

- Alex Osborn's "brainstorming" (1950s to present),
- Genrikh Altshuller's Theory of Inventive Problem Solving (TRIZ, 1950s to present),
- and Edward de Bono's "lateral thinking" (1960s to present).

Creativity in psychology and cognitive science

The study of the mental representations and processes underlying creative thought belongs to the domains of psychology and cognitive science.

A psychodynamic approach to understanding creativity was proposed by Sigmund Freud, who suggested that creativity arises as a result of frustrated desires for fame, fortune, and love, with the energy that was previously tied up in frustration and emotional tension in the neurosis being sublimated into creative activity. Freud later retracted this view.

Graham Wallas

Graham Wallas, in his work *Art of Thought*, published in 1926, 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); and
- (v) *verification* (where the idea is consciously verified, elaborated, and then applied).

In numerous publications, Wallas' model is just treated as four stages, with "intimation" seen as a sub-stage. 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 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. 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.

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

J.P. Guilford

Guilford performed important work in the field of creativity, drawing 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.

Arthur Koestler

In *The Act of Creation*, Arthur Koestler lists three types of creative individual - the *Artist*, the *Sage* and the *Jester*.

Believers in this trinity hold all three elements necessary in business and can identify them all in "truly creative" companies as well. Koestler introduced the concept of *bisociation* - that creativity arises as a result of the intersection of two quite different frames of reference.

Genevieve model

In 1992, Finke et al. proposed the 'Genevieve' 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. Weisberg argued, by contrast, that creativity only involves ordinary cognitive processes yielding extraordinary results.

Conceptual blending

In the 90s, 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.

"Creativity is the ability to illustrate what is outside the box from within the box." -The Ride

Psychological examples from science and mathematics

Jacques Hadamard

Jacques Hadamard, in his book *Psychology of Invention in the Mathematical Field*, uses introspection to describe mathematical thought processes. In contrast to authors who identify language and cognition, he describes his own mathematical thinking as largely wordless, often accompanied by mental images that represent the entire solution to a problem. He surveyed 100 of the leading physicists of his day (ca. 1900), asking them how they did their work. Many of the responses mirrored his own.

Hadamard described the experiences of the mathematicians / theoretical physicists Carl Friedrich Gauss, Hermann von

Helmholtz, Henri Poincaré and others as viewing entire solutions with "sudden spontaneity."

The same has been reported in literature by many others, such as Denis Brian, G. H. Hardy, Walter Heitler, B. L. van der Waerden and Harold Rugg.

To elaborate on one example, Einstein, after years of fruitless calculations, suddenly had the solution to the general theory of relativity revealed in a dream "like a giant die making an indelible impress, a huge map of the universe outlined itself in one clear vision."

Hadamard described the process as having steps (i) preparation, (ii) incubation, (iv) illumination, and (v) verification of the five-step Graham Wallas creative-process model, leaving out (iii) intimation, with the first three cited by Hadamard as also having been put forth by Helmholtz:

Marie-Louise von Franz

Marie-Louise von Franz, a colleague of the eminent psychiatrist Carl Jung, noted that in these unconscious scientific discoveries the "always recurring and important factor ... is the simultaneity with which the complete solution is intuitively perceived and which can be checked later by discursive reasoning." She attributes the solution presented "as an archetypal pattern or image." As cited by von Franz, according to Jung, "Archetypes ... manifest themselves only through their ability to *organize* images and ideas, and this is always an unconscious process which cannot be detected until afterwards."

Creativity and affect

Some theories suggest that creativity may be particularly susceptible to affective influence.

Creativity and positive affect relations

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

Positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association;

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;

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.

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).

Creativity and negative affect relations

On the other hand, some theorists have suggested that negative affect leads to greater creativity. A cornerstone of this perspective is empirical evidence of a relationship between affective illness and creativity. In a study of 1,005 prominent 20th century individuals from over 45 different professions, the University of Kentucky's Arnold Ludwig found a slight but significant correlation between depression and level of creative achievement. In addition, several systematic studies of highly creative individuals and their relatives have uncovered a higher incidence of affective disorders (primarily bipolar illness and depression) than that Creativity and affect at work

Three patterns may exist between affect and creativity at work: positive (or negative) mood, or change in mood, predictably precedes creativity; creativity predictably precedes mood; and whether affect and creativity occur simultaneously.

It was found that not only might affect precede creativity, but creative outcomes might provoke affect as well. At its simplest level, the experience of creativity is itself a work event, and like other events in the organizational context, it could evoke emotion. Qualitative research and anecdotal accounts of creative achievement in the arts and sciences suggest that creative insight is often followed by feelings of elation. For example, Albert Einstein called his 1907 general theory of relativity "the happiest thought of my life." Empirical evidence on this matter is still very tentative.

In contrast to the possible incubation effects of affective state on subsequent creativity, the affective consequences of creativity are likely to be more direct and immediate. In general, affective events provoke immediate and relatively-fleeting emotional reactions. Thus, if creative performance at work is an affective event for the individual doing the creative work, such an effect would likely be evident only in same-day data.

Another longitudinal research found several insights regarding the relations between creativity and emotion at work. First - a positive relationship between positive affect and creativity, and no evidence of a negative relationship. The more positive a person's affect on a given day, the more creative thinking they evidenced that day and the next day - even controlling for that next day's mood. There was even some evidence of an effect two days later.

In addition, the researchers found no evidence that people were more creative when they experienced both positive and negative affect on the same day. The weight of evidence supports a purely linear form of the affect-creativity relationship, at least over the range of affect and creativity covered in our study: the more positive a person's affect, the higher their creativity in a work setting.

Finally, they found four patterns of affect and creativity affect can operate as an antecedent to creativity; as a direct consequence of creativity; as an indirect consequence of creativity; and affect can occur simultaneously with creative

activity. Thus, it appears that people's feelings and creative cognitions are interwoven in several distinct ways within the complex fabric of their daily work lives.

Creativity and intelligence

There has been debate in the psychological literature about whether intelligence and creativity are part of the same process (the conjoint hypothesis) or represent distinct mental processes (the disjoint hypothesis). Evidence from attempts to look at correlations between intelligence and creativity from the 1950s onwards, by authors such as Barron, Guilford or Wallach and Kogan, regularly suggested that correlations between these concepts were low enough to justify treating them as distinct concepts.

A very popular model is what has come to be known as "the threshold hypothesis", proposed by Ellis Paul Torrance, which holds that a high degree of intelligence appears to be a necessary but not sufficient condition for high creativity. This means that, in a general sample, there will be a positive correlation between creativity and intelligence, but this correlation will not be found if only a sample of the most highly intelligent people are assessed. Research into the threshold hypothesis, however, has produced mixed results ranging from enthusiastic support to refutation and rejection.

An alternative perspective, Renzulli's three-rings hypothesis, sees giftedness as based on both intelligence and creativity. More on both the threshold hypothesis and Renzulli's work can be found in O'Hara and Sternberg.

Neurobiology of creativity

The neurobiology of creativity has been addressed 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.

Working memory and the cerebellum

Vandervert 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 are adaptively modeled by the cerebellum. The cerebellum (consisting of 100 billion neurons, which is more than the entirety of the rest of the brain is also widely known to adaptively model all bodily movement. The cerebellum's adaptive models of working memory processing are then fed back to especially frontal lobe working memory control processes where creative and innovative

thoughts arise. (Apparently, creative insight or the "aha" experience is then triggered in the temporal lobe. 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). 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, 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.

REM sleep

Creativity involves the forming of associative elements into new combinations that are useful or meet some requirement. Sleep adds this process. REM rather than NREM appears to be responsible. This has been suggested to be due to changes in cholinergic and noradrenergic neuromodulation that occurs during REM sleep. During this period of sleep, high levels of acetylcholine in the hippocampus suppress feedback from 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. 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 would add 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."

Creativity and mental health

A study by psychologist J. Philippe Rushton found creativity to correlate with intelligence and psychoticism. 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. 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.

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.

Measuring creativity

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. Most measures of creativity are dependent on the personal judgement of the tester, so a standardized measure is difficult, if not impossible, to develop.

Psychometric approach

J. P. Guilford's group, 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 developed the Torrance Tests of Creative Thinking in 1966. 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.

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. Other researchers have related creativity to the trait, *openness to experience*.

Other approaches to measurement

Genrich Altshuller in the 1950s introduced approaching creativity as an *exact science* with TRIZ and a Level-of-Invention measure.

The creativity of thousands of Japanese, expressed in terms of their problem-solving and problem-recognizing capabilities, has been measured in Japanese firms.

Howard Gruber insisted on a case-study approach that expresses the existential and unique quality of the creator. Creativity to Gruber was the product of purposeful work and this work could be described only as a confluence of forces in the specifics of the case.

Creativity in various contexts

Creativity has been studied from a variety of perspectives and is important in numerous contexts. Most of these approaches are undisciplinary, and it is therefore difficult to form a coherent overall view. The following sections examine some of the areas in which creativity is seen as being important.

Creativity Profiles

Creativity comes in different forms. There is kind to produce growth, innovation, speed, etc. There are four "Creativity Profiles" that can help achieve such goals.

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

(ii) *Imagine* (Breakthrough Ideas)

(iii) *Improve* (Incremental Adjustments)

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

Creativity in diverse cultures

Francois Jullien in 'Process and Creation, 1989' is inviting us to look at that concept from a Chinese cultural point of view. Fangqi Xu has reported creativity courses in a range of countries.

Todd Lubart has studied extensively the cultural aspects of creativity and innovation.

Creativity in art and literature

Most people associate creativity with the fields of art and literature. In these fields, *originality* is considered to be a sufficient condition for creativity, unlike other fields where both *originality* and *appropriateness* are necessary.

Within the different modes of artistic expression, one can postulate a continuum extending from "interpretation" to "innovation". Established artistic movements and genres pull practitioners to the "interpretation" end of the scale, whereas original thinkers strive towards the "innovation" pole. Note that we conventionally expect some "creative" people (dancers, actors, orchestral members, etc.) to perform (interpret) while allowing others (writers, painters, composers, etc.) more freedom to express the new and the different.

Contrast alternative theories, for example:

- artistic inspiration, which provides the transmission of visions from divine sources such as the Muses; a taste of the Divine. Compare with invention.
- artistic evolution, which stresses obeying established ("classical") rules and imitating or appropriating to produce subtly different but unshockingly understandable work. Compare with crafts.
- artistic conversation, as in Surrealism, which stresses the depth of communication when the creative product is the language.

In the art practice and theory of Davor Dzalto, human creativity is taken as a basic feature of both the personal existence of human being and art production. For this thinker, creativity is a basic cultural and anthropological category, since it enables human manifestation in the world as a "real presence" in contrast to the progressive "virtualisation" of the world.

Creative industries and services

Today, creativity forms the core activity of a growing section of the global economy — the so-called “creative industries” — capitalistically generating (generally non-tangible) wealth through the creation and exploitation of intellectual property or through the provision of creative services. The Creative Industries Mapping Document 2001 provides an overview of the creative industries in the UK. The creative professional workforce is becoming a more integral part of industrialized nations’ economies.

Creative professions include writing, art, design, theater, television, radio, motion pictures, related crafts, as well as marketing, strategy, some aspects of scientific research and development, product development, some types of teaching and curriculum design, and more. Since many creative professionals (actors and writers, for example) are also employed in secondary professions, estimates of creative professionals are often inaccurate. By some estimates, approximately 10 million US workers are creative professionals; depending upon the depth and breadth of the definition, this estimate may be double.

Creativity in other professions

Creativity is also seen as being increasingly important in a variety of other professions. Architecture and industrial design are the fields most often associated with creativity, and more generally the fields of design and design research. These fields explicitly value creativity, and journals such as *Design Studies* have published many studies on creativity and creative problem solving.

Fields such as science and engineering have, by contrast, experienced a less explicit (but arguably no less important) relation to creativity. Simonton shows how some of the major scientific advances of the 20th century can be attributed to the creativity of individuals. This ability will also be seen as increasingly important for engineers in years to come.

Accounting has also been associated with creativity with the popular euphemism *creative accounting*. Although this term

often implies unethical practices, Amabile has suggested that even this profession can benefit from the (ethical) application of creative thinking.

Creativity in organizations

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

- Expertise (technical, procedural & 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 talent;
- 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. In particular, he emphasized the role that tacit knowledge has to play in the creative process.

In business originality is not enough. Idea must also be appropriate - useful and actionable.

Economic views of creativity

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.

Creativity is also seen by economists such as Paul Romer 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.

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.

Fostering creativity

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).

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

- Establishing purpose and intention

- Building basic skills

- Encouraging acquisitions of domain-specific knowledge

- Stimulating and rewarding curiosity and exploration

- Building motivation, especially internal motivation
- Encouraging confidence and a willingness to take risks
- Focusing on mastery and self-competition
- Promoting supportable beliefs about creativity
- Providing opportunities for choice and discovery
- Developing self-management (metacognitive skills)

Teaching techniques and strategies for facilitating creative performance

Providing balance

Some see the conventional system of schooling as "stifling" of creativity and attempt (particularly in the pre-school/ kindergarten and early school years) to provide a creativity-friendly, rich, imagination-fostering environment for young children. Compare Waldorf School.

A growing number of psychologists are supporting the idea that there are methods of increasing the creativity of an individual. Several different researchers have proposed approaches to prop up this idea, ranging from psychological-cognitive, such as:

- Osborn-Parnes Creative Problem Solving Process
- Synectics ;
- Inventium and science-based creative thinking
- Purdue Creative Thinking Program; and
- lateral thinking (courtesy of Edward de Bono), to the highly-structured, such as:
 - TRIZ (the Theory of Inventive Problem-Solving);
 - ARIZ (the Algorithm of Inventive Problem-Solving), both developed by the Russian scientist Genrich Altshuller; and
- Computer-Aided Morphological analysis

Understanding and enhancing the creative process with new technologies

A simple but accurate review on this new Human-Computer Interactions (HCI) angle for promoting creativity has been written by Todd Lubart, an invitation full of creative ideas to develop further this new field.

Groupware and other Computer Supported Collaborative Work (CSCW) platforms are now the stage of Network Creativity on the web or on other private networks. These tools have made more obvious the existence of a more connective, cooperative and collective nature of creativity rather than the prevailing individual one. Creativity Research on Global Virtual Teams is showing that the creative process is affected by the national identities, cognitive and conative profiles, anonymous interactions at times and many other factors affecting the teams members, depending on the early or later stages of the cooperative creative process. They are also showing how NGO's cross-cultural virtual team's innovation in Africa would also benefit from the pooling of best global practices online. Such tools enhancing cooperative creativity may have a great impact on society and as such should be tested while they are built following the Motto : "Build the Camera while shooting the film". Some European FP7 scientific programs like Paradiso are answering a need for advanced experimentally-driven research including large scale experimentation test-beds to discover the technical, societal, and economic implications of such groupware and collaborative tools to the Internet.

On the other hand, Creativity research may one day be pooled with a computable metalanguage like IEML from the University of Ottawa Collective Intelligence Chair, Pierre Levy. It might be a good tool to provide an interdisciplinary definition and a rather unified theory of creativity. The creative processes being highly fuzzy, the programming of cooperative tools for creativity and innovation should be adaptive and flexible. Empirical Modelling seems to be a good choice for Humanities Computing.

If all the activity of the universe could be traced with appropriate captors, it is likely that one could see the creative nature of the universe to which humans are active contributors. After the web of documents, the Web of Things might shed some light on such a universal creative phenomenon which should not be restricted to humans. In order to trace and enhance cooperative and collective creativity, Metis Reflexive Global Virtual Team has worked for the last few years on the development of a Trace Composer at the intersection of personal experience and social knowledge.

Metis Reflexive Team has also identified a paradigm for the study of creativity to bridge European theory of "useless" and non instrumentalized creativity, North American more pragmatic creativity and Chinese culture stressing more creativity as a holistic process of continuity rather than radical change and originality. This paradigm is mostly based on the work of the German philosopher Hans Joas, one that emphasizes the creative character of human action. This model allows also for a more comprehensive theory of action. Joas elaborates some implications of his model for theories of social movements and social change. The connexion between concepts like creation, innovation, production and expression is facilitated by the creativity of action as a metaphore but also as scientific concept.

The Creativity and Cognition conference series, sponsored by the ACM and running since 1993, has been an important venue for publishing research on the intersection between technology and creativity. The conference now runs biannually, next taking place in 2009.

Social attitudes to creativity

Although the benefits of creativity to society as a whole have been noted, social attitudes about this topic remain divided. The wealth of literature regarding the development of creativity and the profusion of creativity techniques indicate wide acceptance, at least among academics, that creativity is desirable.

There is, however, a dark side to creativity, in that it represents a *"quest for a radical autonomy apart from the constraints of social responsibility"*. In other words, by encouraging creativity we are encouraging a departure from society's existing norms and values. Expectation of conformity runs contrary to the spirit of creativity. Sir Ken Robinson argues that the current education system is *"educating people out of their creativity"* .

Nevertheless, employers are increasingly valuing creative skills. A report by the Business Council of Australia, for example, has called for a higher level of creativity in graduates. The ability to *"think outside the box"* is highly sought after. However, the above-mentioned paradox may well imply that firms pay lip service to thinking outside the box while maintaining traditional, hierarchical organization structures in which individual creativity is not rewarded.

Leonardo da Vinci is well known for his creative works.

Creativity has been associated with right or forehead brain activity or even specifically with lateral thinking.



IDEA

In the most narrow sense, an **idea** is just whatever is before the mind when one thinks. Very often, ideas are construed as representational images; i.e. images of some object. In other contexts, ideas are taken to be concepts, although abstract concepts do not necessarily appear as images. Many philosophers consider ideas to be a fundamental ontological category of being.

The capacity to create and understand the meaning of ideas is considered to be an essential and defining feature of human beings.

In a popular sense, an idea arises in a reflex, spontaneous manner, even without thinking or serious reflection, for example, when we talk about the *idea* of a person or a place.

One view on the nature of ideas is that there exist some ideas (called *innate ideas*) which are so general and abstract, that they could not have arisen as a representation of any object of our perception, but rather were, in some sense, always in the mind before we could learn them. These are distinguished from *adventitious ideas* which are images or concepts which are accompanied by the judgment that they are caused by some object outside of the mind.

Another view holds that we only discover ideas in the same way that we discover the real world, from personal experiences. The view that humans acquire all or almost all their behavioral traits from nurture (life experiences) is known as *tabula rasa* ("blank slate"). Most of the confusions in the way of ideas arise at least in part from the use of the term "idea" to cover both the representation percept and the object of conceptual thought.

This can be illustrated in terms of the doctrines of innate ideas, "concrete ideas versus abstract ideas", as well as "simple ideas versus complex ideas".

Philosophy

Plato

Plato was one of the earliest philosopher to provide a detailed discussion of ideas. He considered the concept of idea in the realm of metaphysics and its implications for epistemology. He asserted that there is realm of Forms or Ideas, which exist independently of anyone who may have thought of these ideas. Material things are then imperfect and transient reflections or instantiations of the perfect and unchanging ideas. From this it follows that these Ideas are the principal reality (see also idealism). In contrast to the individual objects of sense experience, which undergo constant change and flux, Plato held that ideas are perfect, eternal, and immutable. Consequently, Plato considered that knowledge of material things is not really knowledge; real knowledge can only be had of unchanging ideas.

René Descartes

Descartes often wrote of the meaning of *idea* as an image or representation, often but not necessarily "in the mind", which was well known in the vernacular. In spite of the fact that Descartes is usually credited with the invention of the non-Platonic use of the term, we find him at first following this vernacular use.^b In his *Meditations on First Philosophy* he says, "Some of my thoughts are like images of things, and it is to these alone that the name 'idea' properly belongs." He sometimes maintained that ideas were innate and uses of the term *idea* diverge from the original primary scholastic use. He provides multiple non-equivalent definitions of the term, uses it to refer to as many as six distinct kinds of entities, and divides *ideas* inconsistently into various genetic categories. For him knowledge took the form of ideas and philosophical investigation is the deep consideration of these ideas. Many times however his thoughts of knowledge and ideas were like those of Plotinus and

the Neoplatonists. In Neoplatonism, the Intelligence (*Nous*) is the true first principle — the determinate, referential 'foundation' (*arkhe*) — of all existents; for it is not a self-sufficient entity like the One, but rather possesses the ability or capacity to contemplate both the One, as its prior, as well as its own thoughts, which Plotinus identifies with the Platonic Ideas or Forms (*eide*). A non-philosophical definition of *Nous* is **good sense** (a.k.a. "common sense"). Descartes is quoted as saying, "Of all things, **good sense** is the most fairly distributed: everyone thinks he is so well supplied with it that even those who are the hardest to satisfy in every other respect never desire more of it than they already have."q:René Descartes

John Locke

In striking contrast to Plato's use of *idea* is that of John Locke. In his Introduction to *An Essay Concerning Human Understanding*, Locke defines **idea** as "It being that term which, I think, serves best to stand for whatsoever is the object of the understanding when a man thinks, I have used it to express whatever is meant by phantasm, notion, species, or whatever it is which the mind can be employed about in thinking ; and I could not avoid frequently using it." He said he regarded the book necessary to examine our own abilities and see what objects our understandings were, or were not, fitted to deal with. In his philosophy other outstanding figures followed in his footsteps - Hume and Kant in the 18th century, Arthur Schopenhauer in the 19th century, and Bertrand Russell, Ludwig Wittgenstein, and Karl Popper in the 20th century. Locke always believed in **good sense** - not pushing things to extremes and on taking fully into account the plain facts of the matter. He considered his common sense ideas "good-tempered, moderate, and down-to-earth."

David Hume

Hume differs from Locke by limiting "idea" to the more or less vague mental reconstructions of perceptions, the perceptual process being described as an "impression." Hume shared with Locke the basic empiricist premise that it is only from life

experiences (whether their own or others') that humans' knowledge of the existence of anything outside of themselves can be ultimately derived, that they shall carry on doing what they are prompted to do by their emotional drives of varying kinds. In choosing the means to those ends, they shall follow their accustomed associations of ideas.^d Hume has contended and defended the notion that "reason alone is merely the 'slave of the passions'"

Immanuel Kant

Immanuel Kant defines an "idea" as opposed to a "concept". "Regulator ideas" are ideals that one must tend towards, but by definition may not be completely realized. Liberty, according to Kant, is an idea. The autonomy of the rational and universal subject is opposed to the determinism of the empirical subject. Kant felt that it is precisely in knowing its limits that philosophy exists. The business of philosophy he thought was not to give rules, but to analyze the private judgements of good common sense.^e

Rudolf Steiner

Whereas Kant declares limits to knowledge ("we can never know the thing in itself"), in his epistemological work, Rudolf Steiner sees ideas as "objects of experience" which the mind apprehends, much as the eye apprehends light. In *Goethean Science* (1883), he declares, "Thinking... is no more and no less an organ of perception than the eye or ear. Just as the eye perceives colors and the ear sounds, so thinking perceives ideas." He holds this to be the premise upon which Goethe made his natural-scientific observations.

Wilhelm Wundt

Wundt widens the term from Kant's usage to include *conscious representation of some object or process of the external world*. In so doing, he includes not only ideas of memory and imagination, but also perceptual processes, whereas other psychologists confine the term to the first two groups. One of Wundt's main concerns was to investigate

conscious processes in their own context by experiment and introspection. He regarded both of these as *exact methods*, interrelated in that experimentation created optimal conditions for introspection. Where the experimental method failed, he turned to other *objectively valuable aids*, specifically to those *products of cultural communal life which lead one to infer particular mental motives*. Outstanding among these are *speech, myth, and social custom*. Wundt designed the basic mental activity *apperception* - a unifying function which should be understood as an activity of the will. Many aspects of his empirical physiological psychology are used today. One is his principles of mutually enhanced contrasts and of assimilation and dissimilation (i.e. in color and form perception and his advocacy of *objective methods of expression and of recording results*, especially in language. Another is the principle of heterogony of ends - that multiply motivated acts lead to unintended side effects which in turn become motives for new actions.

Charles Sanders Peirce

C. S. Peirce published the first full statement of pragmatism in his important works "How to Make Our Ideas Clear" (1878) and "The Fixation of Belief" (1877). In "How to Make Our Ideas Clear" he proposed that a *clear idea* (in his study he uses *concept* and *idea* as synonymic) is defined as one, when it is apprehended such as it will be recognized wherever it is met, and no other will be mistaken for it. If it fails of this clearness, it is said to be obscure. He argued that to understand an idea clearly we should ask ourselves what difference its application would make to our evaluation of a proposed solution to the problem at hand. Pragmatism (a term he appropriated for use in this context), he defended, was a method for ascertaining the meaning of terms (as a theory of meaning). The originality of his ideas is in their rejection of what was accepted as a view and understanding of knowledge by scientists for some 250 years, i.e. that, he pointed, knowledge was an impersonal fact. Peirce contended that we acquire knowledge as *participants*, not as *spectators*. He felt "the real" is which, sooner or later,

information acquired through ideas and knowledge with the application of logical reasoning would finally result in. He also published many papers on logic in relation to *ideas*.

G. F. Stout and J. M. Baldwin

G. F. Stout and J. M. Baldwin, in the *Dictionary of Philosophy and Psychology*, define "idea" as "the reproduction with a more or less adequate image, of an object not actually present to the senses." They point out that an idea and a perception are by various authorities contrasted in various ways. "Difference in degree of intensity", "comparative absence of bodily movement on the part of the subject", "comparative dependence on mental activity", are suggested by psychologists as characteristic of an idea as compared with a perception.

It should be observed that an idea, in the narrower and generally accepted sense of a mental reproduction, is frequently composite. That is, as in the example given above of the idea of chair, a great many objects, differing materially in detail, all call a single idea. When a man, for example, has obtained an idea of chairs in general by comparison with which he can say "This is a chair, that is a stool", he has what is known as an "abstract idea" distinct from the reproduction in his mind of any particular chair (see abstraction). Furthermore a complex idea may not have any corresponding physical object, though its particular constituent elements may severally be the reproductions of actual perceptions. Thus the idea of a centaur is a complex mental picture composed of the ideas of man and horse, that of a mermaid of a woman and a fish.

In anthropology and the social sciences

Diffusion studies explore the spread of ideas from culture to culture. Some anthropological theories hold that all cultures imitate ideas from one or a few original cultures, the Adam of the Bible or several cultural circles that overlap. Evolutionary diffusion theory holds that cultures are influenced by one another, but that similar ideas can be developed in isolation.

In mid-20th century, social scientists began to study how and why ideas spread from one person or culture to another.

Everett Rogers pioneered diffusion of innovations studies, using research to prove factors in adoption and profiles of adopters of ideas. In 1976, in his book *The Selfish Gene*, Richard Dawkins suggested applying biological evolutionary theories to spread of ideas. He coined the term 'meme' to describe an abstract unit of selection, equivalent to the gene in evolutionary biology.

Validity of ideas

In the objective worth of our *ideas* there remains the problem of the validity. As all cognition is by *ideas*, it is obvious that the question of the validity of *our ideas* in this broad sense is that of the truth of our knowledge as a whole. Otherwise to dispute this is to take up the position of skepticism. This has often been pointed out as a means intellectual suicide. Any chain of reasoning (common sense) by which it is attempted to demonstrate the falsity of our *ideas* has to employ the very concept of *ideas* itself. Then insofar as it demands assent to the conclusion, it implies belief in the validity of all the *ideas* employed in the premises of the argument.

To assent the fundamental mathematical and logical axioms, including that of the principle of contradiction, implies admission of the truth of the *ideas* expressed in these principles. With respect to the objective worth of ideas, as involved in perception generally, the question raised is that of the existence of an independent material world comprising other human beings. The idealism of David Hume and John Stuart Mill would lead logically to solipsism (the denial of any others besides ourselves). The main foundation of all idealism and skepticism is the assumption (explicit or implicit), that the mind can never know what is outside of itself. This is to say that an *idea* as a cognition can never go outside of itself. This can be further expressed as we can never reach to and mentally apprehend anything outside of anything of what is actually a present state of our own consciousness.

First, this is based on a prior assumption for which no real proof is or can be given

Second, it is not only not self-evident, but directly contrary to what our mind affirms to be our direct intellectual experience.

What is possible for a human mind to apprehend cannot be laid down beforehand. It must be ascertained by careful observations and by study of the process of cognition. This postulates that the mind cannot apprehend or cognize any reality existing outside of itself and is not only a self-evident proposition, it is directly contrary to what such observation and the testimony of mankind affirms to be our actual intellectual experience.

John Stuart Mill and most extreme idealists have to admit the validity of memory and expectation. This is to say that in every act of memory or expectation which refers to any experience outside the present instant, our cognition is transcending the present modifications of the mind and judging about reality beyond and distinct from the present states of consciousness. Considering the question as specially concerned with universal concepts, only the theory of moderate realism adopted by Aristotle and Saint Thomas can claim to guarantee objective value to our ideas. According to the nominalist and conceptualist theories there is no true correlate in *rerum naturâ* corresponding to the universal term.

Mathematics, astronomy, physics, chemistry, and the rest claim that their universal propositions are true and deal with realities. It is involved in the very notion of science that the physical laws formulated by the mind do mirror the working of agents in the external universe. The general terms of these sciences and the ideas which they signify have objective correlatives in the common natures and essences of the objects with which these sciences deal. Otherwise these general statements are unreal and each science is nothing more than a consistently arranged system of barren propositions deduced from empty arbitrary definitions. These postulates then have no more genuine objective value than any other coherently devised scheme of artificial symbols standing for imaginary beings. However the fruitfulness of science and the constant

verifications of its predictions are incompatible with such a hypothesis.

Relationship between ideas and patents .

"It has been pretended by some, (and in England especially,) that inventors have a natural and exclusive right to their inventions, and not merely for their own lives, but inheritable to their heirs. But while it is a moot question whether the origin of any kind of property is derived from nature at all, it would be singular to admit a natural and even an hereditary right to inventors. It is agreed by those who have seriously considered the subject, that no individual has, of natural right, a separate property in an acre of land, for instance.

By a universal law, indeed, whatever, whether fixed or movable, belongs to all men equally and in common, is the property for the moment of him who occupies it, but when he relinquishes the occupation, the property goes with it. Stable ownership is the gift of social law, and is given late in the progress of society. It would be curious then, if an idea, the fugitive fermentation of an individual brain, could, of natural right, be claimed in exclusive and stable property.

If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me.

That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density in any point, and like the air in which we breathe, move, and have

our physical being, incapable of confinement or exclusive appropriation. Inventions then cannot, in nature, be a subject of property.

Society may give an exclusive right to the profits arising from them, as an encouragement to men to pursue ideas which may produce utility, but this may or may not be done, according to the will and convenience of the society, without claim or complaint from anybody. Accordingly, it is a fact, as far as I am informed, that England was, until we copied her, the only country on earth which ever, by a general law, gave a legal right to the exclusive use of an idea. In some other countries it is sometimes done, in a great case, and by a special and personal act, but, generally speaking, other nations have thought that these monopolies produce more embarrassment than advantage to society; and it may be observed that the nations which refuse monopolies of invention, are as fruitful as England in new and useful devices."

To protect the cause of invention and innovation, the legal constructions of Copyrights and Patents was established. Patent law regulates various aspects related to the functional manifestation of inventions based on new ideas or an incremental improvements to existing ones. Thus, patents have a direct relationship to ideas.

Relationship between ideas and copyrights

In some cases, authors can be granted limited legal monopolies on the manner in which certain works are expressed. This is known colloquially as copyright, although the term intellectual property is used mistakenly in place of *copyright*. Copyright law regulating the aforementioned monopolies generally does not cover the actual ideas. The law does not bestow the legal status of property upon ideas per se. Instead, laws purport to regulate events related to the usage, copying, production, sale and other forms of exploitation of the fundamental expression of a work, that may or may not carry ideas. Copyright law is fundamentally different to patent law in this respect: patents do grant monopolies on ideas .

A copyright is meant to regulate some aspects of the usage of expressions of a work, **not an idea**. Thus, copyrights have a negative relationship to ideas.

Work means a tangible medium of expression. It may be an original or derivative work of art, be it literary, dramatic, musical recitation, artistic, related to sound recording, etc. In (at least) countries adhering to the Berne Convention, copyright automatically starts covering the work upon the original creation and fixation thereof, without any extra steps. While creation usually involves an idea, the idea in itself does not suffice for the purposes of claiming copyright.

Relationship of ideas to confidentiality agreements

Confidentiality and nondisclosure agreements are legal instruments that assist corporations and individuals in keeping ideas from escaping to the general public. Generally, these instruments are covered by contract law.



THOUGHT

Thought and **thinking** are mental forms and processes, respectively ("thought" is both). Thinking allows beings to model the world and to represent it according to their objectives, plans, ends and desires. Words referring to similar concepts and processes include cognition, sentience, consciousness, ideas, and imagination.

Definition

Representative reactions towards stimuli from internal chemical reactions or external environmental factors (this definition, unfortunately, precludes the notion that anything inorganic could ever be made to 'think': An idea contested by such computer scientists as Alan Turing (see Computing Machinery and Intelligence)). The word comes from Old English . þoht, geþoht, from stem of þencan "to conceive of in the mind, consider"

In common language, the word thinking covers numerous diverse psychological activities. It is sometimes a synonym for "tending to believe," especially with less than full confidence ("I think that it will rain, but I am not sure"). At other times it denotes the degree of attentiveness ("I did it without thinking") or whatever is in consciousness, especially if it refers to something outside the immediate environment ("It made me think of my grandmother").

Biology

A **neuron** (also known as a **neurone** or **nerve cell**) is an excitable cell in the nervous system that processes and transmits information by electrochemical signalling. Neurons are the core components of the brain, the vertebrate spinal cord, the

invertebrate ventral nerve cord, and the peripheral nerves. A number of specialized types of neurons exist: sensory neurons respond to touch, sound, light and numerous other stimuli affecting cells of the sensory organs that then send signals to the spinal cord and brain. Motor neurons receive signals from the brain and spinal cord and cause muscle contractions and affect glands. Interneurons connect neurons to other neurons within the brain and spinal cord. Neurons respond to stimuli, and communicate the presence of stimuli to the central nervous system, which processes that information and sends responses to other parts of the body for action. Neurons do not go through mitosis, and usually cannot be replaced after being destroyed, although astrocytes have been observed to turn into neurons as they are sometimes pluripotent.

Psychology

Psychologists have concentrated on thinking as an intellectual exertion aimed at finding an answer to a question or the solution of a practical problem.

Cognitive psychology is a branch of psychology that investigates internal mental processes such as problem solving, memory, and language.

The school of thought arising from this approach is known as cognitivism which is interested in how people mentally represent information processing. It had its foundations in the Gestalt psychology of Max Wertheimer, Wolfgang Köhler, and Kurt Koffka, and in the work of Jean Piaget, who provided a theory of stages/phases that describe children's cognitive development. Cognitive psychologists use psychophysical and experimental approaches to understand, diagnose, and solve problems, concerning themselves with the mental processes which mediate between stimulus and response. Cognitive theory contends that solutions to problems take the form of algorithms—rules that are not necessarily understood but promise a solution, or heuristics—rules that are understood but that do not always guarantee solutions. Cognitive science differs from cognitive psychology in that algorithms that are intended to

simulate human behavior are implemented or implementable on a computer. In other instances, solutions may be found through insight, a sudden awareness of relationships.

Id, ego, and super-ego are the three parts of the "psychic apparatus" defined in Sigmund Freud's structural model of the psyche; they are the three theoretical constructs in terms of whose activity and interaction mental life is described. According to this model, the uncoordinated instinctual trends are the "id"; the organized realistic part of the psyche is the "ego," and the critical and moralizing function the "super-ego."

The unconscious was considered by Freud throughout the evolution of his psychoanalytic theory a sentient force of will influenced by human desire and yet operating well below the perceptual conscious mind. For Freud, the unconscious is the storehouse of instinctual desires, needs, and psychic drives. While past thoughts and reminiscences may be concealed from immediate consciousness, they direct the thoughts and feelings of the individual from the realm of the unconscious.

For psychoanalysis, the unconscious does not include all that is not conscious, rather only what is actively repressed from conscious thought or what the person is averse to knowing consciously. In a sense this view places the self in relationship to their unconscious as an adversary, warring with itself to keep what is unconscious hidden. If a person feels pain, all he can think of is alleviating the pain. Any of his desires, to get rid of pain or enjoy something, command the mind what to do. For Freud, the unconscious was a repository for socially unacceptable ideas, wishes or desires, traumatic memories, and painful emotions put out of mind by the mechanism of psychological repression. However, the contents did not necessarily have to be solely negative. In the psychoanalytic view, the unconscious is a force that can only be recognized by its effects — it expresses itself in the symptom.

In developmental psychology, Jean Piaget was a pioneer in the study of the development of thought from birth to maturity. In his theory of cognitive development, thought is based on

actions on the environment. That is, Piaget suggests that the environment is understood through assimilations of objects in the available schemes of action and these accommodate to the objects to the extent that the available schemes fall short of the demands. As a result of this interplay between assimilation and accommodation, thought develops through a sequence of stages that differ qualitatively from each other in mode of representation and complexity of inference and understanding. That is, thought evolves from being based on perceptions and actions at the sensorimotor stage in the first two years of life to internal representations in early childhood. Subsequently, representations are gradually organized into logical structures which first operate on the concrete properties of the reality, in the stage of concrete operations, and then operate on abstract principles that organize concrete properties, in the stage of formal operations. In recent years, the Piagetian conception of thought was integrated with information processing conceptions. Thus, thought is considered as the result of information processing mechanisms that are responsible for the representation and processing of information. In this conception, speed of processing, cognitive control, and working memory are the main functions underlying thought. In the neo-Piagetian theories of cognitive development, the development of thought is considered to come from increasing speed of processing, enhanced cognitive control, and increasing working memory.

Sociology

Social psychology is the study of how people and groups interact. Scholars in this interdisciplinary area are typically either psychologists or sociologists, though all social psychologists employ both the individual and the group as their units of analysis.

Despite their similarity, psychological and sociological researchers tend to differ in their goals, approaches, methods, and terminology. They also favor separate academic journals and professional societies. The greatest period of collaboration between sociologists and psychologists was during the years

immediately following World War II. Although there has been increasing isolation and specialization in recent years, some degree of overlap and influence remains between the two disciplines.

The **Collective unconscious**, sometimes known as **collective subconscious**, is a term of analytical psychology, coined by Carl Jung. It is a part of the unconscious mind, shared by a society, a people, or all humanity, in an interconnected system that is the product of all common experiences and contains such concepts as science, religion, and morality. While Freud did not distinguish between an "individual psychology" and a "collective psychology", Jung distinguished the collective unconscious from the personal subconscious particular to each human being. The collective unconscious is also known as "a reservoir of the experiences of our species."

In the "Definitions" chapter of Jung's seminal work *Psychological Types*, under the definition of "collective" Jung references *representations collectives*, a term coined by Lucien Lévy-Bruhl in his 1910 book *How Natives Think*. Jung says this is what he describes as the collective unconscious. Freud, on the other hand, did not accept the idea of a collective unconscious.

Philosophy

Philosophy of mind is a branch of modern analytic philosophy that studies the nature of the mind, mental events, mental functions, mental properties, consciousness and their relationship to the physical body, particularly the brain. The mind-body problem, i.e. the relationship of the mind to the body, is commonly seen as the central issue in philosophy of mind, although there are other issues concerning the nature of the mind that do not involve its relation to the physical body.

The mind-body problem

The mind-body problem concerns the explanation of the relationship that exists between minds, or mental processes, and bodily states or processes. The main aim of philosophers working in this area is to determine the nature of the mind and

mental states/processes, and how—or even if—minds are affected by and can affect the body.

Our perceptual experiences depend on stimuli which arrive at our various sensory organs from the external world and these stimuli cause changes in our mental states, ultimately causing us to feel a sensation, which may be pleasant or unpleasant. Someone's desire for a slice of pizza, for example, will tend to cause that person to move his or her body in a specific manner and in a specific direction to obtain what he or she wants. The question, then, is how it can be possible for conscious experiences to arise out of a lump of gray matter endowed with nothing but electrochemical properties. A related problem is to explain how someone's propositional attitudes (e.g. beliefs and desires) can cause that individual's neurons to fire and his muscles to contract in exactly the correct manner. These comprise some of the puzzles that have confronted epistemologists and philosophers of mind from at least the time of René Descartes.

PHILOSOPHY OF MIND

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Dualism and monism are the two major schools of thought that attempt to resolve the mind-body problem. Dualism can be traced back to Plato Aristotle and the Sankhya and Yoga schools of Hindu philosophy, but it was most precisely formulated by René Descartes in the 17th century. Substance Dualists argue that the mind is an independently existing substance, whereas Property Dualists maintain that the mind is a group of independent properties that emerge from and cannot be reduced to the brain, but that it is not a distinct substance.

Monism is the position that mind and body are not ontologically distinct kinds of entities. This view was first advocated in Western philosophy by Parmenides in the 5th century BC and was later espoused by the 17th century rationalist Baruch Spinoza. Physicalists argue that only the entities postulated by physical theory exist, and that the mind will eventually be explained in terms of these entities as physical theory continues to evolve. Idealists maintain that the mind is all that exists and that the external world is either mental itself, or an illusion created by the mind. Neutral monists adhere to the position that there is some other, neutral substance, and that both matter and mind are properties of this unknown

substance. The most common monisms in the 20th and 21st centuries have all been variations of physicalism; these positions include behaviorism, the type identity theory, anomalous monism and functionalism

Most modern philosophers of mind adopt either a reductive or non-reductive physicalist position, maintaining in their different ways that the mind is not something separate from the body. These approaches have been particularly influential in the sciences, especially in the fields of sociobiology, computer science, evolutionary psychology and the various neurosciences. Other philosophers, however, adopt a non-physicalist position which challenges the notion that the mind is a purely physical construct. Reductive physicalists assert that all mental states and properties will eventually be explained by scientific accounts of physiological processes and states. Non-reductive physicalists argue that although the brain is all there is to the mind, the predicates and vocabulary used in mental descriptions and explanations are indispensable, and cannot be reduced to the language and lower-level explanations of physical science. Continued neuroscientific progress has helped to clarify some of these issues. However, they are far from having been resolved, and modern philosophers of mind continue to ask how the subjective qualities and the intentionality (aboutness) of mental states and properties can be explained in naturalistic terms.

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Dualist solutions to the mind-body problem

Dualism is a set of views about the relationship between mind and matter (or body). It begins with the claim that mental phenomena are, in some respects, non-physical. One of the earliest known formulations of mind-body dualism was expressed in the eastern Sankhya and Yoga schools of Hindu philosophy (c. 650 BCE), which divided the world into *purusha* (mind/spirit) and *prakriti* (material substance). Specifically, the Yoga Sutra of Patanjali presents an analytical approach to the nature of the mind.

In Western Philosophy, the earliest discussions of dualist ideas are in the writings of Plato and Aristotle. Each of these maintained, but for different reasons, that humans' "intelligence" (a faculty of the mind or soul) could not be identified with, or explained in terms of, their physical body. However, the best-known version of dualism is due to René Descartes (1641), and holds that the mind is a non-extended, non-physical substance, a "*res cogitans*". Descartes was the first to clearly identify the mind with consciousness and self-awareness, and to distinguish this from the brain, which was the seat of intelligence. He was therefore the first to formulate the mind-body problem in the form in which it still exists today.

Arguments for dualism

The most frequently used argument in favour of dualism is that it appeals to the common-sense intuition that conscious

experience is distinct from inanimate matter. If asked what the mind is, the average person would usually respond by identifying it with their self, their personality, their soul, or some other such entity. They would almost certainly deny that the mind simply is the brain, or vice-versa, finding the idea that there is just one ontological entity at play to be too mechanistic, or simply unintelligible. Many modern philosophers of mind think that these intuitions are misleading and that we should use our critical faculties, along with empirical evidence from the sciences, to examine these assumptions to determine whether there is any real basis to them.

Another important argument in favor of dualism is that the mental and the physical seem to have quite different, and perhaps irreconcilable, properties. Mental events have a subjective quality, whereas physical events do not. So, for example, one can reasonably ask what a burnt finger feels like, or what a blue sky looks like, or what nice music sounds like to a person. But it is meaningless, or at least odd, to ask what a surge in the uptake of glutamate in the dorsolateral portion of the hippocampus feels like.

The Argument from Reason holds that if, as monism implies, all of our thoughts are the effects of physical causes, then we have no reason for assuming that they are also the consequent of a reasonable ground. Knowledge, however, is apprehended by reasoning from ground to consequent. Therefore, if monism is correct, there would be no way of knowing this—or anything else not the direct result of a physical cause—and we could not even suppose it, except by a fluke.

Philosophers of mind call the subjective aspects of mental events 'qualia' or 'raw feels'. There is something *that it is like* to feel pain, to see a familiar shade of blue, and so on. There are qualia involved in these mental events that seem particularly difficult to reduce to anything physical.

If consciousness (the mind) can exist independently of physical reality (the brain), one must explain how physical memories are created concerning consciousness. Dualism must

therefore explain how consciousness affects physical reality. One possible explanation is that of a miracle, proposed by Arnold Geulincx and Nicholas Malebranche, where all mind-body interactions require the direct intervention of God. Another possible explanation has been proposed by C. S. Lewis. Although at the time Lewis wrote *Miracles*, Quantum Mechanics (and physical indeterminism) was only in the initial stages of acceptance, he stated the logical possibility that if the physical world was proved to be indeterministic this would provide an entry (interaction) point into the traditionally viewed closed system, where a scientifically described physically probable/improbable event could be philosophically described as an action of a non physical entity on physical reality.

The zombie argument is based on a thought experiment proposed by David Chalmers. The basic idea is that one can imagine, and therefore conceive the existence of, one's body without any conscious states being associated with it. Chalmers' argument is that it seems very plausible that such a being could exist because all that is needed is that all and only the things that the physical sciences describe about a zombie must be true of it. Since none of the concepts involved in these sciences make reference to consciousness or other mental phenomena, and any physical entity can be by definition described scientifically via physics, the move from conceivability to possibility is not such a large one. Others such as Dennett have argued that the notion of a philosophical zombie is an incoherent, or unlikely, concept. It has been argued under physicalism, that one must either believe that anyone including oneself might be a zombie, or that no one can be a zombie - following from the assertion that one's own conviction about being (or not being) a zombie is a product of the physical world and is therefore no different from anyone else's. This argument has been expressed by Dennett who argues that "Zombies think, they are conscious, think, they have qualia, think, they suffer pains - they are just 'wrong' (according to this lamentable tradition), in ways that neither they nor we could ever discover!"

Descartes' argument crucially depends on the premise that what Seth believes to be "clear and distinct" ideas in his mind are necessarily true. Many contemporary philosophers doubt this. For example, Joseph Agassi suggests that several scientific discoveries made since the early 20th century have undermined the idea of privileged access to one's own ideas. Freud has shown that a psychologically-trained observer can understand a person's unconscious motivations better than the person himself does. Duhem has shown that a philosopher of science can know a person's methods of discovery better than that person herself does, while Malinowski has shown that an anthropologist can know a person's customs and habits better than the person whose customs and habits they are. He also asserts that modern psychological experiments that cause people to see things that are not there provide grounds for rejecting Descartes' argument, because scientists can describe a person's perceptions better than the person herself can.

Interactionist dualism

Interactionist dualism, or simply interactionism, is the particular form of dualism first espoused by Descartes in the *Meditations*. In the 20th century, its major defenders have been Karl Popper and John Carew Eccles. It is the view that mental states, such as beliefs and desires, causally interact with physical states.

Descartes' famous argument for this position can be summarized as follows: Seth has a clear and distinct idea of his mind as a thinking thing which has no spatial extension (i.e., it cannot be measured in terms of length, weight, height, and so on). He also has a clear and distinct idea of his body as something that is spatially extended, subject to quantification and not able to think. It follows that mind and body are not identical because they have radically different properties.

At the same time, however, it is clear that Seth's mental states (desires, beliefs, etc.) have causal effects on his body and vice-versa: A child touches a hot stove (physical event) which causes pain (mental event) and makes her yell (physical event),

this in turn provokes a sense of fear and protectiveness in the caregiver (mental event), and so on.

Other forms of dualism

Psychophysical parallelism, or simply **parallelism**, is the view that mind and body, while having distinct ontological statuses, do not causally influence one another. Instead, they run along parallel paths (mind events causally interact with mind events and brain events causally interact with brain events) and only seem to influence each other. This view was most prominently defended by Gottfried Leibniz. Although Leibniz was an ontological monist who believed that only one type of substance, the monad, exists in the universe, and that everything is reducible to it, he nonetheless maintained that there was an important distinction between "the mental" and "the physical" in terms of causation. He held that God had arranged things in advance so that minds and bodies would be in harmony with each other. This is known as the doctrine of pre-established harmony.

Occasionalism is the view espoused by Nicholas Malebranche which asserts that all supposedly causal relations between physical events, or between physical and mental events, are not really causal at all. While body and mind are different substances, causes (whether mental or physical) are related to their effects by an act of God's intervention on each specific occasion.

Property dualism asserts that when matter is organized in the appropriate way (i.e. in the way that living human bodies are organized), mental properties emerge. Hence, it is a sub-branch of emergent materialism. These emergent properties have an independent ontological status and cannot be reduced to, or explained in terms of, the physical substrate from which they emerge. A form of property dualism has been espoused by David Chalmers and the concept has undergone something of a renaissance in recent years, but was already suggested in the 19th century by William James.

Epiphenomenalism is a doctrine first formulated by Thomas Henry Huxley. It consists of the view that mental phenomena are causally ineffectual. Physical events can cause other physical events and physical events can cause mental events, but mental events cannot cause anything, since they are just causally inert by-products (i.e. epiphenomena) of the physical world. This view has been defended most strongly in recent times by Frank Jackson . . .

Alternatively, it is stated that all mental states are casually reducible to physical states. Although mental properties form a separate ontological class to physical properties, and mental states (such as qualia) are not reducible to physical states, they are however casually reducible to physical states. The ontological stance towards qualia in the case of this form of non-reductive physicalism does not imply that qualia are causally inert; this is what distinguishes it from epiphenomenalism.

Monist solutions to the mind-body problem

In contrast to dualism, monism states that there are no fundamental divisions. Today, the most common forms of monism in Western philosophy are physicalist. Physicalistic monism asserts that the only existing substance is physical, in some sense of that term to be clarified by our best science. However, a variety of formulations (see below) are possible. Another form of monism, idealism, states that the only existing substance is mental. Although pure idealism, such as that of George Berkeley, is uncommon in contemporary Western philosophy, a more sophisticated variant called panpsychism, according to which mental experience and properties may be at the foundation of physical experience and properties, has been espoused by some philosophers such as William Seager.

Phenomenalism is the theory that representations (or sense data) of external objects are all that exist. Such a view was briefly adopted by Bertrand Russell and many of the logical positivists during the early 20th century. A third possibility is to accept the existence of a basic substance which is neither physical nor mental. The mental and physical would then both

be properties of this neutral substance. Such a position was adopted by Baruch Spinoza and was popularized by Ernst Mach in the 19th century. This neutral monism, as it is called, resembles *property dualism*.

Physicalistic monisms

Behaviorism

Behaviorism dominated philosophy of mind for much of the 20th century, especially the first half. In psychology, behaviorism developed as a reaction to the inadequacies of introspectionism. Introspective reports on one's own interior mental life are not subject to careful examination for accuracy and cannot be used to form predictive generalizations. Without generalizability and the possibility of third-person examination, the behaviorists argued, psychology cannot be scientific. The way out, therefore, was to eliminate the idea of an interior mental life (and hence an ontologically independent mind) altogether and focus instead on the description of observable behavior.

Parallel to these developments in psychology, a philosophical behaviorism (sometimes called logical behaviorism) was developed. This is characterized by a strong verificationism, which generally considers unverifiable statements about interior mental life senseless. For the behaviorist, mental states are not interior states on which one can make introspective reports. They are just descriptions of behavior or dispositions to behave in certain ways, made by third parties to explain and predict others' behavior.

Philosophical behaviorism, notably held by Wittgenstein, has fallen out of favor since the latter half of the 20th century, coinciding with the rise of cognitivism. Cognitivists reject behaviorism due to several perceived problems. For example, behaviorism could be said to be counter-intuitive when it maintains that someone is talking about behavior in the event that a person is experiencing a painful headache.

Identity theory

Type physicalism (or type-identity theory) was developed by John Smart and Ullin Place as a direct reaction to the failure of behaviorism. These philosophers reasoned that, if mental states are something material, but not behavioral, then mental states are probably identical to internal states of the brain. In very simplified terms: a mental state *M* is nothing other than brain state *B*. The mental state "desire for a cup of coffee" would thus be nothing more than the "firing of certain neurons in certain brain regions".

The classic Identity theory and Anomalous Monism in contrast. For the Identity theory, every token instantiation of a single mental type corresponds (as indicated by the arrows) to a physical token of a single physical type. For anomalous monism, the token-token correspondences can fall outside of the type-type correspondences. The result is token identity.

Despite its initial plausibility, the identity theory faces a strong challenge in the form of the thesis of multiple realizability, first formulated by Hilary Putnam. It is obvious that not only humans, but many different species of animal can, for example, experience pain. However, it seems highly unlikely that all of these diverse organisms with the same pain experience are in the same identical brain state. And if the latter is the case, then pain cannot be identical to a specific brain state. The identity theory is thus empirically unfounded.

On the other hand, even granted all above, it does not follow that identity theories of all types must be abandoned. According to token identity theories, the fact that a certain brain state is connected with only one mental state of a person does not have to mean that there is an absolute correlation between types of mental states and types of brain state. The type-token distinction can be illustrated by a simple example: the word "green" contains four types of letters (g, r, e, n) with two tokens (occurrences) of the letter e along with one each of the others. The idea of token identity is that only particular occurrences of mental events are identical with particular occurrences or

tokenings of physical events. Anomalous monism (see below) and most other non-reductive physicalisms are token-identity theories. Despite these problems, there is a renewed interest in the type identity theory today, primarily due to the influence of Jaegwon Kim.

Functionalism

Functionalism was formulated by Hilary Putnam and Jerry Fodor as a reaction to the inadequacies of the identity theory. Putnam and Fodor saw mental states in terms of an empirical computational theory of the mind. At about the same time or slightly after, D.M. Armstrong and David Kellogg Lewis formulated a version of functionalism which analyzed the mental concepts of folk psychology in terms of functional roles. Finally, Wittgenstein's idea of meaning as use led to a version of functionalism as a theory of meaning, further developed by Wilfrid Sellars and Gilbert Harman. Another one, psychofunctionalism, is an approach adopted by naturalistic Philosophy of Mind associated with Jerry Fodor and Zenon Pylyshyn.

What all these different varieties of functionalism share in common is the thesis that mental states are characterized by their causal relations with other mental states and with sensory inputs and behavioral outputs. That is, functionalism abstracts away from the details of the physical implementation of a mental state by characterizing it in terms of non-mental functional properties. For example, a kidney is characterized scientifically by its functional role in filtering blood and maintaining certain chemical balances. From this point of view, it does not really matter whether the kidney be made up of organic tissue, plastic nanotubes or silicon chips: it is the role that it plays and its relations to other organs that define it as a kidney.

Nonreductive physicalism

Non reductionist philosophers hold firmly to two essential convictions with regard to mind-body relations: 1) Physicalism is

true and mental states must be physical states, but 2) All reductionist proposals are unsatisfactory: mental states cannot be reduced to behavior, brain states or functional states. Hence, the question arises whether there can still be a non-reductive physicalism. Donald Davidson's anomalous monism is an attempt to formulate such a physicalism.

Davidson's uses the thesis of supervenience: mental states supervene on physical states, but are not reducible to them. "Supervenience" therefore describes a functional dependence: there can be no change in the mental without some change in the physical.

Because nonreductive physicalist theories attempt to both retain the ontological distinction between mind and body and to try to solve the 'surfeit of explanations puzzle' in some way; critics often see this as a paradox and point out the similarities to epiphenomenalism, in that it is the brain that is seen as the root 'cause' not the mind, and the mind seems to be rendered inert.

Epiphenomenalism regards mental states as a byproduct of physical brain states. The interaction is one-way (solving the 'surfeit of explanations puzzle') but leaving us with non-reducible mental states (as a byproduct of brain states). Pain would be seen by epiphenomenalists as being caused by the brain state but as not having effects on other brain states, though it might have effects on other mental states (i.e. cause distress).

Emergentism

Emergentism is a form of "nonreductive physicalism" that involves a layered view of nature, with the layers arranged in terms of increasing complexity and each corresponding to its own special science. Some philosophers hold that emergent properties causally interact with more fundamental levels, while others maintain that higher-order properties simply supervene over lower levels without direct causal interaction. The latter group therefore holds a stricter definition of emergentism, which can be rigorously stated as follows: a property P of composite object O is emergent if it is metaphysically possible for another

object to lack property P even if that object is composed of parts with intrinsic properties identical to those in O and has those parts in an identical configuration.

Sometimes emergentists use the example of water having a new property when Hydrogen H and Oxygen O combine to form H₂O (water). In this example there "emerges" a new property of a transparent liquid that would not have been predicted by understanding hydrogen and oxygen as a gas. This is analogous to physical properties of the brain giving rise to a mental state. Emergentists try to solve the notorious mind-body gap this way. One problem for emergentism is the idea of "causal closure" in the world that does not allow for a mind-to-body causation.

Eliminative materialism

If one is a materialist but believes that not all aspects of our common sense psychology will find reduction to a mature cognitive-neuroscience, and that a non-reductive materialism is mistaken, then one can adopt a final, more radical position: eliminative materialism.

There are several varieties of eliminative materialism, but all maintain that our common-sense "folk psychology" badly misrepresents the nature of some aspect of cognition. Eliminativists regard folk psychology as a falsifiable theory, and one likely to be falsified by future cognitive-neuroscientific research. Should better theories of the mental come along they argue, we might need to discard certain basic common-sense mental notions that we have always taken for granted, such as belief, consciousness, emotion, qualia, or propositional attitudes.

Eliminativists such as Patricia and Paul Churchland argue that while folk psychology treats cognition as fundamentally sentence-like, the non-linguistic vector/matrix model of neural network theory or connectionism will prove to be a much more accurate account of how the brain works.

The Churchlands often invoke the fate of other, erroneous popular theories and ontologies which have arisen in the course

of history. For example, Ptolemaic astronomy served to explain and roughly predict the motions of the planets for centuries, but eventually this model of the solar system was eliminated in favor of the Copernican model. The Churchlands believe the same eliminative fate awaits the "sentence-cruncher" model of the mind in which thought and behavior are the result of manipulating sentence-like states called "propositional attitudes."

Linguistic criticism of the mind-body problem

Each attempt to answer the mind-body problem encounters substantial problems. Some philosophers argue that this is because there is an underlying conceptual confusion. These philosophers, such as Ludwig Wittgenstein and his followers in the tradition of linguistic criticism, therefore reject the problem as illusory. They argue that it is an error to ask how mental and biological states fit together. Rather it should simply be accepted that human experience can be described in different ways - for instance, in a mental and in a biological vocabulary. Illusory problems arise if one tries to describe the one in terms of the other's vocabulary or if the mental vocabulary is used in the wrong contexts. This is the case, for instance, if one searches for mental states of the brain. The brain is simply the wrong context for the use of mental vocabulary - the search for mental states of the brain is therefore a category error or a sort of fallacy of reasoning.

Today, such a position is often adopted by interpreters of Wittgenstein such as Peter Hacker. However, Hilary Putnam, the originator of functionalism, has also adopted the position that the mind-body problem is an illusory problem which should be dissolved according to the manner of Wittgenstein.

Externalism and internalism

Where is the mind located? If the mind is a physical phenomenon of some kind, it has to be located somewhere. There are two possible options: either the mind is internal to the body internalism or the mind is external to it externalism. More generally, either the mind depends only on events and

properties taking place inside the subject's body or it depends also on factors external to it.

Proponents of internalism are committed to the view that neural activity is *sufficient* to produce the mind. Proponents of externalism maintain that the surrounding world is in some sense constitutive of the mind.

Externalism differentiates into several versions. The main ones are semantic externalism, cognitive externalism, phenomenal externalism. Each of these versions of externalism can further be divided whether they refer only to the content or to the vehicles of mind.

Semantic externalism holds that the semantic content of the mind is totally or partially defined by state of affairs external to the body of the subject. Hilary Putnam's Twin earth thought experiment is a good example.

cognitive externalism is a very broad collections of views that suggests the role of the environment, of tools, of development, and of the body in fleshing out cognition. Embodied cognition, The extended mind, enactivism are good example.

phenomenal externalism suggests that the phenomenal aspects of the mind are external to the body. Authors who addressed this possibility are Ted Honderich, Edwin Holt, Francois Tonneau, Kevin O'Regan, Riccardo Manzotti, Teed Rockwell.

Naturalism and its problems

The thesis of physicalism is that the mind is part of the material (or physical) world. Such a position faces the problem that the mind has certain properties that no other material thing seems to possess. Physicalism must therefore explain how it is possible that these properties can nonetheless emerge from a material thing. The project of providing such an explanation is often referred to as the "naturalization of the mental." Some of the crucial problems that this project attempts to resolve include the existence of qualia and the nature of intentionality.

Qualia

Many mental states have the property of being experienced subjectively in different ways by different individuals. For example, it is characteristic of the mental state of pain that it hurts. Moreover, your sensation of pain may not be identical to mine, since we have no way of measuring how much something hurts nor of describing exactly how it feels to hurt. Philosophers and scientists ask where these experiences come from. Nothing indicates that a neural or functional state can be accompanied by such a pain experience. Often the point is formulated as follows: the existence of cerebral events, in and of themselves, cannot explain why they are accompanied by these corresponding qualitative experiences. The puzzle of why many cerebral processes occur with an accompanying experiential aspect in consciousness seems impossible to explain.

Yet it also seems to many that science will eventually have to explain such experiences. This follows from the logic of reductive explanations. If I try to explain a phenomenon reductively (e.g., water), I also have to explain why the phenomenon has all of the properties that it has (e.g., fluidity, transparency). In the case of mental states, this means that there needs to be an explanation of why they have the property of being experienced in a certain way.

The problem of explaining the introspective, first-person aspects of mental states, and consciousness in general, in terms of third-person quantitative neuroscience is called the explanatory gap. There are several different views of the nature of this gap among contemporary philosophers of mind. David Chalmers and the early Frank Jackson interpret the gap as ontological in nature; that is, they maintain that qualia can never be explained by science because physicalism is false. There are two separate categories involved and one cannot be reduced to the other. An alternative view is taken by philosophers such as Thomas Nagel and Colin McGinn. According to them, the gap is epistemological in nature. For Nagel, science is not yet able to explain subjective experience because it has not yet arrived at the level or kind of knowledge that is required.

We are not even able to formulate the problem coherently. For McGinn, on other hand, the problem is one of permanent and inherent biological limitations. We are not able to resolve the explanatory gap because the realm of subjective experiences is cognitively closed to us in the same manner that quantum physics is cognitively closed to elephants. Other philosophers liquidate the gap as purely a semantic problem.

Intentionality

Intentionality is the capacity of mental states to be directed towards (*about*) or be in relation with something in the external world. This property of mental states entails that they have contents and semantic referents and can therefore be assigned truth values. When one tries to reduce these states to natural processes there arises a problem: natural processes are not true or false, they simply happen. It would not make any sense to say that a natural process is true or false. But mental ideas or judgments are true or false, so how then can mental states (ideas or judgments) be natural processes? The possibility of assigning semantic value to ideas must mean that such ideas are about facts. Thus, for example, the idea that Herodotus was a historian refers to Herodotus and to the fact that he was an historian. If the fact is true, then the idea is true; otherwise, it is false. But where does this relation come from? In the brain, there are only electrochemical processes and these seem not to have anything to do with Herodotus.

Philosophy of mind and science

Humans are corporeal beings and, as such, they are subject to examination and description by the natural sciences. Since mental processes are intimately related to bodily processes, the descriptions that the natural sciences furnish of human beings play an important role in the philosophy of mind. There are many scientific disciplines that study processes related to the mental. The list of such sciences includes: biology, computer science, cognitive science, cybernetics, linguistics, medicine, pharmacology, and psychology.

Neurobiology

The theoretical background of biology, as is the case with modern natural sciences in general, is fundamentally materialistic. The objects of study are, in the first place, physical processes, which are considered to be the foundations of mental activity and behavior. The increasing success of biology in the explanation of mental phenomena can be seen by the absence of any empirical refutation of its fundamental presupposition: "there can be no change in the mental states of a person without a change in brain states."

Within the field of neurobiology, there are many subdisciplines which are concerned with the relations between mental and physical states and processes: Sensory neurophysiology investigates the relation between the processes of perception and stimulation.[63] Cognitive neuroscience studies the correlations between mental processes and neural processes. Neuropsychology describes the dependence of mental faculties on specific anatomical regions of the brain. Lastly, evolutionary biology studies the origins and development of the human nervous system and, in as much as this is the basis of the mind, also describes the ontogenetic and phylogenetic development of mental phenomena beginning from their most primitive stages.

Since the 1980s, sophisticated neuroimaging procedures, such as fMRI (above), have furnished increasing knowledge about the workings of the human brain, shedding light on ancient philosophical problems.

The methodological breakthroughs of the neurosciences, in particular the introduction of high-tech neuroimaging procedures, has propelled scientists toward the elaboration of increasingly ambitious research programs: one of the main goals is to describe and comprehend the neural processes which correspond to mental functions. Several groups are inspired by these advances. New approaches to this question are being pursued by Steven Ericsson-Zenith at the Institute for Advanced Science & Engineering, where they propose a new mechanics

for devices called 'machines' that experience', designed to implement sentience and the fundamental mechanisms of motility and recognition. Jeff Hawkins has established the Redwood Center for Theoretical Neuroscience at Berkeley, where they explore biomimicry for recognition algorithms.

Computer science

Computer science concerns itself with the automatic processing of information (or at least with physical systems of symbols to which information is assigned) by means of such things as computers. From the beginning, computer programmers have been able to develop programs which permit computers to carry out tasks for which organic beings need a mind. A simple example is multiplication. But it is clear that computers do not use a mind to multiply. Could they, someday, come to have what we call a mind? This question has been propelled into the forefront of much philosophical debate because of investigations in the field of artificial intelligence.

Within AI, it is common to distinguish between a modest research program and a more ambitious one: this distinction was coined by John Searle in terms of a weak AI and strong AI. The exclusive objective of "weak AI", according to Searle, is the successful simulation of mental states, with no attempt to make computers become conscious or aware, etc. The objective of strong AI, on the contrary, is a computer with consciousness similar to that of human beings. The program of strong AI goes back to one of the pioneers of computation Alan Turing. As an answer to the question "Can computers think?", he formulated the famous Turing test. Turing believed that a computer could be said to "think" when, if placed in a room by itself next to another room which contained a human being and with the same questions being asked of both the computer and the human being by a third party human being, the computer's responses turned out to be indistinguishable from those of the human. Essentially, Turing's view of machine intelligence followed the behaviourist model of the mind - intelligence is as intelligence does. The Turing test has received many criticisms,

among which the most famous is probably the Chinese room thought experiment formulated by Searle.

The question about the possible sensitivity (qualia) of computers or robots still remains open. Some computer scientists believe that the specialty of AI can still make new contributions to the resolution of the "mind body problem". They suggest that based on the reciprocal influences between software and hardware that takes place in all computers, it is possible that someday theories can be discovered that help us to understand the reciprocal influences between the human mind and the brain (wetware).

Psychology

Psychology is the science that investigates mental states directly. It uses generally empirical methods to investigate concrete mental states like joy, fear or obsessions. Psychology investigates the laws that bind these mental states to each other or with inputs and outputs to the human organism.

An example of this is the psychology of perception. Scientists working in this field have discovered general principles of the perception of forms. A law of the psychology of forms says that objects that move in the same direction are perceived as related to each other. This law describes a relation between visual input and mental perceptual states. However, it does not suggest anything about the nature of perceptual states. The laws discovered by psychology are compatible with all the answers to the mind-body problem already described.

Philosophy of mind in the continental tradition

Most of the discussion in this article has focused on one style or tradition of philosophy in modern Western culture, usually called analytic philosophy (sometimes described as Anglo-American philosophy). Many other schools of thought exist, however, which are sometimes subsumed under the broad label of continental philosophy. In any case, though topics and methods here are numerous, in relation to the philosophy of mind the various schools that fall under this label

(phenomenology, existentialism, etc.) can globally be seen to differ from the analytic school in that they focus less on language and logical analysis alone but also take in other forms of understanding human existence and experience. With reference specifically to the discussion of the mind, this tends to translate into attempts to grasp the concepts of thought and perceptual experience in some sense that does not merely involve the analysis of linguistic forms.

In Georg Wilhelm Friedrich Hegel's *Phenomenology of Mind*, Hegel discusses three distinct types of mind: the *subjective mind*, the mind of an individual; the *objective mind*, the mind of society and of the State; and the *Absolute mind*, a unity of all concepts. See also Hegel's *Philosophy of Mind* from his *Encyclopedia*.

In modern times, the two main schools that have developed in response or opposition to this Hegelian tradition are phenomenology and existentialism. Phenomenology, founded by Edmund Husserl, focuses on the contents of the human mind (see noema) and how phenomenological processes shape our experiences. Existentialism, a school of thought founded upon the work of Søren Kierkegaard and Friedrich Nietzsche, focuses on the content of experiences and how the mind deals with such experiences.

An important, though not very well known, example of a philosopher of mind and cognitive scientist who tries to synthesize ideas from both traditions is Ron McClamrock. Borrowing from Herbert Simon and also influenced by the ideas of existential phenomenologists such as Maurice Merleau-Ponty and Martin Heidegger, McClamrock suggests that humans' condition of being-in-the-world ("Dasein", "In-der-welt-sein") makes it impossible for them to understand themselves by abstracting away from it and examining it as if it were a detached experimental object of which they themselves are not an integral part.

Philosophy of mind in the Eastern tradition

Buddhism

"If one were to ask, 'Which aging & death? And whose is this aging & death?' and if one were to ask, 'Is aging & death one thing, and is this the aging & death of someone/something else?' both of them would have the same meaning, even though their words would differ. When there is the view that the *jiva* is the same as the body, there isn't the leading of the holy life. And when there is the view that the *jiva* is one thing and the body another, there isn't the leading of the holy life. Avoiding these two extremes, the Tathagata points out the Dhamma in between: From birth as a requisite condition comes aging & death."

Eastern traditions such as Buddhism do not hold to the dualistic mind/body model but do assert that the mind and body are separate entities. Buddhism in particular does not hold to the notion of a soul, or atman. Some forms of Buddhism assert that a very subtle level of mind leaves the body at the time of death and goes to a new life. According to Buddhist scholar Dharmakirti, the definition of mind is that which is clarity and cognizes. In this definition, 'clarity' refers to the nature of mind, and 'cognizes' to the function of mind. Mind is clarity because it always lacks form and because it possesses the actual power to perceive objects. Mind cognizes because its function is to know or perceive objects. In *Ornament of the Seven Sets*, Buddhist scholar Khedrubje says that thought, awareness, mind and cognizer are synonyms. Buddha explained that although mind lacks form, it can nevertheless be related to form. Thus, our mind is related to our body and is "located" at different places throughout the body. This is to be understood in the context of how the five sense consciousnesses and the mental consciousness are generated. There are many different types of mind—sense awarenesses, mental awarenesses, gross minds, subtle minds, and very subtle minds—and they are all formless (lacking shape, color, sound, smell, taste or tactile properties) and they all function to cognize or know. There is no such thing as a mind without an object known by that mind. Even though none of these minds is form, they can be related to form.

Consequences of philosophy of mind

There are countless subjects that are affected by the ideas developed in the philosophy of mind. Clear examples of this are the nature of death and its definitive character, the nature of emotion, of perception and of memory. Questions about what a person is and what his or her identity consists of also have much to do with the philosophy of mind. There are two subjects that, in connection with the philosophy of the mind, have aroused special attention: free will and the self.

Free will

In the context of philosophy of mind, the problem of free will takes on renewed intensity. This is certainly the case, at least, for materialistic determinists. According to this position, natural laws completely determine the course of the material world. Mental states, and therefore the will as well, would be material states, which means human behavior and decisions would be completely determined by natural laws. Some take this reasoning a step further: people cannot determine by themselves what they want and what they do. Consequently, they are not free.

This argumentation is rejected, on the one hand, by the compatibilists. Those who adopt this position suggest that the question "Are we free?" can only be answered once we have determined what the term "free" means. The opposite of "free" is not "caused" but "compelled" or "coerced". It is not appropriate to identify freedom with indetermination. A free act is one where the agent could have done otherwise if it had chosen otherwise. In this sense a person can be free even though determinism is true. The most important compatibilist in the history of the philosophy was David Hume. More recently, this position is defended, for example, by Daniel Dennett, and, from a dual-aspect perspective, by Max Velmans.

On the other hand, there are also many incompatibilists who reject the argument because they believe that the will is free in a stronger sense called libertarianism. These philosophers affirm the course of the world is either a) not completely

determined by natural laws and deterministic natural law is broken by dualistic sentient beings, or b) determined by indeterministic natural law only, or c) determined by indeterministic natural law in line with the will of a non physical agency. Under Libertarianism, the will does not have to be deterministic and, therefore, it is potentially free. Critics of the second proposition (b) accuse the incompatibilists of using an incoherent concept of freedom. They argue as follows: if our will is not determined by anything, then we desire what we desire by pure chance. And if what we desire is purely accidental, we are not free. So if our will is not determined by anything, we are not free.

The self

The philosophy of mind also has important consequences for the concept of self. If by "self" or "I" one refers to an essential, immutable nucleus of the *person*, most modern philosophers of mind will affirm that no such thing exists. The idea of a self as an immutable essential nucleus derives from the idea of an immaterial soul. Such an idea is unacceptable to most contemporary philosophers, due to their physicalistic orientations, and due to a general acceptance among philosophers of the scepticism of the concept of 'self' by David Hume, who could never catch himself doing, thinking or feeling anything. However, in the light of empirical results from developmental psychology, developmental biology and neuroscience, the idea of an essential inconstant, material nucleus - an integrated representational system distributed over changing patterns of synaptic connections - seems reasonable. The view of the self as an illusion is widely accepted by many philosophers, such as Daniel Dennett and Thomas Metzinger.



HISTORY OF THE CONCEPT OF CREATIVITY

The ways in which societies have perceived the concept of creativity have changed throughout history, as has the term itself. The ancient Greek concept of art (in Greek, "*techne*" — the root of "technique" and "technology"), with the exception of poetry, involved not freedom of action but subjection to *rules*. In Rome, the Greek concept was partly shaken, and visual artists were viewed as sharing, with poets, imagination and inspiration.

Under medieval Christianity, the Latin "*creatio*" came to designate God's act of "*creatio ex nihilo*" ("creation from nothing"); thus "*creatio*" ceased to apply to human activities. The Middle Ages, however, went even further than antiquity, when they revoked poetry's exceptional status: it, too, was an art and therefore craft and not creativity.

Renaissance men sought to give voice to their sense of their freedom and creativity. The first to apply the word "creativity," however, was the 17th-century Polish poet Maciej Kazimierz Sarbiewski — but he applied it only to poetry. For over a century, and a half, the idea of *human* creativity met with resistance, due to the fact that the term "creation" was reserved for creation "from nothing."

In the 19th century, art took its revenge: now not only was art recognized as creativity, but *it alone* was. When later, at the turn of the 20th century, there began to be discussion as well of creativity in the sciences and in nature, this was taken as the transference, to the sciences and to nature, of concepts that were proper to art.

Term and concept

The ancient Greeks had no terms corresponding to "to create" or "creator." The expression "*poiein*" ("to make") sufficed. And even that was not extended to art in general, but only to *poiesis* (poetry) and to the *poietai* (poet, or "maker") who made it. Plato asks in *The Republic*, "Will we say, of a painter, that he makes something?" and answers, "Certainly not, he merely imitates." To the ancient Greeks, the concept of a creator and of creativity implied freedom of action, whereas the Greeks' concept of art involved subjection to laws and rules. Art (in Greek, "*techne*") was "the making of things, according to rules." It contained no creativity, and it would have been — in the Greeks' view — a bad state of affairs if it had.

This understanding of art had a distinct premise: Nature is perfect and is subject to laws, therefore man ought to discover its laws and submit to them, and not seek freedom, which will deflect him from that *optimum* which he can attain. The artist was a discoverer, not an inventor.

Cicero

The sole exception to this Greek view — a great exception — was poetry. The poet made new things — brought to life a new world — while the artist merely *imitated*. And the poet, unlike the artist, was *not* bound by laws. There were no terms corresponding to "creativity" or "creator," but in reality the poet was understood to be one who creates. And only he was so understood. In music, there was no freedom: melodies were prescribed, particularly for ceremonies and entertainments, and were known tellingly as "*nomoi*" ("laws"). In the visual arts, freedom was limited by the proportions that Polyclitus had established for the human frame, and which he called "the canon" (meaning, "measure"). Plato argued in *Timaeus* that, to execute a good work, one must contemplate an eternal model. Later the Roman, Cicero, would write that art embraces those things "of which we have knowledge" ("*quae sciuntur*").

Horace

Poets saw things differently. Book I of the *Odyssey* asks, "Why forbid the singer to please us with singing as *he himself will?*" Aristotle had doubts as to whether poetry was imitation of reality, and as to whether it required adherence to truth: it was, rather, the realm of that "which is neither true nor false."

In Rome, these Greek concepts were partly shaken. Horace wrote that not only poets but painters as well were entitled to the privilege of daring whatever they wished to ("*quod libet audendi*"). In the declining period of antiquity, Philostratus wrote that "one can discover a similarity between poetry and art and find that they have imagination in common." Callistratos averred that "Not only is the art of the poets and prosaists inspired, but likewise the hands of sculptors are gifted with the blessing of divine inspiration." This was something new: classical Greeks had not applied the concepts of imagination and inspiration to the visual arts but had restricted them to poetry. Latin was richer than Greek: it had a term for "creating" ("*creatio*") and for "creator," and had two expressions — "*facere*" and "*creare*" — where Greek had but one, "*poiein*." Still, the two Latin terms meant much the same thing.

File:Cassiodorus at the Vivarium in Codex Amiantinus.jpg

Cassiodorus

A fundamental change, however, came in the Christian period: "*creatio*" came to designate God's act of "creation from nothing" ("*creatio ex nihilo*"). "*Creatio*" thus took on a different meaning than "*facere*" ("to make"), and ceased to apply to human functions. As the 6th-century Roman official and literary figure Cassiodorus wrote, "things made and created differ, for we can make, who cannot create."

Alongside this new, religious interpretation of the expression, there persisted the ancient view that art is not a domain of creativity. This is seen in two early and influential Christian writers, Pseudo-Dionysius and St. Augustine. Later medieval men such as Hraban the Moor, and Robert Grosseteste

in the 13th century, thought much the same way. The Middle Ages here went even further than antiquity; they made no exception of poetry: it too had its rules, was an art, and was therefore craft and not creativity.

Michelangelo

All this changed in modern times. Renaissance men had a sense of their own independence, freedom and creativity, and sought to give voice to this sense of independence and creativity. The philosopher Marsilio Ficino wrote that the artist "thinks up" (*excogitatio*) his works; the theoretician of architecture and painting, Leon Battista Alberti, that he "preordains" (*preordinazione*); Raphael, that he shapes a painting according to his idea; Leonardo da Vinci, that he employs "shapes that do not exist in nature"; Michelangelo, that the artist realizes his vision rather than imitating nature; Giorgio Vasari, that "nature is conquered by art"; the Venetian art theoretician, Paolo Pino, that painting is "inventing what is not"; Paolo Veronese, that painters avail themselves of the same liberties as do poets and madmen; Federico Zuccari (1542–1609), that the artist shapes "a new world, new paradises"; Cesare Cesariano (1483–1541), that architects are "demi-gods." Among musicians, the Dutch composer and musicologist Jan Tinctoris (1446–1511) demanded novelty in what a composer did, and defined a composer as "one who produces new songs."

Still more emphatic were those who wrote about poetry: G.P. Capriano held (1555) that the poet's invention springs "from nothing." Francesco Patrizi (1586) saw poetry as "fiction," "shaping," "transformation."

Finally, at long last, someone ventured to use the word, "creation." He was the 17th-century Polish poet and theoretician of poetry, Maciej Kazimierz Sarbiewski (1595–1640), known as "the last Latin poet." In his treatise, *De perfecta poesi*, he not only wrote that a poet "invents," "after a fashion builds," but also that the poet "creates anew" (*de novo creat*). Sarbiewski even added: "in the manner of God" (*instar Dei*).

Sarbiewski, however, regarded creativity as the exclusive privilege of poetry; creativity was not open to visual artists. "Other arts merely imitate and copy but do not create, because they assume the existence of the material from which they create or of the subject." As late as the end of the 17th century, André Félibien (1619–75) would write that the painter is "so to speak [a] creator." The Spanish Jesuit Baltasar Gracián (1601–58) wrote similarly as Sarbiewski: "Art is the completion of nature, as it were a *second Creator*..."

By the 18th century, the concept of creativity was appearing more often in art theory. It was linked with the concept of imagination, which was on all lips. Joseph Addison wrote that the imagination "has something in it like creation." Voltaire declared (1740) that "the true poet is creative." With both these authors, however, this was rather only a *comparison* of poet with creator.

Other writers took a different view. Denis Diderot felt that imagination is merely "the memory of forms and contents," and "creates nothing" but only combines, magnifies or diminishes. It was precisely in 18th-century France, indeed, that the idea of man's creativity met with resistance. Charles Batteux wrote that "The human mind cannot create, strictly speaking; all its products bear the stigmata of their model; even monsters invented by an imagination unhampered by laws can only be composed of parts taken from nature." Luc de Clapiers, marquis de Vauvenargues (1715–47), and Étienne Bonnot de Condillac (1715–80) spoke to a similar effect.

Their resistance to the idea of human creativity had a triple source. The expression, "creation," was then reserved for creation *ex nihilo* (Latin: *from nothing*), which was inaccessible to man. Second, creation is a mysterious act, and Enlightenment psychology did not admit of mysteries. Third, artists of the age were attached to their rules, and creativity seemed irreconcilable with rules. The latter objection was the weakest, as it was already beginning to be realized (e.g., by Houdar de la Motte, 1715) that rules ultimately are a *human invention*

In the 19th century, art took its compensation for the resistance of preceding centuries against recognizing it as creativity. Now not only was art regarded as creativity, but *it alone* was so regarded. When later, at the turn of the 20th century, there began to be discussion as well of creativity in the sciences (e.g., Jan Lukasiewicz, 1878–1956) and in nature (e.g., Henri Bergson), this was generally taken as the transference, to the sciences and to nature, of concepts proper to art.

The start of the *scientific* study of creativity is sometimes taken as J. P. Guilford's 1950 address to the American Psychological Association, which helped popularize the subject.

Other students of creativity have taken a more pragmatic approach, teaching practical creativity techniques. Three of the best-known are Alex Osborn's "brainstorming" (1950s to present), Genrikh Altshuller's Theory of Inventive Problem-Solving (TRIZ, 1950s to present), and Edward de Bono's "lateral thinking" (1960s to present).

Periods and Personalities

Ancient Greece

- Archimedes
- Plato's Dialogue of Ion

3rd century

- Porphyry of Tyros graphically visualised the concept categories of Aristotle.

4th century of the Christian Era

- Pappus of Alexandria in Egypt was searching for a science of invention, naming his techniques "heuristics".

1000s - 1500s

About 1275, in an early attempt to use logical means to produce knowledge, Ramon Llull designed a method of combining attributes selected from a number of lists, which he first published in full in his *Ars generalis ultima* or *Ars magna* (1305). This used concept structures of the mind-map form.

1470s

Leonardo da Vinci

1500s - 2000s

There was no real demand for such a science until the 19th century, when the Industrial Revolution started:

- William Gordon - Synectics
- Edward Matchett - Fundamental design method (1968)
- Idan Gafni - Association expansion cards (Object Pairing)
- Edward de Bono - Complex of techniques ...
- L. D. Miles - Value engineering - a technique for operating with available knowledge

Following along Miles' line of thought were :

- Fritz Zwicky - Morphological Analysis
- Yoji Akoa - Quality Function Deployment
- beginning in the mid-1940s - start of *knowledge-based* creativity era by TRIZ

Early 20th century

- Pablo Picasso painter
- Marcel Duchamp artist

1940s

- Fritz Zwicky - Morphological Analysis
- Lawrence Delos Miles - Value engineering - technique for operating with available knowledge, Methods of collecting and organizing knowledge about a problem and the system. Functional analysis. Morphological approach.
- George Polya

1950s

- Alex Osborn - Methods of reducing psychological inertia. Team work.
- Sid Parnes
- Genrikh Altshuller - TRIZ, ARIZ

1960s

- Carl Jung classified creativity as one of the five main instinctive forces in humans (Jung 1964)
- Edward Matchett - Fundamental design method (1968)
- Carl Rogers' essay, "Towards a Theory of Creativity" (1961):
- William Gordon - Synectics
- Edward de Bono - Lateral thinking
- J. P. Guilford - measuring creativity

1970s

- Albert Rothenberg coined the term ' Janusian thinking'
- Yoji Akao - Quality function deployment
- Total creativity - the ultimate goal in the philosophy of John David Garcia
- Carlos Castaneda - A Separate Reality: Further Conversations with Don Juan
- Joseph D. Novak at Cornell University - Concept map
- Ellis Paul Torrance - Torrance Tests of Creative Thinking

1980s

- Paul Palnik- Creative Consciousness The healthiest state of mind. [1981]

1990s

- Tony Buzan - mind map
- Idan Gafni - association expansion cards concept (Object Pairing)

2000s

- Creative capabilities and the promotion of highly innovative research - organizational factors fostering creativity in science

Undated

- Reviewed Dendrogram technique, relies on the experience of designers which may be limited to certain areas of expertise such as chemistry or electronics. Thus, a solution that might be simpler and cheaper using magnetism could be missed.



INSIGHT

Insight can be used with several related meanings:

- a piece of information
- the act or result of apprehending the inner nature of things or of seeing intuitively in Greek called *noesis*
- an introspection
- the power of acute observation and deduction, penetration, discernment, perception called intellection or *noesis*
- an understanding based on identification of relationships and behaviors within a model, context, or scenario

An insight that manifests itself suddenly, such as understanding how to solve a difficult problem, is sometimes called by the German word *Aha-Erlebnis*. The term was coined by the German psychologist and theoretical linguist Karl Bühler. It is also known as an epiphany.

In psychology and psychiatry

In psychology and psychiatry, insight is the ability to recognize one's own mental illness. This form of insight has multiple dimensions, such as recognizing the need for treatment, and recognizing consequences of one's behavior as stemming from an illness. A person with very poor recognition or acknowledgment is referred to as having "poor insight" or "lack of insight." The most extreme form is Anosognosia, which is the total absence of insight into one's own mental illness. Many mental illnesses are associated with varying levels of insight. For example, people with obsessive compulsive disorder and various phobias tend to have relatively good insight that they have a problem and that their thoughts and/or actions are

unreasonable, yet are compelled to carry out the thoughts and actions regardless. Whereas people with Alzheimer's disease, schizophrenia and various psychotic conditions tend to have very poor awareness that anything is wrong with them.

"Insight" can also refer to other matters in psychology. Problem solving behavior requiring insight is the subject of insight phenomenology.

An insight is the derivation of a rule which links cause with effect. The mind is a model of the universe built up from insights.

Thoughts of the mind fall into two categories:

- 1) Analysis of past experience with the purpose of gaining insight for use within this model at a later date
- 2) Simulations of future scenarios using existing insights in the mind model in order to predict outcomes

A mature mind has assimilated many insights and understands cause and effect. When insight is not subordinate to a validation discipline like the 'scientific method', fallacious thinking can result in a confused mind.

Intuition, which is often described in the popular literature as an alternative thought process, is merely another manifestation of insight. In this process, multiple bits of seemingly unrelated data are linked together and a hypothesis or plan of action is generated. Usually this process is generated in a novel situation. Such a circumstance links data which had previously seemed unrelated. The categories and analytical process, however, are not distinct from any other form of insight. The only difference is the degree of novelty of the stimulus. To form an insight the frontal lobe searches through the temporal lobes in search of the data bits. It has been hypothesized that the apparently intuitive mode uses a right temporal search. The majority of insights are derived from the left temporal lobe.

In religion

In religion insight is seen as the divine impartation of knowledge, or wisdom, for various beneficial results:

- To help a sufferer understand a troubling health condition, be it emotional, mental, spiritual or physical (possibly psychosomatic)
- To help a sufferer understand a troubling life situation or circumstance (e.g. relationship/employment problems)
- To give greater understanding about local, national or international social issues, often with a view to assisting intercessory prayer
- To help an enquirer come to faith or belief in the religion or belief system

Sometimes insight is a precursor to miraculous interventions. In those cases the insight can be said to result in deeper understanding, which in turn results in increased faith.

The Pali word for "insight" is "vipassana", which has been adopted as the name of a kind of Buddhist meditation.

In business

Nigel Bradley points out a recent development in the world of business. There has been the emergence of new departments in corporations which carry the word "Insight" in their titles. We have "Customer Insight Departments", Insight Management Unit, Consumer Insight and so on. This extends to the job titles of executives working in those areas. One reason for this development was a realisation that the emphasis of results from individual research projects needed to be shifted to a wider understanding of the dynamics operating in the full market place. Another reason was the impact of information technology. Progress in technology gave way to the availability of masses of information found in databases. The advantages of Insight Management are numerous. By making use of all existing information, there is less need to consult customers, thereby minimising unnecessary contact and costs.



CONCEPT

There are two prevailing theories in contemporary philosophy which attempt to explain the nature of **concepts** (abstract term: **conception**). The representational theory of mind proposes that concepts are mental representations, while the semantic theory of concepts (originating with Frege's distinction between concept and object) holds that they are abstract objects. Ideas are taken to be concepts, although abstract concepts do not necessarily appear to the mind as images as some ideas do. Many philosophers consider concepts to be a fundamental ontological category of being.

A concept is a cognitive unit of *meaning*— an abstract idea or a mental symbol sometimes defined as a "unit of knowledge," built from other units which act as a concept's characteristics. A concept is typically associated with a corresponding representation in a language or symbology such as a single meaning of a term.

The meaning of "concept" is explored in mainstream cognitive science, metaphysics, and philosophy of mind. The term "concept" is traced back to 1554–60 (*l. conceptum* - something conceived), but what is today termed "the classical theory of concepts" is the theory of Aristotle on the definition of terms.

Origin and acquisition of concepts

A posteriori abstractions

John Locke's description of a **general idea** corresponds to a description of a concept. According to Locke, a general idea is created by abstracting, drawing away, or removing the common characteristic or characteristics from several particular

ideas. This common characteristic is that which is similar to all of the different individuals. For example, the abstract general idea or concept that is designated by the word "red" is that characteristic which is common to apples, cherries, and blood. The abstract general idea or concept that is signified by the word "dog" is the collection of those characteristics which are common to Airedales, Collies, and Chihuahuas.

In the same tradition as Locke, John Stuart Mill stated that general conceptions are formed through abstraction. A general conception is the common element among the many images of members of a class. "... [W]hen we form a set of phenomena into a class, that is, when we compare them with one another to ascertain in what they agree, some general conception is implied in this mental operation" (*A System of Logic*, Book IV, Ch. II). Mill did not believe that concepts exist in the mind before the act of abstraction. "It is not a law of our intellect, that, in comparing things with each other and taking note of their agreement, we merely recognize as realised in the outward world something that we already had in our minds. The conception originally found its way to us as the result of such a comparison. It was obtained (in metaphysical phrase) by *abstraction from individual things*" (*Ibid.*).

For Schopenhauer, empirical concepts "... are mere abstractions from what is known through intuitive perception, and they have arisen from our arbitrarily thinking away or dropping of some qualities and our retention of others." (*Parerga and Paralipomena*, Vol. I, "Sketch of a History of the Ideal and the Real"). In his *On the Will in Nature*, "Physiology and Pathology," Schopenhauer said that a concept is "drawn off from previous images ... by putting off their differences. This concept is then no longer intuitively perceptible, but is denoted and fixed merely by words." Nietzsche, who was heavily influenced by Schopenhauer, wrote: "Every concept originates through our equating what is unequal. No leaf ever wholly equals another, and the concept 'leaf' is formed through an arbitrary abstraction from these individual differences, through forgetting the distinctions" .

By contrast to the above philosophers, Immanuel Kant held that the account of the concept as an abstraction of experience is only partly correct. He called those concepts that result of abstraction "a posteriori concepts" (meaning concepts that arise out of experience). An empirical or an a *posteriori* concept is a general representation (*Vorstellung*) or non-specific thought of that which is common to several specific perceived objects.

A concept is a common feature or characteristic. Kant investigated the way that empirical a *posteriori* concepts are created.

Kant's description of the making of a concept has been paraphrased as "... to conceive is essentially to think in abstraction what is common to a plurality of possible instances" (H.J. Paton, *Kant's Metaphysics of Experience*, I, 250). In his discussion of Kant, Christopher Janaway wrote: "... generic concepts are formed by abstraction from more than one species."

A priori concepts

Kant declared that human minds possess pure or a *priori* concepts. Instead of being abstracted from individual perceptions, like empirical concepts, they originate in the mind itself. He called these concepts categories, in the sense of the word that means predicate, attribute, characteristic, or quality. But these pure categories are predicates of things *in general*, not of a particular thing. According to Kant, there are 12 categories that constitute the understanding of phenomenal objects. Each category is that one predicate which is common to multiple empirical concepts. In order to explain how an a *priori* concept can relate to individual phenomena, in a manner analogous to an a *posteriori* concept, Kant employed the technical concept of the schema.

Conceptual structure

It seems intuitively obvious that concepts must have some kind of structure. Up until recently, the dominant view of conceptual structure was a containment model, associated with

the classical view of concepts. According to this model, a concept is endowed with certain necessary and sufficient conditions in their description which unequivocally determine an extension. The containment model allows for no degrees; a thing is either in, or out, of the concept's extension. By contrast, the inferential model understands conceptual structure to be determined in a graded manner, according to the tendency of the concept to be used in certain kinds of inferences. As a result, concepts do not have a kind of structure that is in terms of necessary and sufficient conditions; all conditions are contingent. (Margolis:5)

However, some theorists claim that primitive concepts lack any structure at all. For instance, Jerry Fodor presents his Asymmetric Dependence Theory as a way of showing how a primitive concept's content is determined by a reliable relationship between the information in mental contents and the world. These sorts of claims are referred to as "atomistic", because the primitive concept is treated as if it were a genuine atom.

Content as pragmatic role

A concept may be abstracted from several perceptions, but that is only its origin. In regard to its meaning or its truth, William James proposed his Pragmatic Rule. This rule states that the meaning of a concept may always be found in some particular difference in the course of human experience which its being true will make (*Some Problems of Philosophy*, "Percept and Concept — The Import of Concepts"). In order to understand the meaning of the concept and to discuss its importance, a concept may be tested by asking, "What sensible difference to anybody will its truth make?" There is only one criterion of a concept's meaning and only one test of its truth. That criterion or test is its consequences for human behavior.

In this way, James bypassed the controversy between rationalists and empiricists regarding the origin of concepts. Instead of solving their dispute, he ignored it. The rationalists had asserted that concepts are a revelation of Reason. Concepts

are a glimpse of a different world, one which contains timeless truths in areas such as logic, mathematics, ethics, and aesthetics. By pure thought, humans can discover the relations that really exist among the parts of that divine world. On the other hand, the empiricists claimed that concepts were merely a distillation or abstraction from perceptions of the world of experience. Therefore, the significance of concepts depends solely on the perceptions that are its references. James's Pragmatic Rule does not connect the meaning of a concept with its origin. Instead, it relates the meaning to a concept's purpose, that is, its function, use, or result.

Embodied content

In Cognitive linguistics, abstract concepts are transformations of concrete concepts derived from embodied experience. The mechanism of transformation is structural mapping, in which properties of two or more source domains are selectively mapped onto a blended space (Fauconnier & Turner, 1995; see conceptual blending). A common class of blends are metaphors. This theory contrasts with the rationalist view that concepts are perceptions (or *recollections*, in Plato's term) of an independently existing world of ideas, in that it denies the existence of any such realm. It also contrasts with the empiricist view that concepts are abstract generalizations of individual experiences, because the contingent and bodily experience is preserved in a concept, and not abstracted away. While the perspective is compatible with Jamesian pragmatism (above), the notion of the transformation of embodied concepts through structural mapping makes a distinct contribution to the problem of concept formation.

Philosophical implications

Concepts and metaphilosophy

A long and well-established tradition philosophy posits that philosophy itself is nothing more than conceptual analysis. This view has its proponents in contemporary literature as well as historical. According to Deleuze and Guattari's *What Is Philosophy?* (1991), philosophy is the activity of creating

concepts. This creative activity differs from previous definitions of philosophy as simple reasoning, communication or contemplation of Universals. Concepts are specific to philosophy: science creates "functions", and art "sensations". A concept is always *signed*: thus, Descartes' *Cogito* or Kant's "transcendental". It is a singularity, not universal, and connects itself with others concepts, on a "plane of immanence" traced by a particular philosophy. Concepts can jump from one plane of immanence to another, combining with other concepts and therefore engaging in a "becoming-Other."

Concepts in epistemology

Concepts are vital to the development of scientific knowledge. For example, it would be difficult to imagine physics without concepts like: energy, force, or acceleration. Concepts help to integrate apparently unrelated observations and phenomena into viable hypothesis and theories, the basic ingredients of science. The concept map is a tool that is used to help researchers visualize the inter-relationships between various concepts.

Ontology of concepts

Although the mainstream literature in cognitive science regards the concept as a kind of mental particular, it has been suggested by some theorists that concepts are real things. (Margolis:8) In most radical form, the realist about concepts attempts to show that the supposedly mental processes are not mental at all; rather, they are abstract entities, which are just as real as any mundane object.

Plato was the starkest proponent of the realist thesis of universal concepts. By his view, concepts (and ideas in general) are innate ideas that were instantiations of a transcendental world of pure forms that laid behind the veil of the physical world. In this way, universals were explained as transcendent objects. Needless to say this form of realism was tied deeply with Plato's ontological projects. This remark on Plato is not of merely historical interest. For example, the view that numbers are Platonic objects was revived by Kurt Gödel as a result of

certain puzzles that he took to arise from the phenomenological accounts.

Gottlob Frege, founder of the analytic tradition in philosophy, famously argued for the analysis of language in terms of sense and reference. For him, the sense of an expression in language describes a certain state of affairs in the world, namely, the way that some object is presented. Since many commentators view the notion of sense as identical to the notion of concept, and Frege regards senses as the linguistic representations of states of affairs in the world, it seems to follow that we may understand concepts as the manner in which we grasp the world. Accordingly, concepts (as senses) have an ontological status. (Morgolis:7)

According to Carl Benjamin Boyer, in the introduction to his *The History of the Calculus and its Conceptual Development*, concepts in calculus do not refer to perceptions. As long as the concepts are useful and mutually compatible, they are accepted on their own. For example, the concepts of the derivative and the integral are not considered to refer to spatial or temporal perceptions of the external world of experience. Neither are they related in any way to mysterious limits in which quantities are on the verge of nascence or evanescence, that is, coming into or going out of appearance or existence. The abstract concepts are now considered to be totally autonomous, even though they originated from the process of abstracting or taking away qualities from perceptions until only the common, essential attributes remained.



INNOVATION

Innovation is a new way of doing something or "new stuff that is made useful". It may refer to an incremental emergent or radical and revolutionary changes in thinking, products, processes, or organizations. Following Schumpeter (1934), contributors to the scholarly literature on innovation typically distinguish between invention, an idea made manifest, and innovation, ideas applied successfully in practice. In many fields, such as the arts, economics and government policy, something new must be substantially different to be innovative. In economics the change must increase value, customer value, or producer value. The goal of innovation is positive change, to make someone or something better. Innovation leading to increased productivity is the fundamental source of increasing wealth in an economy.

Innovation is an important topic in the study of economics, business, entrepreneurship, design, technology, sociology, and engineering. Colloquially, the word "innovation" is often synonymous with the output of the process. However, economists tend to focus on the process itself, from the origination of an idea to its transformation into something useful, to its implementation; and on the system within which the process of innovation unfolds. Since innovation is also considered a major driver of the economy, especially when it leads to new product categories or increasing productivity, the factors that lead to innovation are also considered to be critical to policy makers. In particular, followers of innovation economics stress using public policy to spur innovation and growth.

Those who are directly responsible for application of the innovation are often called pioneers in their field, whether they are individuals or organisations.

In the organizational context, innovation may be linked to performance and growth through improvements in efficiency, productivity, quality, competitive positioning, market share, etc. All organizations can innovate, including for example hospitals, universities, and local governments.

While innovation typically adds value, innovation may also have a negative or destructive effect as new developments clear away or change old organizational forms and practices. Organizations that do not innovate effectively may be destroyed by those that do. Hence innovation typically involves risk. A key challenge in innovation is maintaining a balance between process and product innovations where process innovations tend to involve a business model which may develop shareholder satisfaction through improved efficiencies while product innovations develop customer support however at the risk of costly R&D that can erode shareholder return. Innovation can be described as the result of some amount of time and effort into researching an idea, plus some larger amount of time and effort into developing this idea, plus some very large amount of time and effort into commercializing this idea into a market place with customers.

Innovation has been studied in a variety of contexts, including in relation to technology, commerce, social systems, economic development, and policy construction. There are, therefore, naturally a wide range of approaches to conceptualizing innovation in the scholarly literature.

Distinguishing from invention

Invention is the embodiment of something new. While both invention and innovation have "uniqueness" implications, innovation also carries an undertone of profitability and market performance expectation.

An improvement on an existing form or embodiment, composition or processes might be an invention, an innovation,

both or neither if it is not substantial enough. According to certain business literature, an idea, a change or an improvement is only an innovation when it is put to use and effectively causes a social or commercial reorganization.

In organizations

A convenient definition of innovation from an organizational perspective is given by Luecke and Katz (2003), who wrote:

"Innovation . . . is generally understood as the successful introduction of a new thing or method . . . Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services.

Innovation typically involves creativity, but is not identical to it: innovation involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. For example, Amabile et al. (1996) propose:

"All innovation begins with creative ideas . . . We define innovation as the successful implementation of creative ideas within an organization. In this view, creativity by individuals and teams is a starting point for innovation; the first is necessary but not sufficient condition for the second".

For innovation to occur, something more than the generation of a creative idea or insight is required: the insight must be put into action to make a genuine difference, resulting for example in new or altered business processes within the organization, or changes in the products and services provided.

"Innovation, like many business functions, is a management process that requires specific tools, rules, and discipline."

From this point of view emphasis is moved from the introduction of specific novel and useful ideas to the general organizational processes and procedures for generating, considering, and acting on such insights leading to significant organizational improvements in terms of improved or new business products, services, or internal processes.

Through these varieties of viewpoints, creativity is typically seen as the basis for innovation, and innovation as the successful implementation of creative ideas within an organization.

It should be noted, however, that the term 'innovation' is used by many authors rather interchangeably with the term 'creativity' when discussing individual and organizational creative activity.

Economic conceptions

Joseph Schumpeter defined economic innovation in "Theorie der Wirtschaftlichen Entwicklung" (1912). (The Theory of Economic Development, 1934, Harvard University Press, Boston.)

The introduction of a new good — that is one with which consumers are not yet familiar — or of a new quality of a good.

The introduction of a new method of production, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially.

The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.

The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.

Schumpeter's focus on innovation is reflected in Neo-Schumpeterian economics, developed by such scholars as Christopher Freeman and Giovanni Dosi.

Innovation is also studied by economists in a variety of other contexts, for example in theories of entrepreneurship or in Paul Romer's New Growth Theory. In network theory, innovation can be seen as "a new element introduced in the network which changes, even if momentarily, the costs of transactions between at least two actors, elements or nodes, in the network".

Market outcome

Market outcome from innovation can be studied from different lenses. The industrial organizational approach of market characterization according to the degree of competitive pressure and the consequent modelling of firm behavior often using sophisticated game theoretic tools, while permitting mathematical modelling, has shifted the ground away from an intuitive understanding of markets. The earlier visual framework in economics, of market demand and supply along price and quantity dimensions, has given way to powerful mathematical models which though intellectually satisfying has led policy makers and managers groping for more intuitive and less theoretical analyses to which they can relate to at a practical level.

In the management (strategy) literature on the other hand, there is a vast array of relatively simple and intuitive models for both managers and consultants to choose from. Most of these models provide insights to the manager which help in crafting a strategic plan consistent with the desired aims. Indeed most strategy models are generally simple, wherein lie their virtue. In the process however, these models often fail to offer insights into situations beyond that for which they are designed, often due to the adoption of frameworks seldom analytical, seldom rigorous. The situational analyses of these models often tend to be descriptive and seldom robust and rarely present behavioral relationship between variables under study.

From an academic point of view, there is often a divorce between industrial organisation theory and strategic management models. While many economists view management models as being too simplistic, strategic management consultants perceive academic economists as being too theoretical, and the analytical tools that they devise as too complex for managers to understand.

Innovation literature while rich in typologies and descriptions of innovation dynamics is mostly technology focused. Most research on innovation has been devoted to the

process (technological) of innovation, or has otherwise taken a how to (innovate) approach.

Sources of innovation

There are several sources of innovation. In the 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. 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. Eric von Hippel has identified end-user innovation as, by far, the most important and critical in his classic book on the subject, *Sources of Innovation*.

Joseph F. Engelberger, paraphrasing the conclusion of the 1967 US DoD program "Project Hindsight", says that innovations require only three things: 1. A recognized need, 2. Competent people with relevant technology, and 3. Financial support.

Innovation by businesses is achieved in many ways, with much attention now given to formal research and development for "breakthrough innovations." But innovations may be developed by less formal on-the-job modifications of practice, through exchange and combination of professional experience and by many other routes. 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.

Regarding user innovation, a great deal of innovation is done by those actually implementing and using technologies and products as part of their normal activities. 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.

Whether innovation is mainly supply-pushed (based on new technological possibilities) or demand-led (based on social needs and market requirements) has been a hotly debated topic. Similarly, what exactly drives innovation in organizations and economies remains an open question.

More recent theoretical work moves beyond this simple dualistic problem, and through empirical work shows that innovation does not just happen within the industrial supply-side, or as a result of the articulation of user demand, but through a complex set of processes that links many different players together – not only developers and users, but a wide variety of intermediary organisations such as consultancies, standards bodies etc. Work on social networks suggests that much of the most successful innovation occurs at the boundaries of organisations and industries where the problems and needs of users, and the potential of technologies can be linked together in a creative process that challenges both.

Value of experimentation

When an innovative idea requires a new business model, or radically redesigns the delivery of value to focus on the customer, a real world experimentation approach increases the chances of market success. New business models and customer experiences can't be tested through traditional market research methods. Pilot programs for new innovations set the path in stone too early thus increasing the costs of failure. On the other hand, the good news is that recent years have seen considerable progress in identifying important key factors/principles or variables that affect the probability of success in innovation. Of course, building successful businesses is such a complicated process, involving subtle interdependencies among so many variables in dynamic systems, that it is unlikely to ever be made perfectly predictable. But the more business can master the variables and experiment, the more they will be able to create new companies, products, processes and services that achieve

what they hope to achieve. An editor has expressed a concern that this article **lends undue weight to certain ideas relative to the article as a whole**. Please help to discuss and resolve the dispute before removing this message.

Stefan Thomke of Harvard Business School has written a definitive [*neutrality is disputed*] book on the importance of experimentation. *Experimentation Matters* argues that every company's ability to innovate depends on a series of experiments [successful or not], that help create new products and services or improve old ones. That period between the earliest point in the design cycle and the final release should be filled with experimentation, failure, analysis, and yet another round of experimentation. "Lather, rinse, repeat," Thomke says. Unfortunately, uncertainty often causes the most able innovators to bypass the experimental stage.

In his book, Thomke outlines six principles companies can follow to unlock their innovative potential.

Anticipate and exploit early information through 'front-loaded' innovation processes

Experiment frequently but do not overload your organization

Integrate new and traditional technologies to unlock performance

Organize for rapid experimentation

Fail early and often but avoid 'mistakes'

Manage projects as experiments.

Thomke further explores what would happen if the principles outlined above were used beyond the confines of the individual organization. For instance, in the state of Rhode Island, innovators are collaboratively leveraging the state's compact geography, economic and demographic diversity and close-knit networks to quickly and cost-effectively test new business models through a real-world experimentation lab.

Diffusion

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 life cycle 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.

Goals

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) note,

"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" (p.6)

In general, business organisations spend a significant amount of their turnover on innovation, such as making changes to their established products, processes and services. The amount of investment can vary from as low as a half a percent of turnover for organisations with a low rate of change to anything over twenty percent of turnover for organisations with a high rate of change.

The average investment across all types of organizations is four percent. For an organisation with a turnover of one billion currency units, this would represent an investment of forty million units. This budget will typically be spread across various

functions including marketing, product design, information systems, manufacturing systems and quality assurance. The investment may vary by industry and by market positioning.

One survey across a large number of manufacturing and services organisations 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 labour costs
- Improved production processes
- Reduced materials
- Reduced environmental damage
- Replacement of products/services
- Reduced energy consumption
- Conformance to regulations

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. Nevertheless whether innovation goals are successfully achieved or otherwise depends greatly on the environment prevailing in the firm (Khan et al, 1989).

Failure

Research findings vary, ranging from fifty to ninety percent of innovation projects judged to have made little or no contribution to organizational goals. One survey regarding product innovation quotes that out of three thousand ideas for new products, only one becomes a success in the marketplace. Failure is an inevitable part of the innovation process, and most successful organisations factor in an appropriate level of risk.

Perhaps it is because all organisations experience failure that many choose not to monitor the level of failure very closely. The impact of failure goes beyond the simple loss of investment. Failure can also lead to loss of morale among employees, an increase in cynicism and even higher resistance to change in the future.

Innovations that fail are often potentially good ideas but have been rejected or postponed due to budgetary constraints, lack of skills or poor fit with current goals. Failures should be identified and screened out as early in the process as possible. Early screening avoids unsuitable ideas devouring scarce resources that are needed to progress more beneficial ones. Organizations can learn how to avoid failure when it is openly discussed and debated. The lessons learned from failure often reside longer in the organisational consciousness than lessons learned from success. While learning is important, high failure rates throughout the innovation process are wasteful and a threat to the organisation's future.

The causes of failure have been widely researched and can vary considerably. Some causes will be external to the organisation and outside its influence of control. Others will be internal and ultimately within the control of the organisation. Internal causes of failure can be divided into causes associated with the cultural infrastructure and causes associated with the innovation process itself. Failure in the cultural infrastructure varies between organizations but the following are common across all organisations at some stage in their life cycle

Poor Leadership

Poor Organization

Poor Communication

Poor Empowerment

Poor Knowledge Management

Common causes of failure within the innovation process in most organisations 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

Effective goal definition requires that organisations state explicitly what their goals are in terms understandable to everyone involved in the innovation process. This often involves stating goals in a number of ways. Effective alignment of actions to goals should link explicit actions such as ideas and projects to specific goals. It also implies effective management of action portfolios. Participation in teams refers to the behaviour of individuals in and of teams, and each individual should have an explicitly allocated responsibility regarding their role in goals and actions and the payment and rewards systems that link them to goal attainment. Finally, effective monitoring of results requires the monitoring of all goals, actions and teams involved in the innovation process.

Innovation can fail if seen as an organisational process whose success stems from a mechanistic approach i.e. 'pull lever obtain result'. While 'driving' change has an emphasis on control, enforcement and structure it is only a partial truth in achieving innovation. Organisational gatekeepers frame the organisational environment that "Enables" innovation; however innovation is "Enacted" – recognised, developed, applied and adopted – through individuals.

Individuals are the 'atom' of the organisation close to the minutiae of daily activities. Within individuals gritty appreciation of the small detail combines with a sense of desired organisational objectives to deliver (and innovate for) a product/service offer.

From this perspective innovation succeeds from strategic structures that engage the individual to the organisation's benefit. Innovation pivots on intrinsically motivated individuals, within a supportive culture, informed by a broad sense of the future.

Innovation, implies change, and can be counter to an organisation's orthodoxy. Space for fair hearing of innovative ideas is required to balance the potential autoimmune exclusion that quells an infant innovative culture.

Measures

There are two fundamentally different types of measures for innovation: the organizational level and the political level. The measure of innovation at the organizational level relates to individuals, team-level assessments, private companies from the smallest to the largest. 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. For the political level, measures of innovation are more focussing 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.

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. This being said, 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 GNP.

The Oslo Manual is focused on North America, Europe, and other rich economies. In 2001 for Latin America and the Caribbean countries it was created the Bogota Manual

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 widely ignored. For an example, that means you can have the better high tech or software, but there are also crucial learning tasks important for innovation. But these measurements and research are rarely done.

A common industry view (unsupported by empirical evidence) is that comparative cost-effectiveness research (CER) is a form of price control which, by reducing returns to industry, limits R&D expenditure, stifles future innovation and compromises new products access to markets. Some academics claim the CER is a valuable value-based measure of innovation which accords truly significant advances in therapy (those that provide 'health gain') higher prices than free market mechanisms. 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. The Australian academic Thomas Alured Faunce has developed the case that national comparative cost-effectiveness assessment systems should be viewed as measuring 'health innovation' as an evidence-based concept distinct from valuing innovation through the operation of competitive markets (a method which requires strong anti-trust laws to be effective) on the basis that both methods of assessing innovation in pharmaceuticals are mentioned in annex 2C.1 of the AUSFTA.

Political Level Studies

There are several international benchmarking studies of the innovation performance of countries (above called the political level), Global Innovation Index (below) being one. Other examples are Richard Florida's index for the **Creative Class** and 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 being: 1. Sweden 82.2, 2. Finland 77.8, 3. United States 3 77.5.

The **Global Innovation Index** is a global index measuring the level of innovation of a country, produced jointly by The Boston Consulting Group (BCG), the National Association of Manufacturers (NAM), and The Manufacturing Institute (MI), the NAM's nonpartisan research affiliate. NAM describes it as the "largest and most comprehensive global index of its kind".

The International Innovation Index is part of a large research study that looked at both the business outcomes of innovation and government's ability to encourage and support innovation through public policy. The study comprised a survey of more than 1,000 senior executives from NAM member companies across all industries; in-depth interviews with 30 of the executives; and a comparison of the "innovation friendliness" of 110 countries and all 50 U.S. states. The findings are published in the report, "The Innovation Imperative in Manufacturing: How the United States Can Restore Its Edge."

The report discusses not only country performance but also what companies are doing and should be doing to spur innovation. It looks at new policy indicators for innovation, including tax incentives and policies for immigration, education and intellectual property.

The latest index was published in March 2009. To rank the countries, the study measured both innovation inputs and outputs. Innovation inputs included government and fiscal policy, education policy and the innovation environment. Outputs included patents, technology transfer, and other R&D

results; business performance, such as labor productivity and total shareholder returns; and the impact of innovation on business migration and economic growth.

Public awareness of innovation is an important part of the innovation process. This is further discussed in the emerging fields of innovation journalism and innovation communication.



DIFFUSION OF INNOVATIONS

Diffusion of Innovations is a theory of how, why, and at what rate new ideas and technology spread through cultures. The concept was first studied by the French sociologist Gabriel Tarde (1890) and by German and Austrian anthropologists such as Friedrich Ratzel or Leo Frobenius. Its basic epidemiological or internal-influence form was described by H. Earl Pemberton, who provided examples of institutional diffusions such as postage stamps or compulsory school laws. The publication of a study of Ryan and Gross on the diffusion of hybrid corn in Iowa was the first sustainably visible contribution in a broader interest in innovations which was especially popularized by the textbook by Everett Rogers (1962), *Diffusion of Innovations* (Rogers 1962). He defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system."

The origins of the diffusion of innovations theory are varied and span across multiple disciplines. Rogers identifies six main traditions that impacted diffusion research: anthropology, early sociology, rural sociology, education, industrial, and medical sociology. The diffusion of innovation theory has been largely influenced by the work of rural sociologists. In the book *Diffusion of Innovations*, Rogers synthesizes research from over 508 diffusion studies and produces a theory for the adoption of innovations among individuals and organization.

Elements of diffusion of innovations

The key elements in diffusion research are:

Innovation

Rogers defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" .

Communication channels

A communication channel is "the means by which messages get from one individual to another" .

Time

"The innovation-decision period is the length of time required to pass through the innovation-decision process" .

"Rate of adoption is the relative speed with which an innovation is adopted by members of a social system" .

Social system

"A social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" .

Types of innovation-decisions

There are three types of innovation-decisions within diffusion of innovations. An individual or an organization/social system bases the type of decision on whether an innovation is adopted/rejected. The three types of innovation-decisions are: Optional innovation-decisions, collective innovation-decisions, authority innovation-decisions.

Optional Innovation-Decision

This decision is made by an individual who is in some way distinguished from others in a social system.

Collective Innovation-Decision

This decision is made collectively by all individuals of a social system.

Authority Innovation-Decision

This decision is made for the entire social system by few individuals in positions of influence or power.

The adoption process

Diffusion of an innovation occurs through a five-step process. This process is a type of decision-making. It occurs through a series of communication channels over a period of time among the members of a similar social system. Ryan & Gross first indicated the identification of adoption as a process in 1943 (Rogers 1962, p. 79). Rogers categorizes the five stages (steps) as: awareness, interest, evaluation, trial, and adoption. It should be noted that an individual might reject an innovation at anytime during or after the adoption process. In later editions of the Diffusion of Innovations Rogers changes the terminology of the five stages to: knowledge, persuasion, decision, implementation, and confirmation. However the descriptions of the categories have remained similar throughout the editions.

Five stages of the adoption process

In this stage the individual is first exposed to an innovation but lacks information about the innovation. It should be noted that during this stage of the process the individual has not been inspired to find more information about the innovation.

Persuasion

In this stage the individual is interested in the innovation and actively seeks information/detail about the innovation.

Decision

In this stage the individual takes the concept of the innovation and weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject the innovation. Due to the individualistic nature of this stage Rogers notes that it is the most difficult stage to acquire empirical evidence .

Implementation

In this stage the individual employs the innovation to a varying degree depending on the situation. During this stage the individual determines the usefulness of the innovation and may search for further information about it.

Confirmation

Although the name of this stage may be misleading, in this stage the individual finalizes their decision to continue using the innovation and may use the innovation to its fullest potential.

Rates of adoption

The rate of adoption is defined as: the relative speed with which members of a social system adopt an innovation. It is usually measured by the length of time required for a certain percentage of the members of a social system to adopt an innovation. The rates of adoption for innovations are determined by an individual's adopter category. In general individuals who first adopt an innovation require a shorter adoption period (adoption process) than late adopters. Within the rate of adoption there is a point at which an innovation reaches critical mass. This is a point in time within the adoption curve that enough individuals have adopted an innovation in order that the continued adoption of the innovation is self-sustaining. In describing how an innovation reaches critical mass, Rogers outlines several strategies in order to help an innovation reach this stage. These strategies are: have an innovation adopted by a highly respected individual within a social network, creating an instinctive desire for a specific innovation. Inject an innovation into a group of individuals who would readily use an innovation, and provide positive reactions and benefits for early adopters of an innovation.

Characteristics of innovations

Rogers defines several intrinsic characteristics of innovations that influence an individual's decision to adopt or reject an innovation. The relative advantage is how improved an innovation is over the previous generation. Compatibility is the second characteristic, the level of compatibility that an innovation has to be assimilated into an individual's life. The complexity of an innovation is a significant factor in whether it is adopted by an individual. If the innovation is too difficult to use an individual will not likely adopt it. The fourth

characteristic, trialability, determines how easily an innovation may be experimented with as it is being adopted. If a user has a hard time using and trying an innovation this individual will be less likely to adopt it. The final characteristic, observability, is the extent that an innovation is visible to others. An innovation that is more visible will drive communication among the individual's peers and personal networks and will in turn create more positive or negative reactions.

Adopter categories

Rogers defines an adopter category as a classification of individuals within a social system on the basis of innovativeness. In the book *Diffusion of Innovations*, Rogers suggests a total of five categories of adopters in order to standardize the usage of adopter categories in diffusion research. It should be noted that the adoption of an innovation follows an S curve when plotted over a length of time. The categories of adopters are: innovators, early adopters, early majority, late majority, and laggards

Innovators

Innovators are the first individuals to adopt an innovation. Innovators are willing to take risks, youngest in age, have the highest social class, have great financial lucidity, very social and have closest contact to scientific sources and interaction with other innovators.

Early Adopters

This is second fastest category of individuals who adopt an innovation. These individuals have the highest degree of opinion leadership among the other adopter categories. Early adopters are typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters .

Early Majority

Individuals in this category adopt an innovation after a varying degree of time. This time of adoption is significantly longer than the innovators and early adopters. Early Majority tend to be slower in the adoption process, have above average

social status, contact with early adopters, and show some opinion leadership

Late Majority

Individuals in this category will adopt an innovation after the average member of the society. These individuals approach an innovation with a high degree of skepticism and after the majority of society has adopted the innovation. Late Majority are typically skeptical about an innovation, have below average social status, very little financial lucidity, in contact with others in late majority and early majority, very little opinion leadership.

Laggards

Individuals in this category are the last to adopt an innovation. Unlike some of the previous categories, individuals in this category show little to no opinion leadership. These individuals typically have an aversion to change-agents and tend to be advanced in age. Laggards typically tend to be focused on "traditions", have lowest social status, lowest financial fluidity, oldest of all other adopters, in contact with only family and close friends, very little to no opinion leadership.

Heterophily and communication channels

Lazarsfeld and Merton first called attention to the principles of homophily and its opposite, heterophily. Using their definition, Rogers defines homophily as "the degree to which pairs of individuals who interact are similar in certain attributes, such as beliefs, education, social status, and the like". When given the choice, individuals usually choose to interact with someone similar to him or herself. Furthermore, homophilous individuals engage in more effective communication because their similarities lead to greater knowledge gain as well as attitude or behavior change. However, most participants in the diffusion of innovations are heterophilous, meaning they speak different languages, so to speak. The problem is that diffusion requires a certain degree of heterophily; if two individuals are identical, no diffusion occurs because no new information can be exchanged. Therefore, an ideal situation would involve two

individuals who are homophilous in every way, except in knowledge of the innovation .

Opinion leaders within a social system

Throughout the diffusion process there is evidence that not all individuals exert an equal amount of influence over all individuals. In this sense there are Opinion Leaders, leaders who are influential in spreading either positive or negative information about an innovation. Rogers relies on the ideas of Katz & Lazarsfeld and the two-step flow theory in developing his ideas on the influence of Opinion Leaders in the diffusion process. Opinion Leaders have the most influence during the evaluation stage of the innovation-decision process and late adopters. In addition opinion leaders have a set of characteristics that set them apart from their followers and other individuals. Opinion Leaders typically have greater exposure to the mass media, more cosmopolitan, greater contact with change agents, more social experience and exposure, higher socioeconomic status, and are more innovative.

Diffusion in organizations

Innovations are often adopted by organizations through two types of innovation-decisions: collective innovation decisions and authority innovation decisions. The collection-innovation decision occurs when the adoption of an innovation has been made by a consensus among the members of an organization. The authority-innovation decision occurs when the adoption of an innovation has been made by very few individuals with high positions of power within an organization. Unlike the optional innovation decision process, these innovation - decision processes only occur within an organization or hierarchical group. Within the innovation decision process in an organization there are certain individuals termed "champions" who stand behind an innovation and break through any opposition that the innovation may have caused. The champion within the diffusion of innovation theory plays a very similar role as to the champion used within the efficiency business model Six Sigma. The innovation process within an organization contains five

stages that are slightly similar to the innovation-decision process that individuals undertake. These stages are: agenda-setting, matching, redefining/restructuring, clarifying, routinizing.

Consequences of adoption

There are both positive and negative outcomes when an individual or organization chooses to adopt a particular innovation. Rogers states that this is an area that needs further research because of the biased positive attitude that is associated with the adoption of a new innovation. In the *Diffusion of Innovation*, Rogers lists three categories for consequences: desirable vs. undesirable, direct vs. indirect, and anticipated vs. unanticipated.

In her article, "Integrating Models of Diffusion of Innovations," Barbara Wejnert details two categories for consequences: public vs. private and benefits vs. costs.

Public vs. Private

Public consequences refer to the impact of an innovation on those other than the actor, while private consequences refer to the impact on the actor itself. Public consequences usually involve collective actors, such as countries, states, organizations, or social movements. The results are usually concerned with issues of societal well-being. Private consequences usually involve individuals or small collective entities, such as a community. The innovations are usually concerned with the improvement of quality of life or the reform of organizational or social structures.

Benefits vs. Costs

The benefits of an innovation obviously refer to the positive consequences, while the costs refer to the negative. Costs may be monetary or nonmonetary, direct or indirect. Direct costs are usually related to financial uncertainty and the economic state of the actor. Indirect costs are more difficult to identify. An example would be the need to buy a new kind of fertilizer to use innovative seeds. Indirect costs may also be social, such as social conflict caused by innovation.

Diffusion and management

Much of the evidence for the diffusion of innovations gathered by Rogers comes from agricultural methods and medical practice.

Various computer models have been developed in order to simulate the diffusion of innovations. Veneris developed a systems dynamics computer model which takes into account various diffusion patterns modeled via differential equations.

There are a number of criticisms of the model which make it less than useful for managers. First, technologies are not static. There is continual innovation in order to attract new adopters all along the S-curve. The S-curve does not just 'happen'. Instead, the s-curve can be seen as being made up of a series of 'bell curves' of different sections of a population adopting different versions of a generic innovation.

The role of electronic communication social networks in assisting the diffusion of innovation

Prior to the introduction of the Internet, it was argued that social networks had a crucial role in the diffusion of innovation particularly Tacit knowledge in the book *The IRG Solution - hierarchical incompetence and how to overcome it*. The book argued that the widespread adoption of computer networks of individuals would lead to the much better diffusion of innovations, and with greater understanding of their possible shortcomings, and the identification of needed innovations that would not have otherwise occurred - the Relevance paradox.



PRODUCTIVITY

Productivity is a measure of output from a production process, per unit of input. For example, labor productivity is typically measured as a ratio of output per labor-hour, an input. Productivity may be conceived of as a metric of the technical or engineering efficiency of production. As such, the emphasis is on quantitative metrics of input, and sometimes output. Productivity is distinct from metrics of allocative efficiency, which take into account both the monetary value (price) of what is produced and the cost of inputs used, and also distinct from metrics of profitability, which address the difference between the revenues obtained from output and the expense associated with consumption of inputs. (Courbois & Temple 1975, Gollop 1979, Kurosawa 1975, Pineda 1990, Saari 2006).

Economic growth and productivity

Production is a process of combining various material inputs (stuff) and immaterial inputs (plans, know-how) in order to make something for consumption (the output). The methods of combining the inputs of production in the process of making output are called technology. Technology can be depicted mathematically by the production function which describes the relation between input and output. The production function can be used as a measure of relative performance when comparing technologies.

The production function is a simple description of the mechanism of economic growth. Economic growth is defined as any production increase of a business or nation (whatever you are measuring). It is usually expressed as an annual growth percentage depicting growth of the company output (per entity) or the national product (per nation). Real economic growth (as

opposed to inflation) consists of two components. These components are an increase in production input and an increase in productivity. (Genesca & Grifell 1992, Saari 2006)

The figure illustrates an economic growth process (exaggerated for clarity). The Value T2 (value at time 2) represents the growth in output from Value T1 (value at time 1). Each time of measurement has its own graph of the production function for that time (the straight lines). The output measured at time 2 is greater than the output measured at time one for both of the components of growth: an increase of inputs and an increase of productivity. The portion of growth caused by the increase in inputs is shown on line 1 and does not change the relation between inputs and outputs. The portion of growth caused by an increase in productivity is shown on line 2 with a steeper slope. So increased productivity represents greater output per unit of input.

Accordingly, an increase in productivity is characterised by a shift of the production function (steepening slope) and a consequent change to the output/input relation. The formula of total productivity is normally written as follows:

$$\text{Total productivity} = \text{Output quantity} / \text{Input quantity}$$

According to this formula, changes in input and output have to be measured inclusive of both quantitative and qualitative changes. (Jorgenson and Griliches 1967). In practice, quantitative and qualitative changes take place when relative quantities and relative prices of different input and output factors alter. In order to accentuate qualitative changes in output and input, the formula of total productivity shall be written as follows:

$$\text{Total productivity} = \text{Output quality and quantity} / \text{Input quality and quantity}$$

Main processes of a company

A company can be divided into sub-processes in different ways; yet, the following five are identified as main processes, each with a logic, objectives, theory and key figures of its own.

It is important to examine each of them individually, yet, as a part of the whole, in order to be able to measure and understand them. The main processes of a company are as follows

- real process
- income distribution process
- production process
- monetary process
- market value process

Productivity is created in the real process, productivity gains are distributed in the income distribution process and these two processes constitute the production process. The production process and its sub-processes, the real process and income distribution process occur simultaneously, and only the production process is identifiable and measurable by the traditional accounting practices. The real process and income distribution process can be identified and measured by extra calculation, and this is why they need to be analysed separately in order to understand the logic of production performance.

Real process generates the production output from input, and it can be described by means of the production function. It refers to a series of events in production in which production inputs of different quality and quantity are combined into products of different quality and quantity. Products can be physical goods, immaterial services and most often combinations of both. The characteristics created into the product by the manufacturer imply surplus value to the consumer, and on the basis of the price this value is shared by the consumer and the producer in the marketplace. This is the mechanism through which surplus value originates to the consumer and the producer likewise. Surplus value to the producer is a result of the real process, and measured proportionally it means productivity.

Income distribution process of the production refers to a series of events in which the unit prices of constant-quality products and inputs alter causing a change in income

distribution among those participating in the exchange. The magnitude of the change in income distribution is directly proportionate to the change in prices of the output and inputs and to their quantities. Productivity gains are distributed, for example, to customers as lower product sales prices or to staff as higher income pay. Davis has deliberated (Davis 1955) the phenomenon of productivity, measurement of productivity, distribution of productivity gains, and how to measure such gains. He refers to an article (1947, *Journal of Accountancy*, Feb. p. 94) suggesting that the measurement of productivity shall be developed so that it "will indicate increases or decreases in the productivity of the company and also the distribution of the 'fruits of production' among all parties at interest". According to Davis, the price system is a mechanism through which productivity gains are distributed, and besides the business enterprise, receiving parties may consist of its customers, staff and the suppliers of production inputs. In this article, the concept of "distribution of the fruits of production" by Davis is simply referred to as production income distribution or shorter still as distribution.

The production process consists of the real process and the income distribution process. A result and a criterion of success of the production process is profitability. The profitability of production is the share of the real process result the producer has been able to keep to himself in the income distribution process. Factors describing the production process are the components of profitability, i.e., returns and costs. They differ from the factors of the real process in that the components of profitability are given at nominal prices whereas in the real process the factors are at periodically fixed prices.

Monetary process refers to events related to financing the business. Market value process refers to a series of events in which investors determine the market value of the company in the investment markets.

Surplus value as a measure of production profitability

The scale of success run by a going concern is manifold, and there are no criteria that might be universally applicable to success. Nevertheless, there is one criterion by which we can generalise the rate of success in production. This criterion is the ability to produce surplus value. As a criterion of profitability, surplus value refers to the difference between returns and costs, taking into consideration the costs of equity in addition to the costs included in the profit and loss statement as usual. Surplus value indicates that the output has more value than the sacrifice made for it, in other words, the output value is higher than the value (production costs) of the used inputs. If the surplus value is positive, the owner's profit expectation has been surpassed.

The table presents a surplus value calculation. This basic example is a simplified profitability calculation used for illustration and modelling. Even as reduced, it comprises all phenomena of a real measuring situation and most importantly the change in the output-input mix between two periods. Hence, the basic example works as an illustrative "scale model" of production without any features of a real measuring situation being lost. In practice, there may be hundreds of products and inputs but the logic of measuring does not differ from that presented in the basic example.

Both the absolute and relative surplus value have been calculated in the example. Absolute value is the difference of the output and input values and the relative value is their relation, respectively. The surplus value calculation in the example is at a nominal price, calculated at the market price of each period.

Productivity model

The next step is to describe a productivity model (Courbois & Temple 1975, Gollop 1979, Kurosawa 1975, Saari 1976, 2006) by help of which it is possible to calculate the results of the real process, income distribution process and production process. The starting point is a profitability calculation using surplus value as a criterion of profitability. The surplus value

calculation is the only valid measure for understanding the connection between profitability and productivity or understanding the connection between real process and production process. A valid measurement of total productivity necessitates considering all production inputs, and the surplus value calculation is the only calculation to conform to the requirement.

The process of calculating is best understood by applying the clause of *Ceteris paribus*, i.e. "all other things being the same," stating that at a time only the impact of one changing factor be introduced to the phenomenon being examined. Therefore, the calculation can be presented as a process advancing step by step. First, the impacts of the income distribution process are calculated, and then, the impacts of the real process on the profitability of the production .

The first step of the calculation is to separate the impacts of the real process and the income distribution process, respectively, from the change in profitability ($285.12 - 266.00 = 19.12$). This takes place by simply creating one auxiliary column (4) in which a surplus value calculation is compiled using the quantities of Period 1 and the prices of Period 2. In the resulting profitability calculation, Columns 3 and 4 depict the impact of a change in income distribution process on the profitability and in Columns 4 and 7 the impact of a change in real process on the profitability.

Illustration of the real and income distribution processes

Measurement results can be illustrated by models and graphic presentations. The following figure illustrates the connections between the processes by means of indexes describing the change. A presentation by means of an index is illustrative because the magnitudes of the changes are commensurate. Figures are from the above calculation example of the production model. (Loggerenberg van et al. 1982. Saari 2006).

The nine most central key figures depicting changes in production performance can be presented as shown in Figure.

Vertical lines depict the key figures of the real process, production process and income distribution process. Key figures in the production process are a result of the real process and the income distribution process. Horizontal lines show the changes in input and output processes and their impact on profitability. The logic behind the figure is simple. Squares in the corners refer to initial calculation data. Profitability figures are obtained by dividing the output figures by the input figures in each process. After this, the production process figures are obtained by multiplying the figures of the real and income distribution processes.

Depicting the development by time series

Development in the real process, income distribution process and production process can be illustrated by means of time series. (Kendrick 1984, Saari 2006) The principle of a time series is to describe, for example, the profitability of production annually by means of a relative surplus value and also to explain how profitability was produced as a consequence of productivity development and income distribution. A time series can be composed using the chain indexes as seen in the following.

Now the intention is to draw up the time series for the ten periods in order to express the annual profitability of production by help of productivity and income distribution development. With the time series it is possible to prove that productivity of the real process is the distributable result of production, and profitability is the share remaining in the company after income distribution between the company and interested parties participating in the exchange.

The graph shows how profitability depends on the development of productivity and income distribution. Productivity figures are fictional but in practice they are perfectly feasible indicating an annual growth of 1.5 per cent on average. Growth potentials in productivity vary greatly by industry, and as a whole, they are directly proportionate to the technical development in the branch. Fast-developing industries attain stronger growth in productivity. This is a traditional way of

thinking. Today we understand that human and social capitals together with competition have a significant impact on productivity growth. In any case, productivity grows in small steps. By the accurate measurement of productivity, it is possible to appreciate these small changes and create an organisation culture where continuous improvement is a common value.

Measuring and interpreting partial productivity

Measurement of partial productivity refers to the measurement solutions which do not meet the requirements of total productivity measurement, yet, being practicable as indicators of total productivity. In practice, measurement in production means measures of partial productivity. In that case, the objects of measurement are components of total productivity, and interpreted correctly, these components are indicative of productivity development. The term of partial productivity illustrates well the fact that total productivity is only measured partially – or approximately. In a way, measurements are defective but, by understanding the logic of total productivity, it is possible to interpret correctly the results of partial productivity and to benefit from them in practical situations.

- Comparison of basic measure types (Saari 2006)
- Typical solutions of partial productivity are:
 - Single-factor productivity
 - Value-added productivity
 - Unit cost accounting
 - Efficiency ratios
 - Managerial control ratio system

Single-factor productivity refers to the measurement of productivity that is a ratio of output and one input factor. A most well-known measure of single-factor productivity is the measure of output per work input, describing work productivity. Sometimes it is practical to employ the value added as output. Productivity measured in this way is called Value-added

productivity. Also, productivity can be examined in cost accounting using Unit costs. Then it is mostly a question of exploiting data from standard cost accounting for productivity measurements. Efficiency ratios, which tell something about the ratio between the value produced and the sacrifices made for it, are available in large numbers. Managerial control ratio systems are composed of single measures which are interpreted in parallel with other measures related to the subject. Ratios may be related to any success factor of the area of responsibility, such as profitability, quality, position on the market, etc. Ratios may be combined to form one whole using simple rules, hence, creating a key figure system.

The measures of partial productivity are physical measures, nominal price value measures and fixed price value measures. These measures differ from one another by the variables they measure and by the variables excluded from measurements. By excluding variables from measurement makes it possible to better focus the measurement on a given variable, yet, this means a more narrow approach. The table below was compiled to compare the basic types of measurement. The first column presents the measure types, the second the variables being measured, and the third column gives the variables excluded from measurement.

National productivity

Productivity measures are often used to indicate the capacity of a nation to harness its human and physical resources to generate economic growth. Productivity measures are key indicators of economic performance and there is strong interest in comparing them internationally. The OECD publishes an annual Compendium of Productivity Indicators that includes both labour and multi-factor measures of productivity.

Labour productivity and multi-factor productivity

Labour productivity is the ratio of (the real value of) output to the input of labour. Where possible, hours worked, rather than the numbers of employees, is used as the measure of labour input. With an increase in part-time employment, hours

worked provides the more accurate measure of labour input. Labour productivity should be interpreted very carefully if used as a measure of efficiency. In particular, it reflects more than just the efficiency or productivity of workers. Labour productivity is the ratio of output to labour input; and output is influenced by many factors that are outside of workers' influence, including the nature and amount of capital equipment that is available, the introduction of new technologies, and management practices.

Multifactor productivity is the ratio of the real value of output to the combined input of labour and capital. Sometimes this measure is referred to as total factor productivity. In principle, multifactor productivity is a better indicator of efficiency. It measures how efficiently and effectively the main factors of production - labour and capital - combine to generate output. However, in some circumstances, robust measures of capital input can be hard to find.

Labour productivity and multifactor productivity both increase over the long term. Usually, the growth in labour productivity exceeds the growth in multifactor productivity, reflecting the influence of relatively rapid growth of capital on labour productivity.

Importance of national productivity growth

Productivity growth is a crucial source of growth in living standards. Productivity growth means more value is added in production and this means more income is available to be distributed.

At a firm or industry level, the benefits of productivity growth can be distributed in a number of different ways:

- to the workforce through better wages and conditions;
- to shareholders and superannuation funds through increased profits and dividend distributions;
- to customers through lower prices;
- to the environment through more stringent environmental protection; and

- to governments through increases in tax payments (which can be used to fund social and environmental programs).

Productivity growth is important to the firm because it means that it can meet its (perhaps growing) obligations to workers, shareholders, and governments (taxes and regulation), and still remain competitive or even improve its competitiveness in the market place.

There are essentially two ways to promote growth in output:

- bring additional inputs into production; or
- increase productivity.

Adding more inputs will not increase the income earned per unit of input (unless there are increasing returns to scale). In fact, it is likely to mean lower average wages and lower rates of profit.

But, when there is productivity growth, even the existing commitment of resources generates more output and income. Income generated per unit of input increases. Additional resources are also attracted into production and can be profitably employed.

At the national level, productivity growth raises living standards because more real income improves people's ability to purchase goods and services (whether they are necessities or luxuries), enjoy leisure, improve housing and education and contribute to social and environmental programs.

'Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker. World War II veterans came home to an economy that doubled its productivity over the next 25 years; as a result, they found themselves achieving living standards their parents had never imagined.

Vietnam veterans came home to an economy that raised its productivity less than 10 percent in 15 years; as a result, they found themselves living no better - and in many cases worse -

than their parents' (Krugman, 1992). Paul Krugman 1992, *The Age of Diminished Expectations: US Economic Policy in the 1980s*, MIT Press, Cambridge, p. 9.

'Over long periods of time, small differences in rates of productivity growth compound, like interest in a bank account, and can make an enormous difference to a society's prosperity. Nothing contributes more to reduction of poverty, to increases in leisure, and to the country's ability to finance education, public health, environment and the arts' (Blinder and Baumol, 1993). Alan Blinder and William Baumol 1993, *Economics: Principles and Policy*, Harcourt Brace Jovanovich, San Diego, p. 778.

Sources of productivity growth

In the most immediate sense, productivity is determined by:

- the available technology or know-how for converting resources into outputs desired in an economy; and
- the way in which resources are organised in firms and industries to produce goods and services.

Average productivity can improve as firms move toward the best available technology; plants and firms with poor productivity performance cease operation; and as new technologies become available. Firms can change organisational structures (eg core functions and supplier relationships), management systems and work arrangements to take the best advantage of new technologies and changing market opportunities. A nation's average productivity level can also be affected by the movement of resources from low-productivity to high-productivity industries and activities.

National productivity growth stems from a complex interaction of factors. As just outlined, some of the most important immediate factors include technological change, organisational change, industry restructuring and resource reallocation, as well as economies of scale and scope. Over time, other factors such as research and development and

innovative effort, the development of human capital through education, and incentives from stronger competition promote the search for productivity improvements and the ability to achieve them. Ultimately, many policy, institutional and cultural factors determine a nation's success in improving productivity.

Aspects of productivity

Productivity studies

Productivity studies analyze technical processes and engineering relationships such as how much of an output can be produced in a specified period of time (see also Taylorism). It is related to the concept of efficiency. While productivity is the amount of output produced relative to the amount of resources (time and money) that go into the production, efficiency is the value of output relative to the cost of inputs used. Productivity improves when the quantity of output increases relative to the quantity of input. Efficiency improves, when the cost of inputs used is reduced relative the value of output. A change in the price of inputs might lead a firm to change the mix of inputs used, in order to reduce the cost of inputs used, and improve efficiency, without actually increasing the quantity of output relative the quantity of inputs. A change in technology, however, might allow a firm to increase output with a given quantity of inputs; such an increase in productivity would be more technically efficient, but might not reflect any change in allocative efficiency.

Increases in productivity

Companies can increase productivity in a variety of ways. The most obvious methods involve automation and computerization which minimize the tasks that must be performed by employees. Recently, less obvious techniques are being employed that involve ergonomic design and worker comfort. A comfortable employee, the theory maintains, can produce more than a counterpart who struggles through the day. In fact, some studies claim that measures such as raising workplace temperature can have a drastic effect on office productivity. Experiments done by the Japanese Shiseido

corporation also suggested that productivity could be increased by means of perfuming or deodorising the air conditioning system of workplaces. Increases in productivity also can influence society more broadly, by improving living standards, and creating income. They are central to the process generating economic growth and capital accumulation. A new theory suggests that the increased contribution that productivity has on economic growth is largely due to the relatively high price of technology and its exportation via trade, as well as domestic use due to high demand, rather than attributing it to micro economic efficiency theories which tend to downsize economic growth and reduce labor productivity for the most part. Many economists see the economic expansion of the later 1990s in the United States as being allowed by the massive increase in worker productivity that occurred during that period. The growth in aggregate supply allowed increases in aggregate demand and decreases in unemployment at the same time that inflation remained stable. Others emphasize drastic changes in patterns of social behaviour resulting from new communication technologies and changed male-female relationships.

Labor productivity

Labour productivity is generally speaking held to be the same as the "average product of labor" (average output per worker or per worker-hour, an output which could be measured in physical terms or in price terms). It is not the same as the marginal product of labor, which refers to the increase in output that results from a corresponding increase in labor input. The qualitative aspects of labor productivity such as creativity, innovation, teamwork, improved quality of work and the effects on other areas in a company are more difficult to measure.

Marx on productivity

In Karl Marx's labor theory of value, the concept of capital productivity is rejected as an instance of reification, and replaced with the concepts of the organic composition of capital and the value product of labor. A sharp distinction is drawn by Marx for the productivity of *labor* in terms of *physical* outputs

produced, and the *value* or *price* of those outputs. A small physical output might create a large value, while a large physical output might create only a small value - with obvious consequences for the way the labor producing it would be rewarded in the marketplace. Moreover if a large output *value* was created by people, this did not *necessarily* have anything to do with their *physical* productivity; it could be just due to the favorable valuation of that output when traded in markets. Therefore, merely focusing on an output *value* realised, to assess productivity, might lead to mistaken conclusions. In general, Marx rejected the possibility of a concept of productivity that would be completely neutral and unbiased by the interests or norms of different social classes. At best, one could say that objectively, some practices in a society were *generally regarded* as more or less productive, or as improving productivity - irrespective of whether this was really true. In other words, productivity was always interpreted from some definite point of view. Typically, Marx suggested in his critique of political economy, only the *benefits* of raising productivity were focused on, rather than the human (or environmental) costs involved. Thus, Marx could even find some sympathy for the Luddites, and he introduced the critical-concept of the rate of exploitation of human labour power to balance the obvious economic progress resulting from an increase in the productive forces of labor.

Productivity paradox

Despite the proliferation of computers, there has not been any observable increases in productivity as a result. One hypothesis to explain this is that computers are productive, yet their productive gains are realized only after a lag period, during which complementary capital investments must be developed to allow for the use of computers to their full potential. Another hypothesis states that computers are simply not very productivity enhancing because they require time, a scarce complementary human input. This theory holds that although computers perform a variety of tasks, these tasks are not done in any

particularly new or efficient manner, but rather they are only done faster. It has also been argued that computer automation just facilitates ever more complex bureaucracies and regulation, and therefore produces a net reduction in real productivity (see Xiot-Ocio productivity). Another explanation is that knowledge work productivity and IT productivity are linked, and that without improving knowledge work productivity, IT productivity does not have a governing mechanism.



THE ARTS

The arts is a broad subdivision of culture, composed of many creative endeavors and disciplines. It is a broader term than "art," which as a description of a field usually means only the visual arts. *The arts* encompasses visual arts, literature and the performing arts - music, drama, dance and film, among others. This list is by no means comprehensive, but only meant to introduce the concept of the arts.

Definition

A good definition of *the arts* is given by the Free Dictionary as "imaginative, creative, and nonscientific branches of knowledge considered collectively, esp. as studied academically." The singular term art is defined by the Irish Art Encyclopedia as follows: "Art is created when an artist creates a beautiful object, or produces a stimulating experience that is considered by his audience to have artistic merit." So, one could conclude that art is the process that leads to a product (the artwork or piece of art), which is then examined and analyzed by experts in the field of *the arts* or simply enjoyed by those who appreciate *the arts*. The same source states:

Art is a global activity which encompasses a host of disciplines, as evidenced by the range of words and phrases which have been invented to describe its various forms. Examples of such phraseology include: *Fine Arts, Liberal Arts, Visual Arts, Decorative Arts, Applied Arts, Design, Crafts, Performing Arts*, and so on.

The term art commonly refers to the "Visual Arts," as an abbreviation of *creative art* or *fine art*. For example, the *History of art* is described as "the history of the visual arts of painting, sculpture and architecture. It is the history of one of the fine arts,

others of which are the performing arts and literature. It is also one of the humanities. The term sometimes encompasses theory of the visual arts, including aesthetics." In the article for *Fine art*, we read:

Confusion often occurs when people mistakenly refer to the Fine Arts but mean the Performing Arts (Music, Dance, Drama, etc.). However, there is some disagreement here: e.g., at York University (Toronto, Canada) Fine Arts is a faculty that includes the [visual arts], design and the "Performing Arts". Furthermore, creative writing is frequently considered a fine art as well.

To illustrate the previous statements, the College of Fine Arts at Stephen F. Austin State University (Nacogdoches, TX) consists of the Schools of "Art, Music and Theatre," while one of the Bachelor of Fine Arts degrees at the University of British Columbia is attached to the Creative Writing Program.

More work will be required to standardize the use of the terms "art" and "fine art," but for the purpose of this article the definition of "the arts" is not problematic, because it includes all the arts. One artist has even suggested that "[it] would really simplify matters if we could all just stick with visual, auditory, performance or literary - when we speak of The Arts - and eliminate "Fine" altogether."

History

For all intents and purposes, the history of the arts begins with the *history of art*, as dealt with elsewhere. Furthermore, the history of the Performing Arts and Literature have been described in other articles —(Please see: Outline of performing arts; History of literature). Some examples of creative art through the ages can be summarized here, as excerpted from the history of art.

Ancient Greek art saw the veneration of the animal form and the development of equivalent skills to show musculature, poise, beauty and anatomically correct proportions. Ancient Roman art depicted gods as idealized humans, shown with characteristic distinguishing features (i.e. Zeus' thunderbolt).

In Byzantine and Gothic art of the Middle Ages, the dominance of the church insisted on the expression of biblical and not material truths.

Eastern art has generally worked in a style akin to Western medieval art, namely a concentration on surface patterning and local colour (meaning the plain colour of an object, such as basic red for a red robe, rather than the modulations of that colour brought about by light, shade and reflection). A characteristic of this style is that the local colour is often defined by an outline (a contemporary equivalent is the cartoon). This is evident in, for example, the art of India, Tibet and Japan.

Religious Islamic art forbids iconography, and expresses religious ideas through geometry instead.

The physical and rational certainties depicted by the 19th-century Enlightenment were shattered not only by new discoveries of relativity by Einstein and of unseen psychology by Freud, but also by unprecedented technological development. Paradoxically the expressions of new technologies were greatly influenced by the ancient tribal arts of Africa and Oceania, through the works of Paul Gauguin and the Post-Impressionists, Pablo Picasso and the Cubists, as well as the Futurists and others.

The various arts

In the Middle Ages, *Artes Liberales* (liberal arts) taught in medieval universities as part of the Trivium: (grammar, rhetoric, and logic) and the Quadrivium (arithmetic, geometry, music, and astronomy), and the *Artes Mechanicae* (mechanical arts) such as metalworking, farming, cooking, business and the making of clothes or cloth. The modern distinctions between "artistic" and non-artistic skills did not develop until the Renaissance.

In modern academia, the arts are usually grouped with or a subset of the Humanities. Some subjects in the Humanities are history, linguistics, literature, and philosophy. Newspapers typically include a section on the arts.

Fine arts Drawing

Drawing is a means of making an image, using any of a wide variety of tools and techniques. It generally involves making marks on a surface by applying pressure from a tool, or moving a tool across a surface. Common tools are graphite pencils, pen and ink, inked brushes, wax color pencils, crayons, charcoals, pastels, and markers. Digital tools which simulate the effects of these are also used. The main techniques used in drawing are: line drawing, hatching, crosshatching, random hatching, scribbling, stippling, and blending. An artist who excels in drawing is referred to as a *draftswoman* or *draughtsman*.

Gastronomy

"Gastronomy" is the study of the relationship between culture and food. It is often thought erroneously that the term gastronomy refers exclusively to the art of cooking (see Culinary Arts), but this is only a small part of this discipline; it cannot always be said that a cook is also a gourmet. Gastronomy studies various cultural components with food as its central axis.

Architecture

Architecture (from Latin, *architectura* and ultimately from Greek, a a master builder", from "chief, leader" and te "builder, carpenter") is the art and science of designing buildings and structures.

A wider definition would include within its scope the design of the total built environment, from the macrolevel of town planning, urban design, and landscape architecture to the microlevel of creating furniture. Architectural design usually must address both feasibility and cost for the builder, as well as function and aesthetics for the user.

In modern usage, architecture is the art and discipline of creating an actual, or inferring an implied or apparent plan of any complex object or system. The term can be used to connote the *implied architecture* of abstract things such as music or mathematics, the *apparent architecture* of natural things, such as

geological formations or the structure of biological cells, or explicitly *planned architectures* of human-made things such as software, computers, enterprises, and databases, in addition to buildings. In every usage, an architecture may be seen as a *subjective mapping* from a human perspective (that of the *user* in the case of abstract or physical artifacts) to the elements or components of some kind of structure or system, which preserves the relationships among the elements or components.

Planned architecture manipulates space, volume, texture, light, shadow, or abstract elements in order to achieve pleasing aesthetics. This distinguishes it from applied science or engineering, which usually concentrate more on the functional and feasibility aspects of the design of constructions or structures.

In the field of building architecture, the skills demanded of an architect range from the more complex, such as for a hospital or a stadium, to the apparently simpler, such as planning residential houses. Many architectural works may be seen also as cultural and political symbols, and/or works of art. The role of the architect, though changing, has been central to the successful (and sometimes less than successful) design and implementation of pleasingly built environments in which people live.

Painting

Painting taken literally is the practice of applying pigment suspended in a vehicle (or medium) and a binding agent (a glue) to a surface (support) such as paper, canvas, wood panel or a wall. However, when used in an artistic sense it means the use of this activity in combination with drawing, composition and other aesthetic considerations in order to manifest the expressive and conceptual intention of the practitioner. Painting is also used to express spiritual motifs and ideas; sites of this kind of painting range from artwork depicting mythological figures on pottery to The Sistine Chapel to the human body itself.

Colour is the essence of painting as sound is of music. Colour is highly subjective, but has observable psychological

effects, although these can differ from one culture to the next. Black is associated with mourning in the West, but elsewhere white may be. Some painters, theoreticians, writers and scientists, including Goethe, Kandinsky, Newton, have written their own colour theory. Moreover the use of language is only a generalization for a colour equivalent. The word "red", for example, can cover a wide range of variations on the pure red of the spectrum. There is not a formalized register of different colours in the way that there is agreement on different notes in music, such as C or C#, although the Pantone system is widely used in the printing and design industry for this purpose.

Modern artists have extended the practice of painting considerably to include, for example, collage. This began with Cubism and is not painting in strict sense. Some modern painters incorporate different materials such as sand, cement, straw or wood for their texture. Examples of this are the works of Jean Dubuffet or Anselm Kiefer.

Modern and contemporary art has moved away from the historic value of craft in favour of concept; this has led some to say that painting, as a serious art form, is dead, although this has not deterred the majority of artists from continuing to practise it either as whole or part of their work.

Conceptual art

Conceptual art is art in which the concept(s) or idea(s) involved in the work take precedence over traditional aesthetic and material concerns. The inception of the term in the 1960s referred to a strict and focused practice of idea-based art that often defied traditional visual criteria associated with the visual arts in its presentation as text. However, through its association with the Young British Artists and the Turner Prize during the 1990s, its popular usage, particularly in the UK, developed as a synonym for all contemporary art that does not practise the traditional skills of painting and sculpture.

Literature

Literature is literally "acquaintance with letters" as in the first sense given in the Oxford English Dictionary (from the Latin

littera meaning "an individual written character (letter)"). The term has generally come to identify a collection of writings, which in Western culture are mainly prose, both fiction and non-fiction, drama and poetry. In much, if not all of the world, texts can be oral as well, and include such genres as epic, legend, myth, ballad, other forms of oral poetry, and as folktale.

Performing arts

The performing arts differ from the plastic arts insofar as the former uses the artist's own body, face, presence as a medium, and the latter uses materials such as clay, metal or paint which can be molded or transformed to create some art object.

Performing arts include acrobatics, busking, comedy, dance, magic, music, opera, operetta, film, juggling, martial arts, marching arts, such as brass bands, and theatre.

Artists who participate in these arts in front of an audience are called performers, including actors, comedians, dancers, musicians, and singers. Performing arts are also supported by workers in related fields, such as songwriting and stagecraft.

Performers often adapt their appearance, such as with costumes and stage makeup, etc.

There is also a specialized form of fine art in which the artists *perform* their work live to an audience. This is called Performance art. Most performance art also involves some form of plastic art, perhaps in the creation of props. Dance was often referred to as a *plastic art* during the Modern dance era.

Music

Music is an art form whose medium is sound. Common elements of music are pitch (which governs melody and harmony), rhythm (and its associated concepts tempo, meter, and articulation), dynamics, and the sonic qualities of timbre and texture. The creation, performance, significance, and even the definition of music vary according to culture and social context. Music ranges from strictly organized compositions (and their recreation in performance), through improvisational music to aleatoric forms. Music can be divided into genres and

subgenres, although the dividing lines and relationships between music genres are often subtle, sometimes open to individual interpretation, and occasionally controversial. Within "the arts", music may be classified as a performing art, a fine art, and auditory art.

Theatre

Theatre or theater (Greek "theatron",) is the branch of the performing arts concerned with acting out stories in front of an audience using combinations of speech, gesture, music, dance, sound and spectacle — indeed any one or more elements of the other performing arts. In addition to the standard narrative dialogue style, theatre takes such forms as opera, ballet, mime, kabuki, classical Indian dance, Chinese opera and mummers' plays.

Dance

Dance (from Old French *dancier*, perhaps from Frankish) generally refers to human movement either used as a form of expression or presented in a social, spiritual or performance setting.

Dance is also used to describe methods of non-verbal communication between humans or animals (bee dance, mating dance), motion in inanimate objects (*the leaves danced in the wind*), and certain musical forms or genres.

Choreography is the art of making dances, and the person who does this is called a choreographer. People danced to relieve stress.

Definitions of what constitutes dance are dependent on social, cultural, aesthetic, artistic and moral constraints and range from functional movement (such as Folk dance) to codified, virtuoso techniques such as ballet. In sports, gymnastics, figure skating and synchronized swimming are dance disciplines while Martial arts 'kata' are often compared to dances.



BRAINSTROMING

Brainstorming is a group creativity technique designed to generate a large number of ideas for the solution of a problem. In 1953 the method was popularized by Alex Faickney Osborn in a book called *Applied Imagination*. Osborn proposed that groups could double their creative output with brainstorming.

Although brainstorming has become a popular group technique, researchers have not found evidence of its effectiveness for enhancing either quantity or quality of ideas generated. Because of such problems as distraction, social loafing, evaluation apprehension, and production blocking, brainstorming groups are little more effective than other types of groups, and they are actually less effective than individuals working independently. In the *Encyclopedia of Creativity*, Tudor Rickards, in his entry on brainstorming, summarizes its controversies and indicates the dangers of conflating productivity in group work with quantity of ideas.

Although traditional brainstorming does not increase the productivity of groups (as measured by the number of ideas generated), it may still provide benefits, such as boosting morale, enhancing work enjoyment, and improving team work. Thus, numerous attempts have been made to improve brainstorming or use more effective variations of the basic technique.

Ground Rules

There are four basic rules in brainstorming. These are intended to reduce social inhibitions among groups members, stimulate idea generation, and increase overall creativity of the group.

Focus on quantity: This rule is a means of enhancing divergent production, aiming to facilitate problem solving through the maxim, *quantity breeds quality*. The assumption is that the greater the number of ideas generated, the greater the chance of producing a radical and effective solution.

Withhold criticism: In brainstorming, criticism of ideas generated should be put 'on hold'. Instead, participants should focus on extending or adding to ideas, reserving criticism for a later 'critical stage' of the process. By suspending judgment, participants will feel free to generate unusual ideas.

Welcome unusual ideas: To get a good and long list of ideas, unusual ideas are welcomed. They can be generated by looking from new perspectives and suspending assumptions. These new ways of thinking may provide better solutions.

Combine and improve ideas: Good ideas may be combined to form a single better good idea, as suggested by the slogan " $1 + 1 = 3$ ". It is believed to stimulate the building of ideas by a process of association.

Method

Set the problem

Before a brainstorming session, it is critical to define the problem. The problem must be clear, not too big, and captured in a specific question such as "What service for mobile phones is not available now, but needed?". If the problem is too big, the facilitator should break it into smaller components, each with its own question.

Create a background memo

The background memo is the invitation and informational letter for the participants, containing the session name, problem, time, date, and place. The problem is described in the form of a question, and some example ideas are given. The memo is sent to the participants well in advance, so that they can think about the problem beforehand.

Select participants

The facilitator composes the brainstorming panel, consisting of the participants and an idea collector. A group of 10 or fewer members is generally more productive. Many variations are possible but the following composition is suggested.

- Several core members of the project who have proved themselves.
- Several guests from outside the project, with affinity to the problem.
- One idea collector who records the suggested ideas.

Create a list of lead questions

During the brainstorm session the creativity may decrease. At this moment, the facilitator should stimulate creativity by suggesting a lead question to answer, such as *Can we combine these ideas?* or *How about looking from another perspective?* It is best to prepare a list of such leads before the session begins.

Session conduct

The facilitator leads the brainstorming session and ensures that ground rules are followed. The steps in a typical session are:

A warm-up session, to expose novice participants to the criticism-free environment. A simple problem is brainstormed, for example *What should be the CEO's retirement present?* or *What can be improved in Microsoft Windows?*

The facilitator presents the problem and gives a further explanation if needed.

The facilitator asks the brainstorming group for their ideas.

If no ideas are forthcoming, the facilitator suggests a lead to encourage creativity.

All participants present their ideas, and the idea collector records them.

To ensure clarity, participants may elaborate on their ideas.

When time is up, the facilitator organizes the ideas based on the topic goal and encourages discussion.

Ideas are categorized.

The whole list is reviewed to ensure that everyone understands the ideas.

Duplicate ideas and obviously infeasible solutions are removed.

The facilitator thanks all participants and gives each a token of appreciation.

The process

- Participants who have ideas but were unable to present them are encouraged to write down the ideas and present them later.
- The idea collector should number the ideas, so that the chairperson can use the number to encourage an idea generation goal, for example: *We have 44 ideas now, let's get it to 50!*
- The idea collector should repeat the idea in the words he or she has written verbatim, to confirm that it expresses the meaning intended by the originator.
- When more participants are having ideas, the one with the most associated idea should have priority. This to encourage elaboration on previous ideas.
- During a brainstorming session, managers and other superiors may be discouraged from attending, since it may inhibit and reduce the effect of the four basic rules, especially the generation of unusual ideas.

Evaluation

Brainstorming is not just about generating ideas for others to evaluate and select. Usually the group itself will, in its final stage, evaluate the ideas and select one as the solution to the problem proposed to the group.

- The solution should not require resources or skills the members of the group do not have or cannot acquire.
- If acquiring additional resources or skills is necessary, that needs to be the first part of the solution.
- There must be a way to measure progress and success.
- The steps to carry out the solution must be clear to all, and amenable to being assigned to the members so that each will have an important role.
- There must be a common decision making process to enable a coordinated effort to proceed, and to reassign tasks as the project unfolds.
- There should be evaluations at milestones to decide whether the group is on track toward a final solution.
- There should be incentives to participation so that participants maintain their efforts.

Variations

Nominal group technique

The nominal group technique is a type of brainstorming that encourages all participants to have an equal say in the process. It is also used to generate a ranked list of ideas.

Participants are asked to write their ideas anonymously. Then the moderator collects the ideas and each is voted on by the group. The vote can be as simple as a show of hands in favor of a given idea. This process is called distillation.

After distillation, the top ranked ideas may be sent back to the group or to subgroups for further brainstorming. For example, one group may work on the color required in a product. Another group may work on the size, and so forth. Each group will come back to the whole group for ranking the listed ideas. Sometimes ideas that were previously dropped may be brought forward again once the group has re-evaluated the ideas.

It is important that the facilitator be trained in this process before attempting to facilitate this technique. The group should

be primed and encouraged to embrace the process. Like all team efforts, it may take a few practice sessions to train the team in the method before tackling the important ideas.

Group passing technique

Each person in a circular group writes down one idea, and then passes the piece of paper to the next person in a clockwise direction, who adds some thoughts. This continues until everybody gets his or her original piece of paper back. By this time, it is likely that the group will have extensively elaborated on each idea.

The group may also create an "Idea Book" and post a distribution list or routing slip to the front of the book. On the first page is a description of the problem. The first person to receive the book lists his or her ideas and then routes the book to the next person on the distribution list. The second person can log new ideas or add to the ideas of the previous person. This continues until the distribution list is exhausted. A follow-up "read out" meeting is then held to discuss the ideas logged in the book. This technique takes longer, but it allows individuals time to think deeply about the problem.

Team idea mapping method

This method of brainstorming works by the method of association. It may improve collaboration and increase the quantity of ideas, and is designed so that all attendees participate and no ideas are rejected.

The process begins with a well-defined topic. Each participant brainstorms individually, then all the ideas are merged onto one large idea map. During this consolidation phase, participants may discover a common understanding of the issues as they share the meanings behind their ideas. During this sharing, new ideas may arise by the association, and they are added to the map as well. Once all the ideas are captured, the group can prioritize and/or take action.

Electronic brainstorming

Electronic brainstorming is a computerized version of the manual brainwriting technique. It can be done via email and may be browser based, or use peer-to-peer software.

The facilitator sends the question out to group members, and they contribute independently by sending their ideas back to the facilitator. The facilitator then compiles a list of ideas and sends it back to the group for further feedback. Electronic brainstorming eliminates many of the problems of standard brainstorming, such as production blocking and evaluation apprehension. An additional advantage of this method is that all ideas can be archived electronically in their original form, and then retrieved later for further thought and discussion. Electronic brainstorming also enables much larger groups to brainstorm on a topic than would normally be productive in a traditional brainstorming session.

Other brainstorming techniques are web-based, and allow contributors to post their comments anonymously through the use of avatars. This technique also allows users to log on over an extended time period, typically one or two weeks, to allow participants some "soak time" before posting their ideas and feedback. This technique has been used particularly in the field of new product development, but can be applied in any number of areas where collecting and evaluating ideas would be useful. Professor Olivier Toubia of Columbia University has conducted extensive research in the field of idea generation and has concluded that incentives are extremely valuable within the brainstorming context.

Directed brainstorming

Directed brainstorming is a variation of electronic brainstorming (described above). It can be done manually or with computers. Directed brainstorming works when the solution space (that is, the criteria for evaluating a good idea) is known prior to the session. If known, that criteria can be used to intentionally constrain the ideation process.

In directed brainstorming, each participant is given one sheet of paper (or electronic form) and told the brainstorming question. They are asked to produce one response and stop, then all of the papers (or forms) are randomly swapped among the participants. The participants are asked to look at the idea they received and to create a new idea that improves on that idea based on the initial criteria. The forms are then swapped again and respondents are asked to improve upon the ideas, and the process is repeated for three or more rounds.

In the laboratory, directed brainstorming has been found to almost triple the productivity of groups over electronic brainstorming.

Individual brainstorming

"Individual Brainstorming" is the use of brainstorming on a solitary basis. It typically includes such techniques as free writing, free speaking, word association, and drawing a mind map, which is a visual note taking technique in which people diagram their thoughts. Individual brainstorming is a useful method in creative writing and has been shown to be superior to traditional group brainstorming.

Question Brainstorming

This process involves brainstorming the *questions*, rather than trying to come up with immediate answers and short term solutions. This technique stimulates creativity and promotes everyone's participation because no one has to come up with answers. The answers to the questions form the framework for constructing future action plans. Once the list of questions is set, it may be necessary to prioritize them to reach to the best solution in an orderly way. Another of the problems for brainstorming can be to find the best evaluation methods for a problem.

Brainstorming all the questions also has been called *questorming*.

Conclusion

Brainstorming is a popular method of group interaction in both educational and business settings. Although it does not provide a measurable advantage in creative output, brainstorming is an enjoyable exercise that is typically well received by participants. Newer variations of brainstorming seek to overcome barriers like production blocking and may well prove superior to the original technique. How well these newer methods work, and whether or not they should be classified as brainstorming, are questions that require further research.

Controversy over term

Some governmental organisations (The Welsh Development Agency and the Department of Enterprise, Trade and Investment in Belfast) have reached the conclusion that the term 'brainstorming' is offensive to people with epilepsy and have suggested the alternative "thought-showers". However, research by the National Society for Epilepsy found of those affected by epilepsy questioned, 93% considered the term inoffensive. A specific comment states that changes need not be made since that could promote an undesirable image of epileptics being easily offended.



ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is the intelligence of machines and the branch of computer science that aims to create it. Textbooks define the field as "the study and design of intelligent agents," where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. John McCarthy, who coined the term in 1956, defines it as "the science and engineering of making intelligent machines."

The field was founded on the claim that a central property of humans, intelligence—the sapience of *Homo sapiens*—can be so precisely described that it can be simulated by a machine. This raises philosophical issues about the nature of the mind and limits of scientific hubris, issues which have been addressed by myth, fiction and philosophy since antiquity. Artificial intelligence has been the subject of optimism, but has also suffered setbacks and, today, has become an essential part of the technology industry, providing the heavy lifting for many of the most difficult problems in computer science.

AI research is highly technical and specialized, deeply divided into subfields that often fail to communicate with each other. Subfields have grown up around particular institutions, the work of individual researchers, the solution of specific problems, longstanding differences of opinion about how AI should be done and the application of widely differing tools. The central problems of AI include such traits as reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects. General intelligence (or "strong AI") is still a long-term goal of (some) research.

History

Thinking machines and artificial beings appear in Greek myths, such as Talos of Crete, the golden robots of Hephaestus and Pygmalion's Galatea. Human likenesses believed to have intelligence were built in every major civilization: animated statues were worshipped in Egypt and Greece and humanoid automatons were built by Yan Shi, Hero of Alexandria, Al-Jazari and Wolfgang von Kempelen. It was also widely believed that artificial beings had been created by Jabir ibn Hayyan Judah Loew and Paracelsus. By the 19th and 20th centuries, artificial beings had become a common feature in fiction, as in Mary Shelley's *Frankenstein* or Karel Capek's *R.U.R.* (*Rossum's Universal Robots*). Pamela McCorduck argues that all of these are examples of an ancient urge, as she describes it, "to forge the gods". Stories of these creatures and their fates discuss many of the same hopes, fears and ethical concerns that are presented by artificial intelligence.

Mechanical or "formal" reasoning has been developed by philosophers and mathematicians since antiquity. The study of logic led directly to the invention of the programmable digital electronic computer, based on the work of mathematician Alan Turing and others. Turing's theory of computation suggested that a machine, by shuffling symbols as simple as "0" and "1", could simulate any conceivable act of mathematical deduction. This, along with recent discoveries in neurology, information theory and cybernetics, inspired a small group of researchers to begin to seriously consider the possibility of building an electronic brain.

The field of AI research was founded at a conference on the campus of Dartmouth College in the summer of 1956. The attendees, including John McCarthy, Marvin Minsky, Allen Newell and Herbert Simon, became the leaders of AI research for many decades. They and their students wrote programs that were, to most people, simply astonishing: computers were solving word problems in algebra, proving logical theorems and speaking English. By the middle of the 1960s, research in the

U.S. was heavily funded by the Department of Defense and laboratories had been established around the world. AI's founders were profoundly optimistic about the future of the new field: Herbert Simon predicted that "machines will be capable, within twenty years, of doing any work a man can do" and Marvin Minsky agreed, writing that "within a generation ... the problem of creating 'artificial intelligence' will substantially be solved".

They had failed to recognize the difficulty of some of the problems they faced. In 1974, in response to the criticism of England's Sir James Lighthill and ongoing pressure from Congress to fund more productive projects, the U.S. and British governments cut off all undirected, exploratory research in AI. The next few years, when funding for projects was hard to find, would later be called an "AI winter".

In the early 1980s, AI research was revived by the commercial success of expert systems, a form of AI program that simulated the knowledge and analytical skills of one or more human experts. By 1985 the market for AI had reached over a billion dollars. At the same time, Japan's fifth generation computer project inspired the U.S and British governments to restore funding for academic research in the field. However, beginning with the collapse of the Lisp Machine market in 1987, AI once again fell into disrepute, and a second, longer lasting AI winter began.

In the 1990s and early 21st century, AI achieved its greatest successes, albeit somewhat behind the scenes. Artificial intelligence is used for logistics, data mining, medical diagnosis and many other areas throughout the technology industry. The success was due to several factors: the incredible power of computers today, a greater emphasis on solving specific subproblems, the creation of new ties between AI and other fields working on similar problems, and above all a new commitment by researchers to solid mathematical methods and rigorous scientific standards.

Problems

The general problem of simulating (or creating) intelligence has been broken down into a number of specific sub-problems. These consist of particular traits or capabilities that researchers would like an intelligent system to display. The traits described below have received the most attention.

Deduction, reasoning, problem solving

Early AI researchers developed algorithms that imitated the step-by-step reasoning that humans were often assumed to use when they solve puzzles, play board games or make logical deductions. By the late 1980s and '90s, AI research had also developed highly successful methods for dealing with uncertain or incomplete information, employing concepts from probability and economics.

For difficult problems, most of these algorithms can require enormous computational resources — most experience a “combinatorial explosion”: the amount of memory or computer time required becomes astronomical when the problem goes beyond a certain size. The search for more efficient problem solving algorithms is a high priority for AI research.

Human beings solve most of their problems using fast, intuitive judgments rather than the conscious, step-by-step deduction that early AI research was able to model. AI has made some progress at imitating this kind of “sub-symbolic” problem solving: embodied agent approaches emphasize the importance of sensorimotor skills to higher reasoning; neural net research attempts to simulate the structures inside human and animal brains that give rise to this skill.

Knowledge representation

Knowledge representation and knowledge engineering are central to AI research. Many of the problems machines are expected to solve will require extensive knowledge about the world. Among the things that AI needs to represent are: objects, properties, categories and relations between objects; situations, events, states and time; causes and effects; knowledge about

knowledge (what we know about what other people know); and many other, less well researched domains. A complete representation of "what exists" is an ontology[49] (borrowing a word from traditional philosophy), of which the most general are called upper ontologies.

Among the most difficult problems in knowledge representation are:

Default reasoning and the qualification problem

Many of the things people know take the form of "working assumptions." For example, if a bird comes up in conversation, people typically picture an animal that is fist sized, sings, and flies. None of these things are true about all birds. John McCarthy identified this problem in 1969 as the qualification problem: for any commonsense rule that AI researchers care to represent, there tend to be a huge number of exceptions. Almost nothing is simply true or false in the way that abstract logic requires. AI research has explored a number of solutions to this problem.

The breadth of commonsense knowledge

The number of atomic facts that the average person knows is astronomical. Research projects that attempt to build a complete knowledge base of commonsense knowledge (e.g., Cyc) require enormous amounts of laborious ontological engineering — they must be built, by hand, one complicated concept at a time. A major goal is to have the computer understand enough concepts to be able to learn by reading from sources like the internet, and thus be able to add to its own ontology.

The subsymbolic form of some commonsense knowledge

Much of what people know is not represented as "facts" or "statements" that they could actually say out loud. For example, a chess master will avoid a particular chess position because it "feels too exposed" or an art critic can take one look at a statue and instantly realize that it is a fake. These are intuitions or tendencies that are represented in the brain non-consciously and

sub-symbolically. Knowledge like this informs, supports and provides a context for symbolic, conscious knowledge. As with the related problem of sub-symbolic reasoning, it is hoped that situated AI or computational intelligence will provide ways to represent this kind of knowledge.

Planning

Intelligent agents must be able to set goals and achieve them. They need a way to visualize the future (they must have a representation of the state of the world and be able to make predictions about how their actions will change it) and be able to make choices that maximize the utility (or "value") of the available choices.

In classical planning problems, the agent can assume that it is the only thing acting on the world and it can be certain what the consequences of its actions may be. However, if this is not true, it must periodically check if the world matches its predictions and it must change its plan as this becomes necessary, requiring the agent to reason under uncertainty.

Multi-agent planning uses the cooperation and competition of many agents to achieve a given goal. Emergent behavior such as this is used by evolutionary algorithms and swarm intelligence.

Learning

Machine learning has been central to AI research from the beginning. Unsupervised learning is the ability to find patterns in a stream of input. Supervised learning includes both classification and numerical regression. Classification is used to determine what category something belongs in, after seeing a number of examples of things from several categories. Regression takes a set of numerical input/output examples and attempts to discover a continuous function that would generate the outputs from the inputs. In reinforcement learning[63] the agent is rewarded for good responses and punished for bad ones. These can be analyzed in terms of decision theory, using concepts like utility. The mathematical analysis of machine

learning algorithms and their performance is a branch of theoretical computer science known as computational learning theory.

Natural language processing

Natural language processing gives machines the ability to read and understand the languages that humans speak. Many researchers hope that a sufficiently powerful natural language processing system would be able to acquire knowledge on its own, by reading the existing text available over the internet. Some straightforward applications of natural language processing include information retrieval (or text mining) and machine translation.

Motion and manipulation

The field of robotics is closely related to AI. Intelligence is required for robots to be able to handle such tasks as object manipulation and navigation, with sub-problems of localization (knowing where you are), mapping (learning what is around you) and motion planning (figuring out how to get there).

Perception

Machine perception is the ability to use input from sensors (such as cameras, microphones, sonar and others more exotic) to deduce aspects of the world. Computer vision is the ability to analyze visual input. A few selected subproblems are speech recognition, facial recognition and object recognition.

Social intelligence

Kismet, a robot with rudimentary social skills

Emotion and social skills[73] play two roles for an intelligent agent. First, it must be able to predict the actions of others, by understanding their motives and emotional states. (This involves elements of game theory, decision theory, as well as the ability to model human emotions and the perceptual skills to detect emotions.) Also, for good human-computer interaction, an intelligent machine also needs to *display* emotions. At the very least it must appear polite and sensitive to the humans it interacts with. At best, it should have normal emotions itself.

Creativity

A sub-field of AI addresses creativity both theoretically (from a philosophical and psychological perspective) and practically (via specific implementations of systems that generate outputs that can be considered creative). A related area of computational research is Artificial Intuition and Artificial Imagination.

General intelligence

Most researchers hope that their work will eventually be incorporated into a machine with *general* intelligence (known as strong AI), combining all the skills above and exceeding human abilities at most or all of them. A few believe that anthropomorphic features like artificial consciousness or an artificial brain may be required for such a project.

Many of the problems above are considered AI-complete: to solve one problem, you must solve them all. For example, even a straightforward, specific task like machine translation requires that the machine follow the author's argument (reason), know what is being talked about (knowledge), and faithfully reproduce the author's intention (social intelligence). Machine translation, therefore, is believed to be AI-complete: it may require strong AI to be done as well as humans can do it.

Approaches

There is no established unifying theory or paradigm that guides AI research. Researchers disagree about many issues. A few of the most long standing questions that have remained unanswered are these: should artificial intelligence simulate natural intelligence, by studying psychology or neurology? Or is human biology as irrelevant to AI research as bird biology is to aeronautical engineering? Can intelligent behavior be described using simple, elegant principles (such as logic or optimization)? Or does it necessarily require solving a large number of completely unrelated problems? Can intelligence be reproduced using high-level symbols, similar to words and ideas? Or does it require "sub-symbolic" processing?

Cybernetics and brain simulation

In the 1940s and 1950s, a number of researchers explored the connection between neurology, information theory, and cybernetics. Some of them built machines that used electronic networks to exhibit rudimentary intelligence, such as W. Grey Walter's turtles and the Johns Hopkins Beast. Many of these researchers gathered for meetings of the Teleological Society at Princeton University and the Ratio Club in England. By 1960, this approach was largely abandoned, although elements of it would be revived in the 1980s.

Symbolic

When access to digital computers became possible in the middle 1950s, AI research began to explore the possibility that human intelligence could be reduced to symbol manipulation. The research was centered in three institutions: CMU, Stanford and MIT, and each one developed its own style of research. John Haugeland named these approaches to AI "good old fashioned AI" or "GOFAI".

Cognitive simulation

Economist Herbert Simon and Alan Newell studied human problem solving skills and attempted to formalize them, and their work laid the foundations of the field of artificial intelligence, as well as cognitive science, operations research and management science. Their research team used the results of psychological experiments to develop programs that simulated the techniques that people used to solve problems. This tradition, centered at Carnegie Mellon University would eventually culminate in the development of the Soar architecture in the middle 80s.

Logic based

Unlike Newell and Simon, John McCarthy felt that machines did not need to simulate human thought, but should instead try to find the essence of abstract reasoning and problem solving, regardless of whether people used the same algorithms. His laboratory at Stanford (SAIL) focused on using formal logic

to solve a wide variety of problems, including knowledge representation, planning and learning. Logic was also focus of the work at the University of Edinburgh and elsewhere in Europe which led to the development of the programming language Prolog and the science of logic programming.

"Anti-logic" or "scruffy"

Researchers at MIT (such as Marvin Minsky and Seymour Papert) found that solving difficult problems in vision and natural language processing required ad-hoc solutions – they argued that there was no simple and general principle (like logic) that would capture all the aspects of intelligent behavior. Roger Schank described their "anti-logic" approaches as "scruffy" (as opposed to the "neat" paradigms at CMU and Stanford). Commonsense knowledge bases (such as Doug Lenat's Cyc) are an example of "scruffy" AI, since they must be built by hand, one complicated concept at a time.

Knowledge based

When computers with large memories became available around 1970, researchers from all three traditions began to build knowledge into AI applications. This "knowledge revolution" led to the development and deployment of expert systems (introduced by Edward Feigenbaum), the first truly successful form of AI software. The knowledge revolution was also driven by the realization that enormous amounts of knowledge would be required by many simple AI applications.

Sub-symbolic

During the 1960s, symbolic approaches had achieved great success at simulating high-level thinking in small demonstration programs. Approaches based on cybernetics or neural networks were abandoned or pushed into the background. By the 1980s, however, progress in symbolic AI seemed to stall and many believed that symbolic systems would never be able to imitate all the processes of human cognition, especially perception, robotics, learning and pattern recognition. A number of researchers began to look into "sub-symbolic" approaches to specific AI problems.

Bottom-up, embodied, situated, behavior-based or nouvelle AI

Researchers from the related field of robotics, such as Rodney Brooks, rejected symbolic AI and focused on the basic engineering problems that would allow robots to move and survive. Their work revived the non-symbolic viewpoint of the early cybernetics researchers of the 50s and reintroduced the use of control theory in AI. This coincided with the development of the embodied mind thesis in the related field of cognitive science: the idea that aspects of the body (such as movement, perception and visualization) are required for higher intelligence.

Computational Intelligence

Interest in neural networks and "connectionism" was revived by David Rumelhart and others in the middle 1980s. These and other sub-symbolic approaches, such as fuzzy systems and evolutionary computation, are now studied collectively by the emerging discipline of computational intelligence

Statistical

In the 1990s, AI researchers developed sophisticated mathematical tools to solve specific subproblems. These tools are truly scientific, in the sense that their results are both measurable and verifiable, and they have been responsible for many of AI's recent successes. The shared mathematical language has also permitted a high level of collaboration with more established fields (like mathematics, economics or operations research). Stuart Russell and Peter Norvig describe this movement as nothing less than a "revolution" and "the victory of the neats."

Integrating the approaches

Intelligent agent paradigm

An intelligent agent is a system that perceives its environment and takes actions which maximizes its chances of success. The simplest intelligent agents are programs that solve

specific problems. The most complicated intelligent agents are rational, thinking humans. The paradigm gives researchers license to study isolated problems and find solutions that are both verifiable and useful, without agreeing on one single approach. An agent that solves a specific problem can use any approach that works — some agents are symbolic and logical, some are sub-symbolic neural networks and others may use new approaches. The paradigm also gives researchers a common language to communicate with other fields—such as decision theory and economics—that also use concepts of abstract agents. The intelligent agent paradigm became widely accepted during the 1990s.

Agent architectures and cognitive architectures

Researchers have designed systems to build intelligent systems out of interacting intelligent agents in a multi-agent system. A system with both symbolic and sub-symbolic components is a hybrid intelligent system, and the study of such systems is artificial intelligence systems integration. A hierarchical control system provides a bridge between sub-symbolic AI at its lowest, reactive levels and traditional symbolic AI at its highest levels, where relaxed time constraints permit planning and world modelling. Rodney Brooks' subsumption architecture was an early proposal for such a hierarchical system.

Tools

In the course of 50 years of research, AI has developed a large number of tools to solve the most difficult problems in computer science. A few of the most general of these methods are discussed below.

Search and optimization

Many problems in AI can be solved in theory by intelligently searching through many possible solutions: Reasoning can be reduced to performing a search. For example, logical proof can be viewed as searching for a path that leads from premises to conclusions, where each step is the application

of an inference rule. Planning algorithms search through trees of goals and subgoals, attempting to find a path to a target goal, a process called means-ends analysis. Robotics algorithms for moving limbs and grasping objects use local searches in configuration space. Many learning algorithms use search algorithms based on optimization.

Simple exhaustive searches are rarely sufficient for most real world problems: the search space (the number of places to search) quickly grows to astronomical numbers. The result is a search that is too slow or never completes. The solution, for many problems, is to use "heuristics" or "rules of thumb" that eliminate choices that are unlikely to lead to the goal (called "pruning the search tree"). Heuristics supply the program with a "best guess" for what path the solution lies on:

A very different kind of search came to prominence in the 1990s, based on the mathematical theory of optimization. For many problems, it is possible to begin the search with some form of a guess and then refine the guess incrementally until no more refinements can be made. These algorithms can be visualized as blind hill climbing: we begin the search at a random point on the landscape, and then, by jumps or steps, we keep moving our guess uphill, until we reach the top. Other optimization algorithms are simulated annealing, beam search and random optimization.

Evolutionary computation uses a form of optimization search. For example, they may begin with a population of organisms (the guesses) and then allow them to mutate and recombine, selecting only the fittest to survive each generation (refining the guesses). Forms of evolutionary computation include swarm intelligence algorithms (such as ant colony or particle swarm optimization) and evolutionary algorithms (such as genetic algorithms and genetic programming).

Logic

Logic was introduced into AI research by John McCarthy in his 1958 Advice Taker proposal. Logic is used for knowledge representation and problem solving, but it can be applied to

other problems as well. For example, the satplan algorithm uses logic for planning and inductive logic programming is a method for learning.

Several different forms of logic are used in AI research. Propositional or sentential logic is the logic of statements which can be true or false. First-order logic also allows the use of quantifiers and predicates, and can express facts about objects, their properties, and their relations with each other. Fuzzy logic is a version of first-order logic which allows the truth of a statement to be represented as a value between 0 and 1, rather than simply True (1) or False (0). Fuzzy systems can be used for uncertain reasoning and have been widely used in modern industrial and consumer product control systems. Subjective logic models uncertainty in a different and more explicit manner than fuzzy-logic: a given binomial opinion satisfies $\text{belief} + \text{disbelief} + \text{uncertainty} = 1$ within a Beta distribution. By this method, ignorance can be distinguished from probabilistic statements that an agent makes with high confidence. Default logics, non-monotonic logics and circumscription are forms of logic designed to help with default reasoning and the qualification problem. Several extensions of logic have been designed to handle specific domains of knowledge, such as: description logics; situation calculus, event calculus and fluent calculus (for representing events and time); causal calculus; belief calculus; and modal logics

Probabilistic methods for uncertain reasoning

Many problems in AI (in reasoning, planning, learning, perception and robotics) require the agent to operate with incomplete or uncertain information. Starting in the late 80s and early 90s, Judea Pearl and others championed the use of methods drawn from probability theory and economics to devise a number of powerful tools to solve these problems.

Bayesian networks are a very general tool that can be used for a large number of problems: reasoning (using the Bayesian inference algorithm), learning (using the expectation-maximization algorithm), planning (using decision networks)

and perception (using dynamic Bayesian networks). Probabilistic algorithms can also be used for filtering, prediction, smoothing and finding explanations for streams of data, helping perception systems to analyze processes that occur over time (e.g., hidden Markov models or Kalman filters).

A key concept from the science of economics is "utility": a measure of how valuable something is to an intelligent agent. Precise mathematical tools have been developed that analyze how an agent can make choices and plan, using decision theory, decision analysis, information value theory. These tools include models such as Markov decision processes, dynamic decision networks, game theory and mechanism design.

Classifiers and statistical learning methods

The simplest AI applications can be divided into two types: classifiers ("if shiny then diamond") and controllers ("if shiny then pick up"). Controllers do however also classify conditions before inferring actions, and therefore classification forms a central part of many AI systems. Classifiers are functions that use pattern matching to determine a closest match. They can be tuned according to examples, making them very attractive for use in AI. These examples are known as observations or patterns. In supervised learning, each pattern belongs to a certain predefined class. A class can be seen as a decision that has to be made. All the observations combined with their class labels are known as a data set. When a new observation is received, that observation is classified based on previous experience.

A classifier can be trained in various ways; there are many statistical and machine learning approaches. The most widely used classifiers are the neural network, kernel methods such as the support vector machine, k-nearest neighbor algorithm, Gaussian mixture model, naive Bayes classifier, and decision tree. The performance of these classifiers have been compared over a wide range of tasks. Classifier performance depends greatly on the characteristics of the data to be classified. There is no single classifier that works best on all given problems; this

is also referred to as the "no free lunch" theorem. Determining a suitable classifier for a given problem is still more an art than science.

Neural networks

- A neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain.

The study of artificial neural networks began in the decade before the field AI research was founded, in the work of Walter Pitts and Warren McCulloch. Other important early researchers were Frank Rosenblatt, who invented the perceptron and Paul Werbos who developed the backpropagation algorithm.

The main categories of networks are acyclic or feedforward neural networks (where the signal passes in only one direction) and recurrent neural networks (which allow feedback). Among the most popular feedforward networks are perceptrons, multi-layer perceptrons and radial basis networks. Among recurrent networks, the most famous is the Hopfield net, a form of attractor network, which was first described by John Hopfield in 1982.[136] Neural networks can be applied to the problem of intelligent control (for robotics) or learning, using such techniques as Hebbian learning and competitive learning.

Jeff Hawkins argues that research in neural networks has stalled because it has failed to model the essential properties of the neocortex, and has suggested a model (Hierarchical Temporal Memory) that is based on neurological research.

Control theory

Control theory, the grandchild of cybernetics, has many important applications, especially in robotics.

Languages

AI researchers have developed several specialized languages for AI research, including Lisp and Prolog.

Evaluating progress

How can one determine if an agent is intelligent? In 1950, Alan Turing proposed a general procedure to test the

intelligence of an agent now known as the Turing test. This procedure allows almost all the major problems of artificial intelligence to be tested. However, it is a very difficult challenge and at present all agents fail.

Artificial intelligence can also be evaluated on specific problems such as small problems in chemistry, hand-writing recognition and game-playing. Such tests have been termed subject matter expert Turing tests. Smaller problems provide more achievable goals and there are an ever-increasing number of positive results.

The broad classes of outcome for an AI test are:

- Optimal: it is not possible to perform better
- Strong super-human: performs better than all humans
- Super-human: performs better than most humans
- Sub-human: performs worse than most humans

For example, performance at draughts is optimal, performance at chess is super-human and nearing strong super-human, and performance at many everyday tasks performed by humans is sub-human.

A quite different approach measures machine intelligence through tests which are developed from *mathematical* definitions of intelligence. Examples of these kinds of tests start in the late nineties devising intelligence tests using notions from Kolmogorov Complexity and data compression. Similar definitions of machine intelligence have been put forward by Marcus Hutter in his book *Universal Artificial Intelligence* (Springer 2005), an idea further developed by Legg and Hutter. Two major advantages of mathematical definitions are their applicability to nonhuman intelligences and their absence of a requirement for human testers.

Artificial intelligence has successfully been used in a wide range of fields including medical diagnosis, stock trading, robot control, law, scientific discovery, video games, toys, and Web search engines. Frequently, when a technique reaches

mainstream use, it is no longer considered artificial intelligence, sometimes described as the AI effect. It may also become integrated into artificial life.

Competitions and prizes

There are a number of competitions and prizes to promote research in artificial intelligence. The main areas promoted are: general machine intelligence, conversational behavior, data-mining, driverless cars, robot soccer and games.

Platforms

A platform (or "computing platform") is defined as "some sort of hardware architecture or software framework (including application frameworks), that allows software to run." As Rodney Brooks pointed out many years ago, it is not just the artificial intelligence software that defines the AI features of the platform, but rather the actual platform itself that affects the AI that results, i.e., we need to be working out AI problems on real world platforms rather than in isolation.

A wide variety of platforms has allowed different aspects of AI to develop, ranging from expert systems, albeit PC-based but still an entire real-world system to various robot platforms such as the widely available Roomba with open interface.

Philosophy

Artificial intelligence, by claiming to be able to recreate the capabilities of the human mind, is both a challenge and an inspiration for philosophy. Are there limits to how intelligent machines can be? Is there an essential difference between human intelligence and artificial intelligence? Can a machine have a mind and consciousness? A few of the most influential answers to these questions are given below.

Turing's "polite convention"

If a machine acts as intelligently as a human being, then it is as intelligent as a human being. Alan Turing theorized that, ultimately, we can only judge the intelligence of a machine based on its behavior. This theory forms the basis of the Turing test.

The Dartmouth proposal

"Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it." This assertion was printed in the proposal for the Dartmouth Conference of 1956, and represents the position of most working AI researchers.

Newell and Simon's physical symbol system hypothesis

"A physical symbol system has the necessary and sufficient means of general intelligent action." Newell and Simon argue that intelligences consists of formal operations on symbols. Hubert Dreyfus argued that, on the contrary, human expertise depends on unconscious instinct rather than conscious symbol manipulation and on having a "feel" for the situation rather than explicit symbolic knowledge.

Gödel's incompleteness theorem

A formal system (such as a computer program) can not prove all true statements. Roger Penrose is among those who claim that Gödel's theorem limits what machines can do.

Searle's strong AI hypothesis

"The appropriately programmed computer with the right inputs and outputs would thereby have a mind in exactly the same sense human beings have minds." Searle counters this assertion with his Chinese room argument, which asks us to look inside the computer and try to find where the "mind" might be.

The artificial brain argument

The brain can be simulated. Hans Moravec, Ray Kurzweil and others have argued that it is technologically feasible to copy the brain directly into hardware and software, and that such a simulation will be essentially identical to the original.

Prediction

AI is a common topic in both science fiction and projections about the future of technology and society. The existence of an artificial intelligence that rivals human

intelligence raises difficult ethical issues, and the potential power of the technology inspires both hopes and fears.

In fiction, AI has appeared fulfilling many roles, including a servant (R2D2 in *Star Wars*), a law enforcer (K.I.T.T. "Knight Rider"), a comrade (Lt. Commander Data in *Star Trek*), a conqueror/overlord (*The Matrix*), a dictator (*With Folded Hands*), an assassin (*Terminator*), a sentient race (*Battlestar Galactica/Transformers*), an extension to human abilities (*Ghost in the Shell*) and the savior of the human race (R. Daneel Olivaw in the *Foundation Series*).

Mary Shelley's *Frankenstein* considers a key issue in the ethics of artificial intelligence: if a machine can be created that has intelligence, could it also *feel*? If it can feel, does it have the same rights as a human? The idea also appears in modern science fiction, including the films *Blade Runner* and *A.I.: Artificial Intelligence*, in which humanoid machines have the ability to feel human emotions. This issue, now known as "robot rights", is currently being considered by, for example, California's Institute for the Future, although many critics believe that the discussion is premature.

The impact of AI on society is a serious area of study for futurists. Academic sources have considered such consequences as a decreased demand for human labor, the enhancement of human ability or experience, and a need for redefinition of human identity and basic values. Andrew Kennedy, in his musing on the evolution of the human personality, considered that artificial intelligences or 'new minds' are likely to have severe personality disorders, and identifies four particular types that are likely to arise: the autistic, the collector, the ecstatic, and the victim. He suggests that they will need humans because of our superior understanding of personality and the role of the unconscious.

Several futurists argue that artificial intelligence will transcend the limits of progress. Ray Kurzweil has used Moore's law (which describes the relentless exponential improvement in digital technology with uncanny accuracy) to calculate that

desktop computers will have the same processing power as human brains by the year 2029, and that by 2045 artificial intelligence will reach a point where it is able to improve *itself* at a rate that far exceeds anything conceivable in the past, a scenario that science fiction writer Vernor Vinge named the "technological singularity".

Robot designer Hans Moravec, cyberneticist Kevin Warwick and inventor Ray Kurzweil have predicted that humans and machines will merge in the future into cyborgs that are more capable and powerful than either. This idea, called transhumanism, which has roots in Aldous Huxley and Robert Ettinger, has been illustrated in fiction as well, for example in the manga *Ghost in the Shell* and the science-fiction series *Dune*.

Edward Fredkin argues that "artificial intelligence is the next stage in evolution," an idea first proposed by Samuel Butler's "Darwin among the Machines" (1863), and expanded upon by George Dyson in his book of the same name in 1998.

Pamela McCorduck writes that all these scenarios are expressions of the ancient human desire to, as she calls it, "forge the gods".



ACTION SELECTION

Action selection is a way of characterizing the most basic problem of intelligent systems: what to do next. In artificial intelligence and computational cognitive science, "the action selection problem" is typically associated with intelligent agents and animats—artificial systems that exhibit complex behaviour in an agent environment. The term is also sometimes used in ethology or animal behavior.

One problem for understanding action selection is determining the level of abstraction used for specifying an "act". At the most basic level of abstraction, an atomic act could be anything from *contracting a muscle cell* to *provoking a war*. Typically for any one action-selection mechanism, the set of possible actions is predefined and fixed.

Most researchers working in this field place high demands on their agents :

- The acting agent typically must select its action in dynamic and unpredictable environments.
- The agents typically act in real time; therefore they must make decisions in a timely fashion.
- The agents are normally created to perform several different tasks. These tasks may conflict for resource allocation (e.g. can the agent put out a fire and deliver a cup of coffee at the same time?)
- The environment the agents operate in may include humans, who may make things more difficult for the agent (either intentionally or by attempting to assist.)

- The agents themselves are often intended to model animals and/or humans, and animal/human behaviour is quite complicated.

For these reasons action selection is not trivial and attracts a good deal of research.

Characteristics of the action selection problem

The main problem for action selection is complexity. Since all computation takes both time and space (in memory), agents cannot possibly consider every option available to them at every instant in time. Consequently, they must be biased, and constrain their search in some way. For AI, the question of action selection is *what is the best way to constrain this search?* For biology and ethology, the question is *how do various types of animals constrain their search? Do all animals use the same approaches? Why do they use the ones they do?*

One fundamental question about action selection is whether it is really a problem at all for an agent, or whether it is just a description of an emergent property of an intelligent agent's behaviour. However, if we consider how we are going to build an intelligent agent, then it becomes apparent there must be *some* mechanism for action selection. This mechanism may be highly distributed (as in the case of distributed organisms such as social insect colonies or slime mold) or it may be a special-purpose module.

The action selection mechanism (ASM) determines not only the agent's actions in terms of impact on the world, but also directs its perceptual attention, and updates its memory. These egocentric sorts of actions may in turn result in modifying the agents basic behavioural capacities, particularly in that updating memory implies some form of learning is possible. Ideally, action selection itself should also be able to learn and adapt, but there are many problems of combinatorial complexity and computational tractability that may require restricting the search space for learning.

In AI, an ASM is also sometimes either referred to as an agent architecture or thought of as a substantial part of one.

AI mechanisms of action selection

Generally, artificial action selection mechanisms can be divided into several categories: symbol-based systems sometimes known as classical planning, distributed solutions, and reactive or dynamic planning. Some approaches do not fall neatly into any one of these categories. Others are really more about providing scientific models than practical AI control; these last are described further in the next section.

Symbolic approaches

Early in the history of artificial intelligence, it was assumed that the best way for an agent to choose what to do next would be to compute a provably optimal plan, and then execute that plan. This led to the physical symbol system hypothesis, that a physical agent that can manipulate symbols is necessary and sufficient for intelligence. Many software agents still use this approach for action selection. It normally requires describing all sensor readings, the world, all of one's actions and all of one's goals in some form of predicate logic. Critics of this approach complain that it is too slow for real-time planning and that, despite the proofs, it is still unlikely to produce optimal plans because reducing descriptions of reality to logic is a process prone to errors.

Satisficing is a decision-making strategy which attempts to meet criteria for adequacy, rather than identify an optimal solution. A satisficing strategy may often, in fact, be (near) optimal if the costs of the decision-making process itself, such as the cost of obtaining complete information, are considered in the outcome calculus.

Goal driven architectures - In these symbolic architectures, the agent's behaviour is typically described by a set of goals. Each goal can be achieved by a process or an activity, which is described by a prescribed plan. The agent must just decide which process to carry on to accomplish a given goal. The plan can expand to subgoals, which makes the process slightly recursive. Technically, more or less, the plans exploits condition - rules. These architectures are reactive or hybrid. Classical

examples of goal driven architectures are implementable refinements of Belief-Desire-Intention architecture like JAM or IVE.

Excalibur was a research project led by Alexander Nareyek featuring any-time planning agents for computer games. The architecture is based on structural constraint satisfaction, which is an advanced artificial intelligence technique.

Distributed approaches

In contrast to the symbolic approach, distributed systems of action selection actually have no one "box" in the agent which decides the next action. At least in their idealized form, distributed systems have many modules running in parallel and determining the best action based on local expertise. In these idealized systems, overall coherence is expected to emerge somehow, possibly through careful design of the interacting components. This approach is often inspired by neural networks research. In practice, there is almost always some centralised system determining which module is "the most active" or has the most salience. There is evidence real biological brains also have such executive decision systems which evaluate which of the competing systems deserves the most attention, or more properly, has its desired actions disinhibited.

- **Spreading activation** including Maes Nets (ANA)
- **Extended Rosenblatt & Payton** is a spreading activation architecture developed by Toby Tyrrell in 1993. The agent's behaviour is stored in the form of a hierarchical connectionism network, which Tyrrell named free-flow hierarchy. Recently exploited for example by de Sevin & Thalmann (2005) or Kadlec (2001).
- **Behavior based AI** including subsumption architecture; Bruce Blumberg
- **Creatures** are virtual pets from a computer game driven by three-layered neural network, which is adaptive. Their mechanism is reactive since the network in every time step determines the task that has to be performed by the

pet. The network is described well in the paper of Grand et al. (1997) and in The Creatures Developer Resources. See also the Creatures Wiki.

Dynamic planning approaches

Because purely distributed systems are difficult to construct, many researchers have turned to using explicit hard-coded plans to determine the priorities of their system.

Dynamic or reactive planning methods compute just one next action in every instant based on the current context and pre-scripted plans. In contrast to classical planning methods, reactive or dynamic approaches do not suffer combinatorial explosion. On the other hand, they are sometimes seen as too rigid to be considered strong AI, since the plans are coded in advance. At the same time, natural intelligence can be rigid in some contexts although it is fluid and able to adapt in others.

Example dynamic planning mechanisms include :

Finite-state machines : These are reactive architectures used mostly for computer game agents, in particular for first-person shooters bots, or for virtual movie actors. Typically, the state-machines are hierarchical. For concrete game examples, bots paper by Damian Isla (2005) or the Master's Thesis about Quake III bots by Jean Paul van Waveren (2001). For a movie example,

Other **structured reactive plans** tend to look a little more like conventional plans, often with ways to represent hierarchical and sequential structure. Some, such as PRS's 'acts', have support for partial plans. Many agent architectures from the mid 1990s included such plans as a "middle layer" that provided organization for low-level behavior modules while being directed by a higher level real-time planner. Despite this supposed interoperability with automated planners, most structured reactive plans are hand coded.

Examples of structured reactive plans include James Firby's RAP System and the Nils Nilsson's Teleo-reactive plans. PRS, RAPs & TRP are no longer developed or supported. One still-

active (as of 2006) descendent of this approach is the Parallel-rooted Ordered Slip-stack Hierarchical (or POSH) action selection system, which is a part of Joanna Bryson's Behaviour Oriented Design.

Sometimes to attempt to address the perceived inflexibility of dynamic planning, hybrid techniques are used. In these, a more conventional AI planning system searches for new plans when the agent has spare time, and updates the dynamic plan library when it finds good solutions. The important aspect of any such system is that when the agent needs to select an action, some solution exists that can be used immediately .

Others

- CogniTAO is a decision making engine it based on BDI (Belief desire intention), it includes built in teamwork capabilities.
- Soar is a symbolic cognitive architecture. It is based on condition-action rules known as productions. Programmers can use the Soar development toolkit for building both reactive and planning agents, or any compromise between these two extremes.
- ACT-R is similar to Soar. It is less powerful as a programming language, but simpler to get working. It includes a Bayesian learning system to help prioritize the productions.
- **Fuzzy architectures** : The Fuzzy approach in action selection produces more smooth behaviour than can be produced by architectures exploiting boolean condition-action rules (like Soar or POSH). These architectures are mostly reactive and symbolic. See the work of Alex Champandard.

Theories of action selection in nature

Many dynamic models of artificial action selection were originally inspired by research in ethology. In particular, Konrad Lorenz and Nikolaas Tinbergen provided the idea of an innate releasing mechanism to explain instinctive behaviors (fixed

action patterns). Influenced by the ideas of William McDougall, Lorenz developed this into a "psychohydraulic" model of the motivation of behavior. In ethology, these ideas were influential in the 1960s, but they are now regarded as outdated because of their use of an energy flow metaphor; the nervous system and the control of behavior are now normally treated as involving information transmission rather than energy flow. Dynamic plans and neural networks are more similar to information transmission, while spreading activation is more similar to the diffuse control of emotional / hormonal systems.

Stan Franklin has proposed that **action selection** is the right perspective to take in understanding the role and evolution of mind.



IMAGINATION

Imagination, also called the faculty of **imagining**, is the ability of forming mental images, sensations and concepts, in a moment when they are not perceived through sight, hearing or other senses. Imagination is the work of the mind that helps create fantasy. Imagination helps provide meaning to experience and understanding to knowledge; it is a fundamental facility through which people make sense of the world, and it also plays a key role in the learning process. A basic training for imagination is the listening to storytelling (narrative), in which the exactness of the chosen words is the fundamental factor to 'evoke worlds.'

Imagination is the faculty through which we encounter everything. The things that we touch, see and hear coalesce into a "picture" via our imagination.

It is accepted as the innate ability and process of inventing partial or complete personal realms within the mind from elements derived from sense perceptions of the shared world. The term is technically used in psychology for the process of reviving in the mind, percepts of objects formerly given in sense perception. Since this use of the term conflicts with that of ordinary language, some psychologists have preferred to describe this process as "imaging" or "imagery" or to speak of it as "reproductive" as opposed to "productive" or "constructive" imagination. Imagined images are seen with the "mind's eye."

Imagination can also be expressed through stories such as fairy tales or fantasies. Most famous inventions or entertainment products were created from the inspiration of someone's imagination.

One hypothesis for the evolution of human imagination is that it allowed conscious beings to solve problems (and hence increase an individual's survival fitness) by use of mental simulation.

Children often use narratives or pretend play in order to exercise their imagination. When children create fantasy they play at two levels: first, they use role playing to act out what they have created with their imagination, and at the second level they play again with their make-believe situation by acting as if what they have created is an actual reality that already exists in narrative myth.

The common use of the term is for the process of forming new images in the mind that have not been previously experienced, or at least only partially or in different combinations. Some typical examples follow:

- Fairy tale
- Fiction
- A form of verisimilitude often invoked in fantasy and science fiction invites readers to pretend such stories are true by referring to objects of the mind such as fictional books or years that do not exist apart from an imaginary world.

Imagination in this sense, not being limited to the acquisition of exact knowledge by the requirements of practical necessity, is, up to a certain point, free from objective restraints. The ability to imagine one's self in another person's place is very important to social relations and understanding. Albert Einstein said, "Imagination...is more important than knowledge. Knowledge is limited. Imagination encircles the world."

In various spheres, however, even imagination is in practice limited: thus a person whose imaginations do violence to the elementary laws of thought, or to the necessary principles of practical possibility, or to the reasonable probabilities of a given case is regarded as insane.

The same limitations beset imagination in the field of scientific hypothesis. Progress in scientific research is due largely to provisional explanations which are constructed by imagination, but such hypotheses must be framed in relation to previously ascertained facts and in accordance with the principles of the particular science.

Imagination is an experimental partition of the mind used to create theories and ideas based on functions. Taking objects from real perceptions, the imagination uses complex IF-functions to create new or revised ideas. This part of the mind is vital to developing better and easier ways to accomplish old and new tasks. These experimental ideas can be safely conducted inside a virtual world and then, if the idea is probable and the function is true, the idea can be actualized in reality. Imagination is the key to new development of the mind and can be shared with others, progressing collectively.

Regarding the volunteer effort, imagination can be classified as :- volunteer (the dream from the sleep, the daydream) - involuntary (the reproductive imagination, the creative imagination, the dream of perspective).

Imagination and perception

From the work of Piaget it is known that perceptions depend on the world view of a person. The world view is the result of arranging perceptions into existing imagery by imagination. Piaget cites the example of a child saying that the moon is following her when she walks around the village at night. Like this perceptions are integrated into the world view to make sense. Imagination is needed to make sense of perceptions.

Imagination vs. belief

Imagination differs fundamentally from belief because the subject understands that what is personally invented by the mind does not necessarily impact the course of action taken in the apparently shared world while beliefs are part of what one holds as truths about both the shared and personal worlds. The

play of imagination, apart from the obvious limitations (e.g. of avoiding explicit self-contradiction), is conditioned only by the general trend of the mind at a given moment. Belief, on the other hand, is immediately related to practical activity: it is perfectly possible to imagine oneself a millionaire, but unless one believes it one does not, therefore, act as such. Belief endeavours to conform to the subject's experienced conditions or faith in the possibility of those conditions; whereas imagination as such is specifically free. The dividing line between imagination and belief varies widely in different stages of technological development. Thus someone from a primitive culture who ill frames an ideal reconstruction of the causes of his illness, and attributes it to the hostile magic of an enemy based on faith and tradition rather than science. In ignorance of the science of pathology the subject is satisfied with this explanation, and actually believes in it, sometimes to the point of death, due to what is known as the *nocebo* effect.

It follows that the learned distinction between imagination and belief depends in practice on religion, tradition, and culture.

Imagination as a reality

The world as experienced is an interpretation of data arriving from the senses, as such it is perceived as real by contrast to most thoughts and imaginings. Users of hallucinogenic drugs are said to have a heightened imagination. This difference is only one of degree and can be altered by several historic causes, namely changes to brain chemistry, hypnosis or other altered states of consciousness, meditation, many hallucinogenic drugs, and electricity applied directly to specific parts of the brain. The difference between imagined and perceived reality can be so imperceptible as to cause acute states of psychosis. Many mental illnesses can be attributed to this inability to distinguish between the sensed and the internally created worlds. Some cultures and traditions even view the apparently shared world as an illusion of the mind as with the Buddhist *maya* or go to the opposite extreme and accept the imagined and dreamed realms as of equal validity to

the apparently shared world as the Australian Aborigines do with their concept of dreamtime.

Imagination, because of having freedom from external limitations, can often become a source of real pleasure and unnecessary suffering. A person of vivid imagination often suffers acutely from the imagined perils besetting friends, relatives, or even strangers such as celebrities. Also crippling fear can result from taking an imagined painful future too seriously.

Imagination can also produce some symptoms of real illnesses. In some cases, they can seem so "real" that specific physical manifestations occur such as rashes and bruises appearing on the skin, as though imagination had passed into belief or the events imagined were actually in progress. See, for example, psychosomatic illness and folie a deux.

It has also been proposed that the whole of human cognition is based upon imagination. That is, nothing that is perceived is purely observation but all is a morph between sense and imagination.

Imagination preceding reality

When two existing perceptions (thesis and antithesis) are combined within the mind, a third perception (called synthesis) is formed. At this point, perception only exists as part of the imagination and can become the inspiration for a new invention or technique.



KEY ISSUES IN SIMULATION

Key issues in simulation include acquisition of valid source information about the relevant selection of key characteristics and behaviours, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.

Simulation is the imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviours of a selected physical or abstract system.

Simulation is used in many contexts, including the modeling of natural systems or human systems in order to gain insight into their functioning. Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education. Simulation can be used to show the eventual real effects of alternative conditions and courses of action.

Historically, simulations used in different fields developed largely independently, but 20th century studies of Systems theory and Cybernetics combined with spreading use of computers across all those fields have led to some unification and a more systematic view of the concept.

Physical simulation refers to simulation in which physical objects are substituted for the real thing (some circles use the term for computer simulations modelling selected laws of physics, but this article doesn't). These physical objects are often chosen because they are smaller or cheaper than the actual object or system.

Interactive simulation is a special kind of physical simulation, often referred to as a *human in the loop* simulation, in which physical simulations include human operators, such as in a flight simulator or a driving simulator.

Human in the loop simulations can include a computer simulation as a so-called *synthetic environment*.

Computer simulation

A computer simulation (or "sim") is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables, predictions may be made about the behaviour of the system.

Computer simulation has become a useful part of modeling many natural systems in physics, chemistry and biology, and human systems in economics and social science (the computational sociology) as well as in engineering to gain insight into the operation of those systems. A good example of the usefulness of using computers to simulate can be found in the field of network traffic simulation. In such simulations, the model behaviour will change each simulation according to the set of initial parameters assumed for the environment.

Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions enabling the prediction of the behaviour of the system from a set of parameters and initial conditions. Computer simulation is often used as an adjunct to, or substitution for, modeling systems for which simple closed form analytic solutions are not possible. There are many different types of computer simulation, the common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states would be prohibitive or impossible.

Several software packages exist for running computer-based simulation modeling (e.g. Monte Carlo simulation, stochastic modeling, multimethod modeling) that makes the modeling almost effortless.

Modern usage of the term "computer simulation" may encompass virtually any computer-based representation.

Computer science

In computer science, simulation has some specialized meanings: Alan Turing used the term "simulation" to refer to what happens when a universal machine executes a state transition table (in modern terminology, a computer runs a program) that describes the state transitions, inputs and outputs of a subject discrete-state machine. The computer simulates the subject machine. Accordingly, in theoretical computer science the term *simulation* is a relation between state transition systems, useful in the study of operational semantics.

Less theoretically, an interesting application of computer simulation is to simulate computers using computers. In computer architecture, a type of simulator, typically called an *emulator*, is often used to execute a program that has to run on some inconvenient type of computer (for example, a newly designed computer that has not yet been built or an obsolete computer that is no longer available), or in a tightly controlled testing environment (see *Computer architecture simulator* and *Platform virtualization*). For example, simulators have been used to debug a microprogram or sometimes commercial application programs, before the program is downloaded to the target machine. Since the operation of the computer is simulated, all of the information about the computer's operation is directly available to the programmer, and the speed and execution of the simulation can be varied at will.

Simulators may also be used to interpret fault trees, or test VLSI logic designs before they are constructed. Symbolic simulation uses variables to stand for unknown values.

Simulation is often used in the training of civilian and military personnel. This usually occurs when it is prohibitively expensive or simply too dangerous to allow trainees to use the real equipment in the real world. In such situations they will spend time learning valuable lessons in a "safe" virtual environment. Often the convenience is to permit mistakes

during training for a safety-critical system. For example, in simSchool teachers practice classroom management and teaching techniques on simulated students, which avoids "learning on the job" that can damage real students. There is a distinction, though, between simulations used for training and Instructional simulation.

Training simulations typically come in one of three categories:

- "live" simulation (where real people use simulated (or "dummy") equipment in the real world);
- "virtual" simulation (where real people use simulated equipment in a simulated world, or *virtual environment*), or
- "constructive" simulation (where simulated people use simulated equipment in a simulated environment). Constructive simulation is often referred to as "wargaming" since it bears some resemblance to table-top w a r games in which players command armies of soldiers and equipment that move around a board.

In standardized tests, "live" simulations are sometimes called "high-fidelity", producing "samples of likely performance", as opposed to "low-fidelity", "pencil-and-paper" simulations producing only "signs of possible performance" but the distinction between high, moderate and low fidelity remains relative, depending on the context of a particular comparison.

Simulations in education are somewhat like training simulations. They focus on specific tasks. The term 'microworld' is used to refer to educational simulations which model some abstract concept rather than simulating a realistic object or environment, or in some cases model a real world environment in a simplistic way so as to help a learner develop an understanding of the key concepts. Normally, a user can create some sort of construction within the microworld that will behave in a way consistent with the concepts being modeled. Seymour Papert was one of the first to advocate the value of microworlds,

and the Logo (programming language) programming environment developed by Papert is one of the most famous micro-worlds. As another example, the Global Challenge Award online STEM learning web site uses microworld simulations to teach science concepts related to global warming and the future of energy. Other projects for simulations in education are Open Source Physics and its EJS environment.

Management games (or business simulations) have been finding favour in business education in recent years. Business simulations that incorporate a dynamic model enable experimentation with business strategies in a risk free environment and provide a useful extension to case study discussions.

Social simulations may be used in social science classrooms to illustrate social and political processes in anthropology, economics, history, political science, or sociology courses, typically at the high school or university level. These may, for example, take the form of civics simulations, in which participants assume roles in a simulated society, or international relations simulations in which participants engage in negotiations, alliance formation, trade, diplomacy, and the use of force. Such simulations might be based on fictitious political systems, or be based on current or historical events. An example of the latter would be Barnard College's "Reacting to the Past" series of educational simulations. The "Reacting to the Past" series also includes simulation games that address science education.

In recent years, there has been increasing use of social simulations for staff training in aid and development agencies. The Carana simulation, for example, was first developed by the United Nations Development Programme, and is now used in a very revised form by the World Bank for training staff to deal with fragile and conflict-affected countries

Medical simulators are increasingly being developed and deployed to teach therapeutic and diagnostic procedures as well as medical concepts and decision making to personnel in the health professions. Simulators have been developed for training

procedures ranging from the basics such as blood draw, to laparoscopic surgery and trauma care. They are also important to help on prototyping new devices for biomedical engineering problems. Currently, simulators are applied to research and development of tools for new therapies, treatments and early diagnosis in medicine.

Many medical simulators involve a computer connected to a plastic simulation of the relevant anatomy. Sophisticated simulators of this type employ a life size mannequin that responds to injected drugs and can be programmed to create simulations of life-threatening emergencies. In other simulations, visual components of the procedure are reproduced by computer graphics techniques, while touch-based components are reproduced by haptic feedback devices combined with physical simulation routines computed in response to the user's actions. Medical simulations of this sort will often use 3D CT or MRI scans of patient data to enhance realism. Some medical simulations are developed to be widely distributed (such as web-enabled simulations that can be viewed via standard web browsers) and can be interacted with using standard computer interfaces, such as the keyboard and mouse.

Another important medical application of a simulator — although, perhaps, denoting a slightly different meaning of *simulator* — is the use of a placebo drug, a formulation that simulates the active drug in trials of drug efficacy.

Patient Safety

Patient safety is a concern in the medical industry. Patients have been known to suffer injuries and even death due to management error, and lack of using best standards of care and training. According to Building a National Agenda for Simulation-Based Medical Education (Eder-Van Hook, Jackie, 2004), "A health care provider's ability to react prudently in an unexpected situation is one of the most critical factors in creating a positive outcome in medical emergency, regardless of whether it occurs on the battlefield, freeway, or hospital emergency room." simulation. Eder-Van Hook (2004) also noted

that medical errors kill up to 98,000 with an estimated cost between \$37 and \$50 million and \$17 to \$29 billion for preventable adverse events dollars per year. "Deaths due to preventable adverse events exceed deaths attributable to motor vehicle accidents, breast cancer, or AIDS" Eder-Van Hook (2004). With these types of statistics it is no wonder that improving patient safety is a prevalent concern in the industry.

New innovative simulation training solutions are now being used to train medical professionals in an attempt to reduce the number of safety concerns that have adverse effects on the patients. However, according to the article *Does Simulation Improve Patient Safety? Self-efficacy, Competence, Operational Performance, and Patient Safety* (Nishisaki A., Keren R., and Nadkarni, V., 2007), the jury is still out. Nishisaki states that "There is good evidence that simulation training improves provider and team self-efficacy and competence on manikins. There is also good evidence that procedural simulation improves actual operational performance in clinical settings. However, no evidence yet shows that crew resource management training through simulation, despite its promise, improves team operational performance at the bedside. Also, no evidence to date proves that simulation training actually improves patient outcome. Even so, confidence is growing in the validity of medical simulation as the training tool of the future." This could be because there are not enough research studies yet conducted to effectively determine the success of simulation initiatives to improve patient safety. Examples of [recently implemented] research simulations used to improve patient care [and its funding] can be found at *Improving Patient Safety through Simulation Research* (US Department of Human Health Services).

One such attempt to improve patient safety through the use of simulations training is pediatric care to deliver just-in-time service or/and just-in-place. This training consists of 20 minutes of simulated training just before workers report to shift. It is hoped that the recentness of the training will increase the positive and reduce the negative results that have generally been

associated with the procedure. The purpose of this study is to determine if just-in-time training improves patient safety and operational performance of orotracheal intubation and decrease occurrences of undesired associated events and "to test the hypothesis that high fidelity simulation may enhance the training efficacy and patient safety in simulation settings." The conclusion as reported in Abstract P38: Just-In-Time Simulation Training Improves ICU Physician Trainee Airway Resuscitation Participation without Compromising Procedural Success or Safety (Nishisaki A., 2008), were that simulation training improved resident participation in real cases; but did not sacrifice the quality of service. It could be therefore hypothesized that by increasing the number of highly trained residents through the use of simulation training, that the simulation training does in fact increase patient safety. This hypothesis would have to be researched for validation and the results may or may not generalize to other situations.

History of simulation in healthcare

The first medical simulators were simple models of human patients.

Since antiquity, these representations in clay and stone were used to demonstrate clinical features of disease states and their effects on humans. Models have been found from many cultures and continents. These models have been used in some cultures (e.g., Chinese culture) as a "diagnostic" instrument, allowing women to consult male physicians while maintaining social laws of modesty. Models are used today to help students learn the anatomy of the musculoskeletal system and organ systems.

Type of models

Active models

Active models that attempt to reproduce living anatomy or physiology are recent developments. The famous "Harvey" mannikin was developed at the University of Miami and is able to recreate many of the physical findings of the cardiology

examination, including palpation, auscultation, and electrocardiography.

Interactive models

More recently, interactive models have been developed that respond to actions taken by a student or physician. Until recently, these simulations were two dimensional computer programs that acted more like a textbook than a patient. Computer simulations have the advantage of allowing a student to make judgements, and also to make errors. The process of iterative learning through assessment, evaluation, decision making, and error correction creates a much stronger learning environment than passive instruction.

Computer simulators

Simulators have been proposed as an ideal tool for assessment of students for clinical skills.

Programmed patients and simulated clinical situations, including mock disaster drills, have been used extensively for education and evaluation. These "lifelike" simulations are expensive, and lack reproducibility. A fully functional "3Di" simulator would be the most specific tool available for teaching and measurement of clinical skills.

Immersive disease state simulations allow a doctor or HCP to experience what a disease actually feels like. Using sensors and transducers symptomatic effects can be delivered to a participant allowing them to experience the patients disease state.

Such a simulator meets the goals of an objective and standardized examination for clinical competence. This system is superior to examinations that use "standard patients" because it permits the quantitative measurement of competence, as well as reproducing the same objective findings.

Simulation in entertainment

Entertainment simulation is a term that encompasses many large and popular industries such as film, television, video games (including serious games) and rides in theme parks.

Although modern simulation is thought to have its roots in training and the military, in the 20th century it also became a conduit for enterprises which were more hedonistic in nature. Advances in technology in the 1980's and 1990's caused simulation to become more widely used and it began to appear in movies such as *Jurassic Park* (1993) and in computer-based games such as Atari's *Battlezone*.

History

Early History (1940's and 50's)

The first simulation game may have been created as early as 1947 by Thomas T. Goldsmith Jr. and Estle Ray Mann. This was a straightforward game that simulated a missile being fired at a target. The curve of the missile and its speed could be adjusted using several knobs. In 1958 a computer game called "*Tennis for Two*" was created by Willy Higginbotham which simulated a tennis game between two players who could both play at the same time using hand controls and was displayed on an oscilloscope. This was one of the first electronic video games to use a graphical display.

Computer-generated imagery was used in film to simulate objects as early as 1976, though in 1982 the movie *Tron* was the first film to use computer-generated imagery for more than a couple of minutes. However, the commercial failure of the movie may have caused the industry to step away from the technology. In 1993, the movie *Jurassic Park* became the first popular film to use computer-generated graphics extensively, integrating the simulated dinosaurs almost seamlessly into live action scenes. This event transformed the film industry; in 1995 the movie *Toy Story* was the first film to use only computer-generated images and by the new millennium computer generated graphics were the leading choice for special effects in movies.

Simulators have been used for entertainment since the Link Trainer in the 1930's. The first modern simulator ride to open at a theme park was Disney's Star Tours in 1987 soon followed by Universal's The Funtastic World of Hanna-Barbera in 1990

which was the first ride to be done entirely with computer graphics .

Examples of entertainment simulation

Computer and video games

Simulation games, as opposed to other genres of video and computer games, represent or simulate an environment accurately. Moreover, they represent the interactions between the playable characters and the environment realistically. These kinds of games are usually more complex in terms of game play. Simulation games have become incredibly popular among people of all ages and the industry has proven to be one of the few resistant to recession conditions . Popular simulation games include *SimCity*, *Tiger Woods PGA Tour* and *Virtonomics*.

Film

Computer-generated imagery is "the application of the field of 3D computer graphics to special effects". This technology is used for visual effects because they are high in quality, controllable, and can create effects that would not be feasible using any other technology either because of cost, resources or safety . Computer-generated graphics can be seen in many live action movies today, especially those of the action genre. Further, computer generated imagery has almost completely supplanted hand-drawn animation in children's movies which are increasingly computer-generated only. Examples of movies that use computer-generated imagery include *Finding Nemo*, *300* and *Iron Man*.

Modern Simulation (1980's-present)

Advances in technology in the 1980's made the computer more affordable and more capable than they were in previous decades which facilitated the rise of computer gaming. The first video game consoles released in the 1970's and early 80's fell prey to the industry crash in 1983, but in 1985 Nintendo released the Nintendo Entertainment System (NES) which became the best selling console in video game history . In the 1990's computer games became widely popular with the release

mass group processes which involved the group as a whole adopting an orientation which, in his opinion, interfered with the ability of a group to accomplish the work it was nominally engaged in. His experiences are reported in his published books, especially *Experiences in Groups*. The Tavistock Institute has further developed and applied the theory and practices developed by Bion.

Bruce Tuckman (1965) proposed the four-stage model called Tuckman's Stages for a group. Tuckman's model states that the ideal group decision-making process should occur in four stages:

- *Forming* (pretending to get on or get along with others);
- *Storming* (letting down the politeness barrier and trying to get down to the issues even if tempers flare up);
- *Norming* (getting used to each other and developing *Performing* (working in a group to a common goal on a highly efficient and cooperative basis).

Tuckman later added a fifth stage for the dissolution of a group called *adjourning*. (*Adjourning* may also be referred to as *mourning*, i.e. mourning the adjournment of the group). It should be noted that this model refers to the overall pattern of the group, but of course individuals within a group work in different ways. If distrust persists, a group may never even get to the norming stage.

M. Scott Peck developed stages for larger-scale groups (i.e., communities) which are similar to Tuckman's stages of group development. Peck describes the stages of a community as:

- *Pseudo-community*
- *Chaos*
- *Emptiness*
- *True Community*

Communities may be distinguished from other types of groups, in Peck's view, by the need for members to eliminate barriers to communication in order to be able to form true community. Examples of common barriers are: expectations and preconceptions; prejudices; ideology, counterproductive norms,

theology and solutions; the need to heal, convert, fix or solve and the need to control. A community is born when its members reach a stage of "emptiness" or peace.

Dimensions of group process

Aspects of group process include:

- Patterns of communication and coordination
- Patterns of influence
- Roles / relationship
- Patterns of dominance (e.g. who leads, who defers)
- Balance of task focus vs social focus
- Level of group effectiveness
- How conflict is handled
- Emotional state of the group as a whole, what Wilfred Bion called basic assumptions.

Groups of individuals gathered together to achieve a goal or objective, either as a committee or some other grouping, go through several predictable stages before useful work can be done. These stages are a function of a number of variables, not the least of which is the self-identification of the role each member will tend to play, and the emergence of natural leaders and individuals who will serve as sources of information. Any individual in a leadership position whose responsibilities involve getting groups of individuals to work together should both be conversant with the phases of the group process and possess the skills necessary to capitalize on these stages to accomplish the objective of forming a productive, cohesive team.

Various theories of group development exist. The model below combines elements of theories by Jones (1973), Tuckman (1965), and Banet (1976). In this model, each phase of group development is looked at with respect to group members' concerns with task and personal relations (process) functions

Application

Group dynamics form a basis for group therapy, often with therapeutic approaches that are formed of groups such as family therapy and the expressive therapies. Politicians and sales personnel may use their knowledge of the principles of group dynamics to aid their cause. Increasingly, group dynamics are of interest in light of online social interaction and virtual communities made possible by the internet.



SOCIAL CLASS

Social classes are the hierarchical arrangements of people in society as economic or cultural groups. Class is an essential object of analysis for sociologists, anthropologists, political economists, and social historians. In the social sciences, social class is often discussed in terms of 'social stratification'.

In sociology and political philosophy, the most basic class distinction is between the powerful and the powerless. In Marxist theory and historical materialism, social class is caused by the fundamental economic structure of work and property. Various social and political theories propose that social classes with greater power attempt to cement their own ranking above the lower social classes in the social hierarchy to the detriment of the society overall. By contrast, conservatives and structural functionalists have presented class difference as intrinsic to the structure of any society and to that extent ineradicable. Social classes with a great deal of power are usually viewed as "the elites" within their own societies.

In so-called non-stratified societies or acephalous societies, there is no concept of social class, power, or hierarchy beyond temporary or limited social statuses. In such societies, every individual has a roughly equal social standing in most situations.

In class societies a person's class status is a type of group membership. Theorists disagree about the elements determining membership, but common features appear in many accounts. Among these are:

- Relationships of production, ownership and consumption
- A common legal status, including ceremonial, occupational and reproductive rights

- Family, kinship or tribal group structures or membership
- Acculturation, including education

Classes often have a distinct lifestyle that emphasizes their class. The most powerful class in a society often uses markers such as costume, grooming, manners and language codes that mark insiders and outsiders ; unique political rights such as honorary titles; and, concepts of social honour or face that are claimed to only be applicable to the in group. But each class has distinctive features, often becoming defining elements of personal identity and uniting factors in group behaviour. French sociologist Pierre Bourdieu suggests a notion of high and low classes with a distinction between bourgeois tastes and sensitivities and the working class tastes and sensitivities .

Race and other large-scale groupings can also influence class standing. The association of particular ethnic groups with class statuses are common in many societies. As a result of conquest or internal ethnic differentiation, a ruling class is often ethnically homogenous and particular races or ethnic groups in some societies are legally or customarily restricted to occupying particular class positions . Which ethnicities are considered as belonging to high or low classes varies from society to society. In modern societies strict legal links between ethnicity and class have been drawn, such as in apartheid, the Caste system in Africa, and in the position of the Burakumin in Japanese society

A distinction often made is that of Ascribed status versus Achieved status. This deals with difference between obtained class identification, and whether social standing is determined at birth or earned over a lifetime. Achieved statuses are acquired based on merit, skills, abilities, and actions. Examples of achieved status include being a doctor or even being a criminal—the status then determines a set of behaviors and expectations for the individual .

Consequences of class position

Different consumption of social goods is the most visible consequence of class. In modern societies, it manifests as income inequality, though in subsistence societies it manifested

as malnutrition and periodic starvation. Although class status is not a causal factor for income, there is consistent data that show those in higher classes have higher incomes than those in lower classes. This inequality still persists when controlling for occupation. The conditions at work vary greatly depending on class. Those in the upper-middle class and middle-class enjoy greater freedoms in their occupations. They generally are more respected, enjoy more diversity, and are able to exhibit some authority. Those in lower classes tend to feel more alienated and have lower work satisfaction overall. The physical conditions of the workplace differ greatly between classes. While middle-class workers may "suffer alienating conditions" or "lack of job satisfaction", blue-collar workers suffer alienating, often routine, work with obvious physical health hazards, injury, and even death.

In the more social sphere, class has direct consequences on lifestyle. Lifestyle includes tastes, preferences, and a general style of living. These lifestyles could quite possibly affect educational attainment, and therefore status attainment. Class lifestyle also affects how children are raised. For example, a working-class person is more likely to raise their child to be working class and middle-class children are more likely to be raised to be middle-class. This perpetuates the idea of class for future generations.

Marxist

The Marxist conception of class involves a collective group of individuals that share similar economic and social relations relative to each other in society. A class is a group with intrinsic tendencies and interests that are different from, and may be opposed to the interests of other groups in society. For example, it is in the laborers best interest to maximize wages and benefits and in the capitalists best interest to maximize profit at the expense of such, leading to a contradiction within the capitalist system, even if the laborers and capitalists themselves are unaware of these class dichotomies.

For Marx, class involves two factors:

Objective factors

A class shares a common relationship to the means of production. That is, all people in one class make their living in a common way in terms of ownership of the things that produce social goods. A class may own things, own land, own people, be owned, own nothing but their labor. A class will extract tax, produce agriculture, enslave and work others, be enslaved and work, or work for a wage.

Subjective factors

The members will necessarily have some perception of their similarity and common interest. Marx termed this Class consciousness. Class consciousness is not simply an awareness of one's own class interest (for instance, the maximisation of shareholder value; or, the maximization of the wage with the minimization of the working day), class consciousness also embodies deeply shared views of how society should be organized legally, culturally, socially and politically.

The first criteria divides a society into the owners and non-owners of means of production. In capitalism, these are capitalist (bourgeoisie) and proletariat. Finer divisions can be made, however: the most important subgroup in capitalism being petite bourgeoisie (small bourgeoisie), people who possess their own means of production but utilize it primarily by working on it themselves rather than hiring others to work on it. They include self-employed artisans, small shopkeepers, and many professionals. Jon Elster has found mention in Marx of 15 classes from various historical periods.

A prerequisite for classes is existence of sufficient surplus product. Marxists explain the history of "civilized" societies in terms of a war of classes between those who control production and those who produce the goods or services in society. In the Marxist view of capitalism, this is a conflict between capitalists (bourgeoisie) and wage-workers (the proletariat). For Marxists, class antagonism is rooted in the situation that control over social production necessarily entails control over the class which

produces goods—in capitalism this is the exploitation of workers by the bourgeoisie.

Marx himself argued that it was the goal of the proletariat itself to displace the capitalist system with socialism, changing the social relationships underpinning the class system and then developing into a future communist society in which: “..the free development of each is the condition for the free development of all.” (Communist Manifesto) This would mark the beginning of a classless society in which human needs rather than profit would be motive for production. In a society with democratic control and production for use, there would be no class, no state and no need for money.

Vladimir Lenin has defined classes as “large groups of people differing from each other by the place they occupy in a historically determined system of social production, by their relation (in most cases fixed and formulated in law) to the means of production, by their role in the social organization of labor, and, consequently, by the dimensions of the share of social wealth of which they dispose and the mode of acquiring it.” A *Great Beginning*

Proletarianisation

The most important transformation of society for Marxists has been the massive and rapid growth of the proletariat in the world population during the last two hundred and fifty years. Starting with agricultural and domestic textile laborers in England and Flanders, more and more occupations only provide a living through wages or salaries. Private enterprise or self-employment in a variety of occupations is no longer as viable as it once was, and so many people who once controlled their own labor-time are converted into proletarians. Today groups which in the past subsisted on stipends or private wealth—like doctors, academics or lawyers—are now increasingly working as wage laborers. Marxists call this process proletarianization, and point to it as the major factor in the proletariat being the largest class in current societies in the rich countries of the “first world.”

The increasing dissolution of the peasant-lord relationship (see pre-capitalist societies), initially in the commercially active and industrializing countries, and then in the unindustrialized countries as well, has virtually eliminated the class of peasants. Poor rural laborers still exist, but their current relationship with production is predominantly as landless wage labourers or rural proletarians. The destruction of the peasantry, and its conversion into a rural proletariat, is largely a result of the general proletarianization of all work. This process is today largely complete, although it was arguably incomplete in the 1960s and 1970s.

Dialectics, or historical materialism, in Marxist class

Marx saw class categories as defined by continuing historical processes. Classes, in Marxism, are not static entities, but are regenerated daily through the productive process. Marxism views classes as human social relationships which change over time, with historical commonality created through shared productive processes. A 17th century farm labourer who worked for day wages shares a similar relationship to production as an average office worker of the 21st century. In this example, it is the shared structure of wage labour that makes both of these individuals "working class."

Objective and subjective factors in class in Marxism

Marxism has a rather heavily defined dialectic between objective factors (i.e., material conditions, the social structure) and subjective factors (i.e. the conscious organization of class members). While most Marxism analyses people's class based on objective factors (class structure), major Marxist trends have made greater use of subjective factors in understanding the history of the working class. E.P. Thompson's *The Making of the English Working Class* is a definitive example of this "subjective" Marxist trend. Thompson analyses the English working class as a group of people with shared material conditions coming to a positive self-consciousness of their social position. This feature of social class is commonly termed class consciousness in Marxism, a concept which became famous with Georg Lukács'

History and Class Consciousness (1923). It is seen as the process of a "class in itself" moving in the direction of a "class for itself," a collective agent that changes history rather than simply being a victim of the historical process. In Lukács' words, the proletariat was the "subject-object of history", and the first class which could separate false consciousness (inherent to the bourgeois's consciousness), which reified economic laws as universal (whereas they are only a consequence of historic capitalism).

The seminal sociological interpretation of class was advanced by Max Weber. Weber formulated a three-component theory of stratification, with class, status and party (or politics) as subordinate to the ownership of the means of production, but for Weber how they interact is a contingent question and one that will vary from society to society. Weber is also known for his six "American Dream" Values which are: 1) Hard work, 2) Universalism, 3) Individualism, 4) Wealth, 5) Activism, and 6) Rationality.

Academic models

Schools of sociology differ in how they conceptualize class. A distinction can be drawn between *analytical* concepts of social class, such as the Marxian and Weberian traditions, and the more *empirical* traditions such as socio-economic status approach, which notes the correlation of income, education and wealth with social outcomes without necessarily implying a particular theory of social structure. The Warnerian approach can be considered *empirical* in the sense that it is more descriptive than analytical.

The traditional 'pigeon-holing' mainstay of much of the advertising industry used to be that of social class. Recently, however, as affluence has become more widespread, the process has become much less clear. It is now argued that the new 'opinion leaders' come from within the same social class. The class groupings that were traditionally used by advertising agencies (for example in the NRS social grade schema were: AB - Managerial and professional, C1 - Supervisory and clerical, C2-

Skilled manual, DE-Unskilled manual and unemployed.) have been reported to be of decreasing value in recent decades, especially in the distinction between clerical workers and manual workers in education and disposable income.

Whereas some four decades ago, when these groupings were first widely used, the numbers in each of the main categories (C, D and E) were reasonably well balanced, today the C group in total (although now usually split to give C1 and C2) forms such a large sector that it dominates the whole classification system and offers less in terms of usable concentration of marketing effort.

An early example of a stratum class model was developed by the sociologist William Lloyd Warner in his 1949 book, *Social Class in America*. For many decades, the Warnerian theory was dominant in U.S. sociological theory.

Wealthy citizens from the Canadian city of Toronto attend a formal dinner

Based on social anthropology, Warner divided Americans into three classes (upper, middle, and lower), then further subdivided each of these into an "upper" and "lower" segment, with the following postulates:

- **Upper-upper class.** "Old money." People who have been born into and raised with wealth; mostly consists of old "noble" or prestigious families (e.g., Earl of Shrewsbury, Vanderbilt, Rockefeller).
- **Lower-upper class.** "New money." Individuals who have become rich within their own lifetimes (e.g., entrepreneurs, movie stars, top athletes, as well as some prominent professionals).
- **Upper-middle class.** Professionals with a college education, and more often with postgraduate degrees like MBAs, Ph.D.s, MDs, JDs, MSs, etc. (e.g., doctors, dentists, lawyers, bankers, corporate executives, head teachers, university professors, scientists, pharmacists, airline pilots, ship captains, actuaries, high level civil servants,

politicians, and military officers, architects, artists, writers, poets, and musicians).

- **Lower-middle class.** Lower-paid white collar workers, but not manual laborers. Often hold Associates or Bachelor degrees. (e.g., police officers, fire fighters, primary and high school teachers, engineers, accountants, nurses, municipal office workers and low to mid-level civil servants, sales representatives, non-management office workers, clergy, technicians, small business owners).
- **Upper-lower class.** Blue-collar workers and manual labourers. Also known as the "working class."
- **Lower-lower class.** The homeless and permanently unemployed, as well as the "working poor."

To Warner, American social class was based more on attitudes than on the actual amount of money an individual made. For example, the richest people in America would belong to the "lower-upper class" since many of them created their own fortunes; one can only be born into the highest class. Nonetheless, members of the wealthy upper-upper class tend to be more powerful, as a simple survey of U.S. presidents may demonstrate (i.e., the Roosevelts; Kennedys; Bushes).

Another observation: members of the upper-lower class might make more money than members of the lower-middle class (i.e., a well-salaried factory worker vs. a secretarial worker), but the class difference is based on the type of work they perform.

Another observation: members of the upper-lower class might make more money than members of the lower-middle class (i.e., a well-salaried factory worker vs. a secretarial worker), but the class difference is based on the type of work they perform.

In his research findings, Warner observed that American social class was largely based on these shared attitudes. For example, he noted that the lower-middle class tended to be the most conservative group of all, since very little separated them from the working class. The upper-middle class, while a

relatively small section of the population, usually "set the standard" for proper American behavior, as reflected in the mass media.

Professionals with salaries and educational attainment higher than those found near the middle of the income strata (e.g. bottom rung professors, managerial office workers, architects) may also be considered as being true middle class.

Coleman and Rainwater

In 1978 sociologists Coleman and Rainwater conceived the "Metropolitan Class Structure" consisting of three social classes, each with a number sub-classes.

Upper Americans

- **Upper-upper class;** (ca. 1%) Old money stemming from inherited wealth. Persons in this class typically have an "Ivy league college degree." Their household income in 1978 was over \$500,000 (\$1,673,215 in 2005 dollars)
- **Lower-upper class;** (ca. 1%) This is the "Success elite" consisting of "Top professionals [and] senior corporate executives." People in this class have degrees from "Good colleges." Their household income was also commonly in excess of \$77,000 (\$251,000 in 2005 dollars).
- **Upper-middle class;** (ca. 19%) Also called the "Professional and Managerial" class, it consists of "Middle professionals and managers" with a college and often graduate degrees. Household incomes for this group lay between \$35,000 (\$114,000 in 2005 dollars) and \$60,000 (\$183,000 in 2005 dollars)

Middle Americans

- **Middle-class;** (ca. 31%) This class consists of "Lower-level managers; small-business owners; lower-status professionals (accountants, teachers); sales and clerical" workers. Middle class persons had a high school and some college education. Their household incomes commonly ranged between \$10,000 and \$20,000 (\$30,000 - \$60,000 in 2005 dollars)

- **Working class;** (ca. 35%) This class consists of "Higher blue collar (craftsman, truck drivers); lowest-paid sales and clerical" workers.
- Younger individuals in 1978 who were members of this class had a high school education. Their household income lay in between \$7,500 and \$15,000 (\$23,000 - \$45,000 in 2005 dollars)
- **Lower Americans** (ca. 13%)
- **Semipoor;** This class had high school education and consisted of "labor and service" workers with household incomes ranging from \$4,500 to \$6,000 (\$14,000 - \$18,000 in 2005 dollars)
- **The bottom;** Those who are "Often unemployed" or rely on welfare payments. Household incomes of less than \$4,500 (\$14,000 in 2005 dollars)

Thompson & Hickey

The Thompson & Hickey model found in their 2005 book, *Society in Focus*.

In their 2005 sociology textbook, *Society in Focus*, sociologists William Thompson and Joseph Hickey present a five class model in which the middle class is divided into two sections and the term working class is applied to clerical and pink collar workers. Their class system goes as follows:

- **Upper class,** (ca. 1%-5%) individuals with considerable power over the nation's economic and political institutions. This group owns a disproportionate share of the nation's resources. The top 1% had incomes exceeding \$250,000 with the top 5% having household incomes exceeding \$140,000. This group features strong group solidarity and is largely constituted by the heirs to multi-generational fortunes. Prominent government officials, CEOs and successful entrepreneurs are among the upper class even if not of elite background.
- **Upper middle class,** (ca. 15%) white collar professionals with advanced post-secondary education such as physi-

cians, professors, lawyers, corporate executives, and other management. While households commonly have six figure incomes in this group, the majority of income earners do not. Only 6% of persons had six figure incomes while 15% were upper middle class. While high educational attainment commonly serves as the staple mark of this group, entrepreneurs and business owners may also be upper middle class even if lacking advanced educational attainment.

- **Lower middle class**, (ca. 33%) individuals who worked their way through college and commonly have a Bachelor's degree or some college education. School teachers, sales-employees and lower to mid level supervisors rank among those in this particular group. Household income is generally in the range of \$30,000 to \$75,000. Workers in this group are mostly white collar but have less autonomy in their work than do upper middle class professionals. Members of this class often attempt to emulate those in the two higher classes and have recently become overly indebted by their desire to have a comfortable lifestyle.
- **Working class**, (ca. 30%) individuals who occupy both blue and white collar occupations. Pink collar workers in predominantly female clerical positions are common in this class. Job security tends to be low for this group and unemployment as well as losing health insurance remain potent economic threats. Household incomes typically range from \$16,000 to \$30,000.
- **Lower class**, repeated cycles of unemployment, working multiple low-level part-time jobs are common among this group. Many families fall below the poverty line from time to time when employment opportunities are scarce.

Gilbert & Kahl

In *The American Class Structure*, 6th edition (Wadsworth 2002) as well the preceding 5th edition, Dennis Gilbert lays out an even more precise breakdown of American social classes.

Dennis Gilbert stresses that "there is really no way to establish that a particular model is 'true' and another 'false.'" He furthermore states that his "model emphasizes sources of income" and that household income, being very dependent on the number of income earners, varies greatly within each social class.

Capitalist class; (ca. 1%) *"Subdivided into nationals and locals, whose income is derived largely from return on assets."* However, the top 1.5% of households made \$250,000 or more with only 146,000, 0.01% of households having incomes of \$1,600,000 or more. **Upper middle class;** (ca. 14%) *"...college trained professionals and managers (a few of whom ascend to such heights of bureaucratic dominance or accumulated wealth that they become part of the capitalist class)."* Educational attainment is the main feature of this class. They enjoy great job autonomy and economic security. Household incomes vary greatly depending of the number of income earners." Considering US Census Bureau According to the 2005 Economic Survey, the top 15% of income earners made \$62,500 or more with the top 15% of households having six figure incomes. **Middle class;** (ca. 30%) *"...members have significant skills and perform varied tasks at work, under loose supervision. They earn enough to afford a comfortable, mainstream lifestyle. Most wear white collars, but some wear blue."* In 2005 incomes for this group would have ranged from \$50,000 to \$90,000 for households and \$27,500 to \$52,500 for individuals. **Working class;** (ca. 30%) *"People who are less skilled than members of the middle class and work at highly routinized, closely supervised manual and clerical jobs. Their work provides them with a relatively stable income sufficient to maintain a living standard just below the mainstream."* Incomes in 2005 would have ranged from \$10,000 to \$27,500 for individuals and \$20,000 to \$50,000 for households **Working poor;** (ca. 13%) *"...people employed in low-skill jobs, often at marginal firms. The members of this class are typically laborers, service workers, or low-paid operators. Their incomes leave them well below mainstream living standards. Moreover, they cannot*

Step 4: "Generate Answers"

Through the use of brainstorming and other idea-generating techniques, the fourth step is designed to create a long list of possible solutions to the problem question. One of those solutions (or several, combined) is selected for further development.

Step 5: "Forge the Solution"

Uses a specific tool called "POWER" to develop the selected solution into something more robust. POWER is short for:

- Positives - what's good about the idea?
- Objections - what's bad about it?
- What else? - what does it remind you of?
- Enhancements - how can what's good about it be made better?
- Remedies - how can the things that are bad about it be corrected?

Step 6: "Align Resources"

The final step translates the selected, developed solution into an action plan that may include, among other things:

- to do lists
- timelines and milestones
- lists of people who need to get involved
- lists of issues that need further work.



CRITICAL THINKING

Critical thinking involves determining the meaning and significance of what is observed or expressed, or, concerning a given inference or argument, determining whether there is adequate justification to accept the conclusion as true. Hence, Fisher & Scriven define critical thinking as "Skilled, active, interpretation and evaluation of observations, communications, information, and argumentation." Moore & Parker define it more naturally as the careful, deliberate determination of whether one should accept, reject, or suspend judgment about a claim and the degree of confidence with which one accepts or rejects it.

Critical thinking gives due consideration to the evidence, the context of judgment, the relevant criteria for making the judgment well, the applicable methods or techniques for forming the judgment, and the applicable theoretical constructs for understanding the problem and the question at hand. Critical thinking employs not only logic but broad intellectual criteria such as clarity, credibility, accuracy, precision, relevance, depth, breadth, significance and fairness.

In contemporary usage "critical" has the connotation of expressing disapproval, which is not always true of critical thinking. A critical evaluation of an argument, for example, might conclude that it is valid.

Thinking is often casual and informal, whereas critical thinking deliberately evaluates the quality of thinking. In a seminal study on critical thinking and education in 1941, Edward Glaser writes that the ability to think critically involves three things:

An attitude of being disposed (state of mind regarding something) to consider in a thoughtful way the problems and subjects that come within the range of one's experiences,

Knowledge of the methods of logical inquiry and reasoning,

Some skill in applying those methods.

Critical thinking calls for a persistent effort to examine any belief or supposed form of knowledge in the light of the evidence that supports it and the further conclusions to which it tends. It also generally requires ability to recognize problems, to find workable means for meeting those problems, to gather and marshal pertinent (relevant) information, to recognize unstated assumptions and values, to comprehend and use language with accuracy, clarity, and discrimination, to interpret data, to appraise evidence and evaluate arguments, to recognize the existence (or non-existence) of logical relationships between propositions, to draw warranted conclusions and generalizations, to put to test the conclusions and generalizations at which one arrives, to reconstruct one's patterns of beliefs on the basis of wider experience, and to render accurate judgments about specific things and qualities in everyday life.

Critical thinking can occur whenever one judges, decides, or solves a problem; in general, whenever one must figure out what to believe or what to do, and do so in a reasonable and reflective way. Reading, writing, speaking, and listening can all be done critically or uncritically. Critical thinking is crucial to becoming a close reader and a substantive writer. Expressed most generally, critical thinking is "a way of taking up the problems of life." Irrespective of the sphere of thought, "a well cultivated critical thinker":

- raises important questions and problems, formulating them clearly and precisely;
- gathers and assesses relevant information, using abstract ideas to interpret it effectively
- comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards;

- thinks open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences; and
- communicates effectively with others in figuring out solutions to complex problems; without being unduly influenced by others' thinking on the topic.

Principles and Dispositions

Critical thinking is based on self-corrective concepts and principles, not on hard and fast, or step-by-step, procedures.

Critical thinking employs not only logic (either formal or, much more often, informal) but broad intellectual criteria such as clarity, credibility, accuracy, precision, relevance, depth, breadth, significance.

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. Given research in cognitive psychology, some educators believe that schools should focus on teaching their students critical thinking skills and cultivation of intellectual traits.

Applications

Critical thinking is about being both willing and able to evaluate one's thinking. Thinking might be criticised because one does not have all the relevant information - indeed, important information may remain undiscovered, or the information may not even be knowable - or because one makes unjustified inferences, uses inappropriate concepts, or fails to notice important implications. One's thinking may be unclear, inaccurate, imprecise, irrelevant, narrow, shallow, illogical, or trivial, due to ignorance or misapplication of the appropriate skills of thinking. On the other hand, one's thinking might be criticised as being the result of a sub-optimal disposition. The dispositional dimension of critical thinking is characterological. Its focus is in developing the habitual intention to be truth-seeking, open-minded, systematic, analytical, inquisitive, confident in reasoning, and prudent in making judgments. Those who are ambivalent on one or more of these aspects of the disposition toward critical thinking, or who have an opposite disposition (intellectually arrogant, bias, intolerant, disorganized, lazy, heedless of consequences, indifferent toward new information, mistrustful of reasoning, or imprudent) are more likely to encounter problems in using their critical thinking skills. Failure to recognize the importance of correct dispositions can lead to various forms of self-deception and closed-mindedness, both individually and collectively.

When individuals possess intellectual skills alone, without the intellectual traits of mind, *weak sense critical thinking* results. *Fair-minded or strong sense critical thinking* requires intellectual humility, empathy, integrity, perseverance, courage,

autonomy, confidence in reason, and other intellectual traits. Thus, critical thinking without essential intellectual traits often results in clever, but manipulative and often unethical or subjective thought.

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. Two measures of critical thinking dispositions are the California Critical Thinking Disposition Inventory and the California Measure of Mental Motivation.

The key to seeing the significance of critical thinking in academics is in understanding the significance of critical thinking in learning. There are two meanings to the learning of this content. The first occurs when learners (for the first time) construct in their minds the basic ideas, principles, and theories that are inherent in content. This is a process of internalization. The second occurs when learners effectively use those ideas, principles, and theories as they become relevant in learners' lives. This is a process of application. Good teachers cultivate critical thinking (intellectually engaged thinking) at every stage of learning, including initial learning. This process of intellectual engagement is at the heart of the Oxford, Durham, Cambridge and London School of Economics tutorials. The tutor questions the students, often in a Socratic manner (see Socratic questioning). The key is that the teacher who fosters critical thinking fosters reflectiveness in students by asking questions that stimulate thinking essential to the construction of knowledge.

As emphasized above, 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.

In the UK school system, *Critical Thinking* is offered as a subject which 16-18 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 analyse 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. 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 is also 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. From 2008, Assessment and Qualifications Alliance will also be offering an A-level Critical Thinking specification; 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.

Research suggests a widespread skepticism about universities' effectiveness in fostering critical thinking. For example, in a three year study of 68 public and private colleges in California, though the overwhelming majority (89%) claimed critical thinking to be a primary objective of their instruction, only a small minority (19%) could give a clear explanation of what critical thinking is. Furthermore, although the overwhelming majority (78%) claimed that their students lacked

appropriate intellectual standards (to use in assessing their thinking), and 73% considered that students learning to assess their own work was of primary importance, only a very small minority (8%) could enumerate any intellectual criteria or standards they required of students or could give an intelligible explanation of what those criteria and standards were.

This study mirrors a meta-analysis of the literature on teaching effectiveness in higher education. According to the study, critical reports by authorities on higher education, political leaders and business people have claimed that higher education is failing to respond to the needs of students, and that many of our graduates' knowledge and skills do not meet society's requirements for well-educated citizens. Thus the meta-analysis focused on the question: How valid are these claims? Researchers concluded:

- "Faculty aspire to develop students' thinking skills, but research consistently shows that in practice we tend to aim at facts and concepts in the disciplines, at the lowest cognitive levels, rather than development of intellect or values."
- "Faculty agree almost universally that the development of students' higher-order intellectual or cognitive abilities is the most important educational task of colleges and universities."
- "These abilities underpin our students' perceptions of the world and the consequent decisions they make."
- "Specifically, critical thinking – the capacity to evaluate skillfully and fairly the quality of evidence and detect error, hypocrisy, manipulation, dissembling, and bias – is central to both personal success and national needs."
- A 1972 study of 40,000 faculty members by the American Council on Education found that 97 percent of the respondents indicated the most important goal of undergraduate education is to foster students' ability to think critically.
- Process-oriented instructional orientations "have long been more successful than conventional instruction in

fostering effective movement from concrete to formal reasoning. Such programs emphasize students' active involvement in learning and cooperative work with other students and de-emphasize lectures..."

- Numerous studies of college classrooms reveal that, rather than actively involving our students in learning, we lecture, even though lectures are not nearly as effective as other means for developing cognitive skills."
- "In addition, students may be attending to lectures only about one-half of their time in class, and retention from lectures is low."
- "Studies suggest our methods often fail to dislodge students' misconceptions and ensure learning of complex, abstract concepts. Capacity for problem solving is limited by our use of inappropriately simple practice exercises."
- "Classroom tests often set the standard for students' learning. As with instruction, however, we tend to emphasize recall of memorized factual information rather than intellectual challenge."
- "Taken together with our preference for lecturing, our tests may be reinforcing our students' commonly fact-oriented memory learning, of limited value to either them or society."

In contrast to these results, for students to excel at thinking critically, especially at the graduate level and in research, where it is crucial, they must be taught not how to know the answer, but how to ask the question. As Schwartz explains in "The importance of stupidity in scientific research," researchers must embrace what they do not know. Critical thinking is a primary tool in approaching this.

There is no simple way to develop the intellectual traits of a critical thinker. One important way requires developing one's intellectual empathy and intellectual humility. The first requires extensive experience in entering and accurately constructing points of view toward which one has negative feelings. The second requires extensive experience in identifying the extent of

one's own ignorance in a wide variety of subjects (ignorance whose admission leads one to say, "I thought I *knew*, but I merely *believed*"). One becomes less biased and more broad-minded when one becomes more intellectually empathic and intellectually humble, and that involves time, deliberate practice and commitment. It involves considerable personal and intellectual development.

To develop one's critical thinking traits, one should learn the art of suspending judgment (for example, when reading a novel, watching a movie, engaging in dialogical or dialectical reasoning). Ways of doing this include adopting a perceptive rather than judgmental orientation; that is, avoiding moving from perception to judgment as one applies critical thinking to an issue.

One should become aware of one's own fallibility by:

accepting that everyone has subconscious biases, and accordingly questioning any reflexive judgments;

adopting an ego-sensitive and, indeed, intellectually humble stance;

recalling previous beliefs that one once held strongly but now rejects;

tendency towards group think; the amount your belief system is formed by what those around you say instead of what you have personally witnessed;

realizing one still has numerous blind spots, despite the foregoing.

An integration of insights from the critical thinking literature and cognitive psychology literature is the "Method of Argument and Heuristic Analysis." This technique illustrates the influences of heuristics and biases on human decision making along with the influences of thinking critically about reasons and claims.



INTELLIGENCE

Intelligence is an umbrella term describing a property of the mind comprehending related abilities, such as the capacities for abstract thought, reasoning, planning, problem solving, speech, and learning.

Theories of intelligence are two-fold: (i) the "single intelligence" based upon the unilinear construct of "general intelligence", and (ii) the construct of multiple intelligences. Influenced by his cousin Charles Darwin, Francis Galton was the first scientist to propose a theory of general intelligence; that intelligence is a true, biologically-based mental faculty that can be studied by measuring a person's reaction times to cognitive tasks. Galton's research in measuring the head sizes of British scientists and laymen led to the conclusion that head-size is unrelated to a person's intelligence.

Alfred Binet, and the French school of intelligence, believed intelligence was a median average of dissimilar abilities, not a unitary entity with specific, identifiable properties.

Definitions

Intelligence derives from the Latin verb *intelligere* ("to understand", "to choose between"); per that rationale, "understanding" (intelligence) is different from being "smart" (capable of adapting to the environment). Scientists have proposed two major "consensus" definitions of intelligence:

(i) from *Mainstream Science on Intelligence* (1994), a report by fifty-two researchers:

A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think

abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings — “catching on”, “making sense” of things, or “figuring out” what to do.

(ii) from *Intelligence: Knowns and Unknowns* (1995), a report published by the Board of Scientific Affairs of the American Psychological Association:

Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, [and] to overcome obstacles by taking thought. Although these individual differences can be substantial, they are never entirely consistent: a given person's intellectual performance will vary on different occasions, in different domains, as judged by different criteria. Concepts of “intelligence” are attempts to clarify and organize this complex set of phenomena. Although considerable clarity has been achieved in some areas, no such conceptualization has yet answered all the important questions, and none commands universal assent. Indeed, when two dozen prominent theorists were recently asked to define intelligence, they gave two dozen, somewhat different, definitions.

Practical application — Furthermore, in clinical and therapeutic practice, such theoretic and academic definitions of intelligence might not apply to patients with borderline intellectual and adaptive functioning, whose treatments require comprehensive analysis of every diagnostic, testing, educational placement, and psychosocial factor. The eighth (2005) and ninth (2009) editions of the *Kaplan & Sadock's Comprehensive Textbook of Psychiatry*, by Frank John Ninivaggi, MD, address these matters.

Theories of intelligence

A popular theory of intelligence is based on psychometric testing, i.e. intelligence quotient (IQ) tests; however, some

researchers' dissatisfaction with traditional IQ tests prompted their developing alternative theories of intelligence suggesting that intelligence results from independent capabilities that uniquely contribute to human intellectual performance.

Psychometric approach

Despite the variety of concepts of intelligence, the approach to understanding intelligence with the most supporters and published research over the longest period of time is based on psychometrics testing. Such intelligence quotient (IQ) tests include the Stanford-Binet, Raven's Progressive Matrices, the Wechsler Adult Intelligence Scale and the Kaufman Assessment Battery for Children.

Charles Spearman is generally credited with discovering general intelligence, which he reported in his 1904 *American Journal of Psychology* article titled "General Intelligence," Objectively Determined and Measured. Based on the results of a series of studies collected in Hampshire, England, Spearman concluded that there was a common function (or group of functions) across intellectual activities including what he called intelligence (i.e., school rank, which Spearman thought of as "present efficiency" in school courses; the difference between school rank and age, which was conceptualized as "native capacity;" teacher ratings; and peer ratings provided by the two oldest students, which was termed "common sense") and sensory discriminations (i.e., discrimination of pitch, brightness, and weight). This common function became known as "g" or general intelligence.

To objectively determine and measure general intelligence, Spearman invented the first technique of factor analysis (the method of Tetrad Differences) as a mathematical proof of the Two-Factor Theory. The factor analytic results indicated that every variable measured a common function to varying degrees, which led Spearman to develop the somewhat misleadingly named Two-Factor Theory of Intelligence. The Two-Factor Theory of Intelligence holds that every test can be divided into a "g" factor and an "s" factor. The g-factor measures the

"general" factor or common function among ability tests. The s-factor measures the "specific" factor unique to a particular ability test. Based on a more modern interpretation of his work, Spearman's g factor represents the fact that any set of cognitive ability tests, no matter how different, tend to all correlate positively.

L. L. Thurstone extended and generalized Spearman's method of factor analysis into what is called the Centroid method and which became the basis for modern factor analysis. Thurstone demonstrated that Spearman's one common factor method (Spearman's method yielded only a single factor) was a special case of his multiple factor analysis. Thurstone's research lead him to propose a model of intelligence that included seven orthogonal (unrelated) factors (i.e., verbal comprehension, word fluency, number facility, spatial visualization, associative memory, perceptual speed and reasoning) referred to as the Primary Mental Abilities.

In a critical review of the adult testing literature, Raymond B. Cattell found that a considerable percentage of intelligence tests that purported to measure adult intellectual functioning had all of the trappings of using college students in their development. To account for differences between children/adolescents and adults, which past theory did not address, Cattell proposed two types of cognitive abilities in a revision of Spearman's concept of general intelligence. Fluid intelligence (Gf) was hypothesized as the ability to discriminate and perceive relations (e.g., analogical and syllogistic reasoning), and crystallized intelligence (Gc) was hypothesized as the ability to discriminate relations that had been established originally through Gf, but no longer required the identification of the relation (commonly assessed using information or vocabulary tests). In addition, fluid intelligence was hypothesized to increase until adolescence and then to slowly decline, and crystallized intelligence increases gradually and stays relatively stable across most of adulthood until it declines in late adulthood.

With his student John L. Horn, Cattell indicated that Gf and Gc were only two among several factors manifest in intelligence tests scores under the umbrella of what became known as Gf/Gc Theory. General visualization (Gv; visual acuity, depth perception), general fluency (F, facility in recalling words), general speediness (Gs; performance on speeded, simple tasks) were among several cognitive ability factors added to Gf/Gc Theory.

J. P. Guilford sought to more fully explore the scope of the adult intellect by providing the concept of intelligence with a strong, comprehensive theoretical backing. The Structure-of-Intellect model (SI model) was designed as a cross classification system with intersections in the model providing the basis for abilities similar to Mendeleev's periodic table in chemistry. The three-dimensional cube-shaped model includes five content categories (the way in which information is presented on a test; visual, auditory, symbolic, semantic, and behavioral), six operation categories (what is done on a test; evaluation, convergent production, divergent production, memory retention, memory recording, and cognition), and six product categories (the form in which information is processed on a test; units, classes, relations, systems, transformations, and implications). The intersection of three categories provides a frame of reference for generating one or more new hypothetical factors of intelligence.

John B. Carroll re-analyzed 461 datasets in the single most comprehensive study of cognitive abilities. This analysis led him to propose the Three Stratum Theory, which is a hierarchical model of intellectual functioning. The strata represent three different levels of generality over the domain of cognitive abilities. At the bottom is the first stratum, which is represented by narrow abilities that are highly specialized (e.g., induction, spelling ability). The second stratum is represented by broad abilities that include moderate specializations in various domains. Carroll identified eight second-stratum factors: fluid intelligence, crystallized intelligence, general memory and

learning, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness, and processing speed (reaction time decision speed). Carroll has noted the similarity of his second stratum abilities and the Gf/Gc factors, although the Three-Stratum Theory does not incorporate the developmental trajectories associated with Gf/Gc Theory. Carroll accepted Spearman's concept of general intelligence, for the most part, as a representation of the uppermost third stratum.

More recently, an amalgamation the Gf-Gc theory of Cattell and Horn with Carroll's Three-Stratum theory has led to the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. CHC researchers have produced numerous studies that have influenced diagnostic issues and test development.

Intelligence, as measured by IQ and other aptitude tests, is widely used in educational, business, and military settings due to its efficacy in predicting behavior. *g* is highly correlated with many important social outcomes - individuals with low IQs are more likely to be divorced, have a child out of marriage, be incarcerated, and need long term welfare support, while individuals with high IQs are associated with more years of education, higher status jobs and higher income. Intelligence is significantly correlated with successful training and performance outcomes, and *g* is the single best predictor of successful job performance.

IQ tests were originally designed to identify mentally "defective" children. The inventors of the IQ did not necessarily believe they were measuring fixed intelligence. Despite this, critics argue that intelligence tests have been used to support nativistic theories which view intelligence as a qualitative object with a relatively fixed quantity.

Critics of the psychometrics point out that intelligence is often more complex and broader in conception than what is measured by IQ tests. Furthermore, skeptics argue that even though tests of mental abilities are correlated, people still have unique strengths and weaknesses in specific areas. Consequently they argue that psychometric theorists over-emphasize *g*, despite

the fact that g was defined so as to encompass all inter-correlated capabilities and skills.

Researchers in the field of human intelligence have encountered a considerable amount of public concern and criticism — much more than scientists in other areas normally receive. A number of critics have challenged the relevance of psychometric intelligence in the context of everyday life. There have also been controversies over genetic factors in intelligence, particularly questions regarding the relationship between race and intelligence and sex and intelligence. Another controversy in the field is how to interpret the increases in test scores that have occurred over time, the so-called Flynn effect.

Stephen Jay Gould was one of the most vocal critics of intelligence testing. In his book *The Mismeasure of Man* Gould argued that intelligence could not be quantified to a single numerical entity. He also challenged the hereditarian viewpoint on intelligence. Many of Gould's criticisms were aimed at Arthur Jensen, who responded that his work had been misrepresented. Gould also investigated the methods of nineteenth century craniometry. Jensen stated that drawing conclusions from early intelligence research is like condemning the auto industry by criticizing the performance of the Model T.

Rushton and Jensen, 2005, report in their paper "30 Years of Race Differences in Cognitive Ability", as published in *Psychology, Public Policy and Law*, that MRI studies of brain size correlates with intelligence. Adult Asians average 1 cubic inch more brain mass than Whites and Whites average 5 cubic inches more brain mass than Blacks. They state that race differences in brain size are present at birth; and larger brains contain more neurons and synapses to process information faster.

Multiple intelligences

Howard Gardner's theory of multiple intelligences is based on studies not only of normal children and adults but also by studies of gifted individuals (including so-called "savants"), of persons who have suffered brain damage, of experts and

virtuosos, and of individuals from diverse cultures. This led Gardner to break intelligence down into at least eight different components: logical, linguistic, spatial, musical, kinesthetic, interpersonal, intrapersonal in 1983 and naturalist intelligences added in 1999 he argues that psychometric tests address only linguistic and logical plus some aspects of spatial intelligence; other forms have been entirely ignored. Moreover, the paper-and-pencil format of most tests rules out many kinds of intelligent performance that matter in everyday life, such as social intelligence.

Most theories of multiple intelligences are relatively recent in origin, though Louis Thurstone proposed a theory of multiple "primary abilities" in the early 20th Century. Further research is required into the reliability and validity of Gardner's multiple intelligences.

Triarchic Theory of Intelligence

Robert Sternberg proposed the Triarchic Theory of Intelligence to provide a more comprehensive description of intellectual competence than traditional differential or cognitive theories of human ability. The Triarchic Theory describes three fundamental aspects of intelligence. Analytic intelligence comprises the mental processes through which intelligence is expressed. Creative intelligence is necessary when an individual is confronted with a challenge that is nearly, but not entirely, novel or when an individual is engaged in automatizing the performance of a task. Practical intelligence is bound in a sociocultural milieu and involves adaptation to, selection of, and shaping of the environment to maximize fit in the context. The Triarchic Theory does not argue against the validity of a general intelligence factor; instead, the theory posits that general intelligence is part of analytic intelligence, and only by considering all three aspects of intelligence can the full range of intellectual functioning be fully understood.

More recently, the Triarchic Theory has been updated and renamed the Theory of Successful Intelligence by Sternberg. Intelligence is defined as an individual's assessment of success

in life by the individual's own (idiographic) standards and within the individual's sociocultural context. Success is achieved by using combinations of analytical, creative, and practical intelligence. The three aspects of intelligence are referred to as processing skills. The processing skills are applied to the pursuit of success through what were the three elements of practical intelligence: adapting to, shaping of, and selecting of one's environments.

The mechanisms that employ the processing skills to achieve success include utilizing one's strengths and compensating or correcting for one's weaknesses.

Sternberg's theories and research on intelligence remain contentious within the scientific community.

Developmental approach

Jean Piaget was the founder of the developmental approach to the study of intelligence. According to his theory of cognitive development, intelligence is the basic mechanism of ensuring equilibrium in the relations between the person and the environment. This is achieved through the actions of the developing person on the world. At any moment in development, the environment is assimilated in the schemes of action that are already available and these schemes are transformed or accommodated to the peculiarities of the objects of the environment, if they are not completely appropriate. Thus, the development of intelligence is a continuous process of assimilations and accommodations that lead to increasing expansion of the field of application of schemes, increasing coordination between them, increasing interiorization, and increasing abstraction. Piaget described four main periods or stages in the development towards completely equilibrated thought and problem solving. In the sensorimotor stage (0-2 years), thought is based on perceptions and external actions and their coordination. In the preoperational stage, sensorimotor schemes are internalized and thought occurs mentally rather than externally, through the manipulation of representations and symbols that stand for sensorimotor schemes and objects.

At the beginning, however, mental schemes are not coordinated. As a result, systematic logical reasoning is not possible (that, for example, $A = C$, if $A = B$ and $B = C$). When mental schemes are coordinated, thinking enters the concrete operational stage. In this period, thinking is logical, but limited to the concrete aspects of the world. That is, children can grasp several important aspects of the world, such as the conservation of number, matter, length, weight, volume, etc. despite external transformation. Gradually, concrete operational schemes are coordinated with each other and cognitive development enters the final formal operational stage. In this period reality is subsumed to possibilities and reasoning becomes formal. As a result, abstract scientific concepts such as the concept of inertia, energy, algebra, and proportionality can be grasped and scientific experiments can be designed. All in all, for Piaget intelligence is not the same at different ages. It changes qualitatively, thereby allowing access to different levels of organization of the world. Research shows that Piagetian intelligence is correlated but it is not identical with psychometric intelligence and IQ.

The neo-Piagetian theories of cognitive development advanced by Case, Demetriou, Halford, and Pascual-Leone, attempted to integrate Piaget's theory with cognitive and differential theories of cognitive organization and development. Their aim was to better account for the cognitive factors of development and for intra-individual and inter-individual differences in cognitive development. They suggested that development along Piaget's stages is due to increasing processing efficiency which is defined in terms of speed of processing and working memory capacity. Moreover, Demetriou's theory ascribes an important role to hypercognitive processes of self-recording, self-monitoring, and self-regulation and it recognizes the operation of several relatively autonomous domains of thought.

Overall, this approach suggests that there indeed is a general intelligence factor. This factor is geared on general processing efficiency functions that enable humans to represent and process information, that processing involves general

inferential processes that are gradually constructed, and self-awareness and reflection are instrumental in this construction. The general understanding and problem solving ability associated with this factor changes qualitatively with age and this change is related to the succession of Piagetian stages. At the same time, individual differences in the state of the general efficiency factors may cause differences in the rate of intellectual development of different individuals and these differences may be reflected in psychometric measures of cognitive ability, such as the IQ tests. Moreover differences between individuals may come from differences in their predispositions or facility related to different domains of knowledge and problem solving.

Emotional intelligence

Daniel Goleman and several other researchers have developed the concept of emotional intelligence and claim it is at least as "important" as more traditional sorts of intelligence. These theories grew from observations of human development and of brain injury victims who demonstrate an acute loss of a particular cognitive function — e.g. the ability to think numerically, or the ability to understand written language — without showing any loss in other cognitive areas.

PASS Theory

PASS theory has been offered as an alternative to general intelligence, and is based on a description of neuropsychological processes. These authors suggested that a unidimensional model with just intelligence fails to assist researchers and clinicians who study learning disabilities, disorders of attention, mental retardation, and interventions designed for special populations who face those challenges. The PASS model covers four kinds of competencies that are associated with areas of the brain. (1) The planning processes involve decision making, problem solving, and performing activities and requires goal setting and self-monitoring. (2) The attention/arousal component involves selectively attending to a particular stimulus, ignoring distractions, and maintaining vigilance. (3) Simultaneous processing involves the integration

of stimuli into a group and requires the observation of relationships. (4) Successive processing involves the integration of stimuli into serial order. The planning and attention/arousal components comes from structures located in the frontal lobe, and the simultaneous and successive processes come from structures located in the posterior region of the cortex.

Empirical evidence

IQ proponents have claimed that IQ's predictive validity has been demonstrated, for example in predicting non-academic outcomes such as job performance , and that the various multiple intelligence theories have little or no such support. Meanwhile, it has been claimed that the relevance and existence of multiple intelligences have not been borne out when tested. A set of ability tests that do not correlate together would support the claim that multiple intelligences are independent of each other.

Evolution of intelligence

Our hominid and human ancestors evolved large and complex brains exhibiting an ever-increasing intelligence through a long and mostly unknown evolutionary process. This process was either driven by the direct adaptive benefits of intelligence , or - alternatively - driven by its indirect benefits within the context of sexual selection as a reliable signal of genetic resistance against pathogens.

Factors affecting intelligence

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

Biological

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

Other biological factors correlating with IQ include ratio of brain weight to body weight and the volume and location of gray matter tissue in the brain.

Because intelligence appears to be at least partly dependent on brain structure and the genes shaping brain development, it has been proposed that genetic engineering could be used to enhance the intelligence of animals, a process sometimes called biological uplift in science fiction. Experiments on mice have demonstrated superior ability in learning and memory in various behavioural tasks.

Environmental

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

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

Cultural factors also play a role in intelligence. For example, on a sorting task to measure intelligence, Westerners tend to take a taxonomic approach while the Kpelle people take a more functional approach. For example, instead of grouping food and tools into separate categories, a Kpelle participant stated "the knife goes with the orange because it cuts it"

Ethical issues

Since intelligence is susceptible to modification through the manipulation of environment, the ability to influence intelligence raises ethical issues. Transhumanist theorists study the possibilities and consequences of developing and using techniques to enhance human abilities and aptitudes, and ameliorate what it regards as undesirable and unnecessary aspects of the human condition; eugenics is a social philosophy which advocates the improvement of human hereditary traits through various forms of intervention. The perception of eugenics has varied throughout history, from a social responsibility required of society, to an immoral, racist stance.

Neuroethics considers the ethical, legal and social implications of neuroscience, and deals with issues such as difference between treating a human neurological disease and enhancing the human brain, and how wealth impacts access to neurotechnology. Neuroethical issues interact with the ethics of human genetic engineering.

Although humans have been the primary focus of intelligence researchers, scientists have also attempted to investigate animal intelligence, or more broadly, animal cognition. These researchers are interested in studying both mental ability in a particular species, and comparing abilities between species. They study various measures of problem solving, as well as mathematical and language abilities. Some challenges in this area are defining intelligence so that it means the same thing across species (eg. comparing intelligence between literate humans and illiterate animals), and then operationalizing a measure that accurately compares mental ability across different species and contexts.

Wolfgang Köhler's pioneering research on the intelligence of apes is a classic example of research in this area. Stanley Coren's book, *The Intelligence of Dogs* is a notable popular book on the topic. Nonhuman animals particularly noted and studied for their intelligence include chimpanzees, bonobos (notably the language-using Kanzi) and other great apes,

dolphins, elephants and to some extent parrots and ravens. Controversy exists over the extent to which these judgments of intelligence are accurate.

Cephalopod intelligence also provides important comparative study. Cephalopods appear to exhibit characteristics of significant intelligence, yet their nervous systems differ radically from those of most other notably intelligent life-forms (mammals and birds).

Anthony Trewavas has argued that plants should also be classified as being intelligent based on their ability to sense the environment and adjust their morphology, physiology and phenotype accordingly.

Artificial intelligence

Artificial intelligence (or AI) is both the intelligence of machines and the branch of computer science which aims to create it, through "the study and design of intelligent agents" or "rational agents", where an intelligent agent is a system that perceives its environment and takes actions which maximize its chances of success. Achievements in artificial intelligence include constrained and well-defined problems such as games, crossword-solving and optical character recognition. General intelligence or strong AI has not yet been achieved and is a long-term goal of AI research.

Among the traits that researchers hope machines will exhibit are reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects.

Phenomenal and access consciousness

Phenomenal consciousness (P-consciousness) is simply experience; it is moving, colored forms, sounds, sensations, emotions and feelings with our bodies and responses at the center. These experiences, considered independently of any impact on behavior, are called *qualia*. The *hard problem of consciousness*, formulated by David Chalmers in 1996, deals with the issue of "how to explain a state of phenomenal consciousness in terms of its neurological basis".

Access consciousness (A-consciousness) is the phenomenon whereby information in our minds is accessible for verbal report, reasoning, and the control of behavior. So, when we perceive, information about what we perceive is often access conscious; when we introspect, information about our thoughts is access conscious; when we remember, information about the past (e.g., something that we learned) is often access conscious, and so on. Chalmers thinks that access consciousness is less mysterious than phenomenal consciousness, so that it is held to pose one of the *easy problems* of consciousness. Daniel Dennett denies that there is a "hard problem", asserting that the totality of consciousness can be understood in terms of impact on behavior, as studied through heterophenomenology. There have been numerous approaches to the processes that act on conscious experience from instant to instant. Dennett suggests that what people think of as phenomenal consciousness, such as *qualia*, are judgments and consequent behavior. He extends this analysis by arguing that phenomenal consciousness can be explained in terms of access consciousness, denying the existence of *qualia*, hence denying the existence of a "hard problem." Chalmers, on the other hand, argues that Dennett's explanatory processes merely address aspects of the easy problem. Eccles and others have pointed out the difficulty of explaining the evolution of *qualia*, or of 'minds' which experience them, given that all the processes governing evolution are physical and so have no direct access to them. There is no guarantee that all people have minds, nor any way to verify whether one does or does not possess one.

Events that occur in the mind or brain that are not within phenomenal or access consciousness are known as *sub-conscious* events.

For centuries, philosophers have investigated phenomenal consciousness. René Descartes, who coined the famous dictum 'cogito ergo sum', wrote *Meditations on First Philosophy* in the seventeenth century. According to Descartes, all thought is conscious. Conscious experience, according to Descartes, included such ideas as imaginings and perceptions laid out in

space and time that are viewed from a point, and appearing as a result of some quality (qualia) such as color, smell, and so on. (Modern readers are often confused by this Descartes' notion of interchangeability between the terms 'idea' and 'imaginings'.)

Descartes defines *ideas* as extended things, as in this excerpt from his *Treatise on Man*:

Now among these figures, it is not those imprinted on the external sense organs, or on the internal surface of the brain, which should be taken to be ideas - but only those which are traced in the spirits on the surface of gland H [where the seat of the imagination and the 'common sense' is located]. That is to say, it is only the latter figures which should be taken to be the forms or images which the rational soul united to this machine will consider directly when it imagines some object or perceives it by the senses.

Thus Descartes does not identify mental ideas or 'qualia' with activity within the sense organs, or even with brain activity, but rather with the "forms or images" that unite the body and the 'rational soul', through the mediating 'gland H'. This organ is now known as the pineal gland. Descartes notes that, anatomically, while the human brain consists of two symmetrical hemispheres the pineal gland, which lies close to the brain's centre, appears to be singular. Thus he extrapolated from this that it was the mediator between body and soul.

Philosophical responses, including those of Nicolas Malebranche, Thomas Reid, John Locke, David Hume and Immanuel Kant, were varied. Malebranche, for example, agreed with Descartes that the human being was composed of two elements, body and mind, and that conscious experience resided in the latter. He did, however, disagree with Descartes as to the ease with which we might become aware of our mental constitution, stating 'I am not my own light unto myself'. David Hume and Immanuel Kant also differ from Descartes, in that they avoid mentioning a place from which experience is viewed (see "Further reading" below); certainly, few if any modern philosophers have identified the pineal gland as the seat of dualist interaction.

The extension of things in time was considered in more detail by Kant and James. Kant wrote that "only on the presupposition of time can we represent to ourselves a number of things as existing at one and the same time [simultaneously] or at different times [successively]." William James stressed the extension of experience in time and said that time is "the short duration of which we are immediately and incessantly sensible."

When we look around a room or have a dream, things are laid out in space and time and viewed as if from a point. However, when philosophers and scientists consider the location of the form and contents of this phenomenal consciousness, there are fierce disagreements. As an example, Descartes proposed that the contents are brain activity seen by a non-physical place without extension (the *Res Cogitans*), which, in *Meditations on First Philosophy*, he identified as the soul. This idea is known as *Cartesian Dualism*. Another example is found in the work of Thomas Reid who thought the contents of consciousness are the world itself, which becomes conscious experience in some way. This concept is a type of Direct realism. The precise physical substrate of conscious experience in the world, such as photons, quantum fields, etc. is usually not specified.

Other philosophers, such as George Berkeley, have proposed that the contents of consciousness are an aspect of minds and do not necessarily involve matter at all. This is a type of Idealism. Yet others, such as Leibniz, have considered that each point in the universe is endowed with conscious content. This is a form of Panpsychism. Panpsychism is the belief that all matter, including rocks for example, is sentient or conscious. The concept of the things in conscious experience being impressions in the brain is a type of representationalism, and representationalism is a form of indirect realism.

It is sometimes held that consciousness emerges from the complexity of brain processing. The general label 'emergence' applies to new phenomena that emerge from a physical basis without the connection between the two explicitly specified.

Some theorists hold that phenomenal consciousness poses an explanatory gap. Colin McGinn takes the New Mysterianism position that it can't be solved, and Chalmers criticizes purely physical accounts of mental experiences based on the idea that philosophical zombies are logically possible and supports property dualism. But others have proposed speculative scientific theories to explain the explanatory gap, such as Quantum mind, space-time theories of consciousness, reflexive monism, and Electromagnetic theories of consciousness to explain the correspondence between brain activity and experience.

Parapsychologists sometimes appeal to the unproven concepts of psychokinesis or telepathy to support the belief that consciousness is not confined to the brain.

From the eighteenth to twentieth centuries many philosophers concentrated on relations, processes and thought as the most important aspects of consciousness. These aspects would later become known as "access consciousness" and this focus on relations allowed philosophers such as Marx, Nietzsche and Foucault to claim that individual consciousness was dependent on such factors as social relations, political relations and ideology.

Locke's "forensic" notion of personal identity founded on an individual conscious subject would be criticized in the 19th century by Marx, Nietzsche, and Freud following different angles. Martin Heidegger's concept of the *Dasein* ("Being-there") would also be an attempt to think beyond the conscious subject.

Marx considered that social relations ontologically preceded individual consciousness, and criticized the conception of a conscious subject as an ideological conception on which liberal political thought was founded. Marx in particular criticized the 1789 Declaration of the Rights of Man and of the Citizen, considering that the so-called individual natural rights were ideological fictions camouflaging social inequality in the attribution of those rights. Later, Louis Althusser would criticize the "bourgeois ideology of the subject" through the concept of *interpellation* ("Hey, you!").

Nietzsche, for his part, once wrote that "they give you free will only to later blame yourself", thus reversing the classical liberal conception of free will in a critical account of the genealogy of consciousness as the effect of guilt and resentment, which he described in *On the Genealogy of Morals*. Hence, Nietzsche was the first one to make the claim that the modern notion of consciousness was indebted to the modern system of penalty, which judged a man according to his "responsibility", that is by the consciousness through which acts can be attributed to an individual subject: "I did this! this is me!". Consciousness is thus related by Nietzsche to the classic philosopheme of recognition which, according to him, defines knowledge.

According to Pierre Klossowski (1969), Nietzsche considered consciousness to be a hypostatization of the body, composed of multiple forces (the "Will to Power"). According to him, the subject was only a "grammatical fiction": we believed in the existence of an individual subject, and therefore of a specific author of each act, insofar as we speak. Therefore, the conscious subject is dependent on the existence of language, a claim which would be generalized by critical discourse analysis.

Michel Foucault's analysis of the creation of the individual subject through *disciplines*, in *Discipline and Punish* (1975), would extend Nietzsche's genealogy of consciousness and personal identity - i.e. individualism - to the change in the juridico-penal system: the emergence of penology and the disciplinization of the individual subject through the creation of a penal system which judged not the acts as it alleged to, but the personal identity of the wrong-doer. In other words, Foucault maintained that, by judging not the acts (the crime), but the person behind those acts (the criminal), the modern penal system was not only following the philosophical definition of consciousness, once again demonstrating the imbrications between ideas and social institutions ("material ideology" as Althusser would call it); it was by itself creating the individual person, categorizing and dividing the masses into a category of

poor but honest and law-abiding citizens and another category of "professional criminals" or recidivists.

Gilbert Ryle has argued that traditional understandings of consciousness depend on a Cartesian outlook that divides into mind and body, mind and world. He proposed that we speak not of minds, bodies, and the world, but of individuals, or persons, acting in the world. Thus, by saying 'consciousness,' we end up misleading ourselves by thinking that there is any sort of thing as consciousness separated from behavioral and linguistic understandings.

The failure to produce a workable definition of consciousness also raises formidable philosophical questions. It has been argued that when Antonio Damasio defines consciousness as "an organism's awareness of its own self and its surroundings", the definition has not escaped circularity, because awareness in that context can be considered a synonym for consciousness.

The notion of consciousness as passive awareness can be contrasted with the notion of the active construction of mental representations. Maturana and Varela showed that the brain is massively involved with creating worlds of experience for us with meager input from the senses. Evolutionary biologist Richard Dawkins sums up the interactive view of experience: "In a way, what sense organs do is assist our brains to construct a useful model and it is this model that we move around in. It is a kind of virtual reality simulation of the world."

Because humans express their conscious states using language, it is tempting to equate language abilities and consciousness. There are, however, speechless humans (infants, feral children, aphasics, severe forms of autism), to whom consciousness is attributed despite language lost or not yet acquired. Moreover, the study of brain states of non-linguistic primates, in particular the macaques, has been used extensively by scientists and philosophers in their quest for the neural correlates of the contents of consciousness.

Julian Jaynes argued to the contrary, in *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, that for consciousness to arise in a person, language needs to have reached a fairly high level of complexity. According to Jaynes, human consciousness emerged as recently as 1300 BCE or thereabouts. He defines consciousness in such a way as to show how he conceives of it as a type of thinking which builds upon non human ways of perceiving, for example (p. 55)...

Subjective conscious mind is an analog of what is called the real world. It is built up like a vocabulary or lexical field whose terms are all metaphors or analogs of behavior in the physical world. Its reality is of the same order as mathematics. It allows us to shortcut behavioral processes and arrive at more adequate decisions. Like mathematics, it is an operator rather than a repository. And it is intimately bound up with volition and decision.

...and page 65...

It operates by way of analogy, by way of constructing an analog space with an analog "I" that can observe that space, and move metaphorically in it.

...and perhaps most tellingly, page 66...

there is nothing in consciousness that is not an analog of something that was in behavior first.

Some philosophers, including W.V. Quine, and some neuroscientists, including Christof Koch, contest this hypothesis, arguing that it suggests that prior to this "discovery" of consciousness, experience simply did not exist. Ned Block argued that Jaynes had confused consciousness with the concept of consciousness, the latter being what was discovered between the Iliad and the Odyssey. Daniel Dennett points out that these approaches misconceive Jaynes's definition of consciousness as more than mere perception or awareness of an object. He notes that consciousness is like money in that having the thing requires having the concept of it, so it is a revolutionary proposal and not a ridiculous error to suppose that consciousness only emerges when its concept does.

More recently, Merlin Donald, seeing a similar connection between language and consciousness, and a similar link to cultural, and not purely genetic, evolution, has put a similar proposal to Jaynes' forward - though relying on less specific speculation about the more recent pre-history of consciousness. He writes...

To understand consciousness fully, the generation of culture must be explained. Enculturation has been neglected as a possible formative process in its own right, but we have no alternative other than to give it pride of place in any evolutionary theory .

He argues that an earlier "symbol using culture" must have preceded both the personal symbol using of individual consciousness, as well as language itself.

The idea that language and consciousness are not innate to humans, a characteristic of human nature, but rather the result of cultural evolution, beginning with something similar to the culture of chimpanzees, goes back before Darwin to Rousseau's Second Discourse.

Vedanta

According to *Vedanta*, awareness is not a product of physical processes and can be considered under four aspects. The first is waking consciousness (*jagaritasthana*), the identification with "I" or "me" in relationship with phenomenal experiences with external objects. The second aspect is dream consciousness (*svapna-sthana*), which embodies the same subject/object duality as the waking state. The third aspect of consciousness is deep sleep (*susupti*), which is non-dual as a result of holding in abeyance all feelings, thoughts, and sensations. The final aspect is the consciousness that underlies and transcends the first three aspects (*turiya*) also referred to as a trans-cognitive state (*anubhava*) or a state of self-realization or freedom from body-mind identification (*moksha*). Gaudiya Vedanta recognizes a fifth aspect of consciousness in which God becomes subordinate to *bhakti*.

For a long time in scientific psychology, consciousness as a research topic or explanatory concept had been banned. Research on topics associated with consciousness were conducted under the banner of attention. Modern investigations into consciousness are based on psychological statistical studies and case studies of consciousness states and the deficits caused by lesions, stroke, injury, or surgery that disrupt the normal functioning of human senses and cognition. These discoveries suggest that the mind is a complex structure derived from various localized functions that are bound together with a unitary awareness.

Several studies point to common mechanisms in different clinical conditions that lead to loss of consciousness. Persistent vegetative state (PVS) is a condition in which an individual loses the higher cerebral powers of the brain, but maintains sleep-wake cycles with full or partial autonomic functions. Studies comparing PVS with healthy, awake subjects consistently demonstrate an impaired connectivity between the deeper (brainstem and thalamic) and the upper (cortical) areas of the brain. In addition, it is agreed that the general brain activity in the cortex is lower in the PVS state. Some electroneurobiological interpretations of consciousness characterize this loss of consciousness as a loss of the ability to resolve time (similar to playing an old phonographic record at very slow or very rapid speed), along a continuum that starts with inattention, continues on sleep, and arrives to coma and death. It is likely that different components of consciousness can be teased apart with anesthetics, sedatives and hypnotics. These drugs appear to differentially act on several brain areas to disrupt, to varying degrees, different components of consciousness. The ability to recall information, for example, may be disrupted by anesthetics acting on the hippocampal cortex. Neurons in this region are particularly sensitive to anesthetics at the time loss of recall occurs. Direct anesthetic actions on hippocampal neurons have been shown to underlie EEG effects that occur in humans and animals during loss of recall.

Loss of consciousness also occurs in other conditions, such as general (tonic-clonic) epileptic seizures, in general anaesthesia, maybe even in deep (slow-wave) sleep. At present, the best-supported hypotheses about such cases of loss of consciousness (or loss of time resolution) focus on the need for 1) a widespread cortical network, including particularly the frontal, parietal and temporal cortices, and 2) cooperation between the deep layers of the brain, especially the thalamus, and the upper layers, the cortex. Such hypotheses go under the common term "globalist theories" of consciousness, due to the claim for a widespread, global network necessary for consciousness to interact with non-mental reality in the first place.

Brain chemistry affects human consciousness. Sleeping drugs (such as Midazolam = Dormicum) can bring the brain from the awake condition (conscious) to the sleep (unconscious). Wake-up drugs such as flumazenil reverse this process. Many other drugs (such as alcohol, nicotine, Tetrahydrocannabinol (THC), heroin, cocaine, LSD, MDMA) have a consciousness-changing effect.

There is a neural link between the left and right hemispheres of the brain, known as the corpus callosum. This link is sometimes surgically severed to control severe seizures in epilepsy patients. This procedure was first performed by Roger Sperry in the 1960s. Tests of these patients have shown that after the link is completely severed, the hemispheres are no longer able to communicate, leading to certain problems that usually arise only in test conditions. For example, while the left side of the brain can verbally describe what is going on in the right visual field, the right hemisphere is essentially mute, instead relying on its spatial abilities to interact with the world on the left visual field. Some say that it is as if two separate minds now share the same skull, but both still represent themselves as a single "I" to the outside world.

The bilateral removal of the centromedian nucleus (part of the Intra-laminar nucleus of the Thalamus) appears to abolish

consciousness, causing coma, PVS, severe mutism and other features that mimic brain death. The centromedian nucleus is also one of the principal sites of action of general anaesthetics and anti-psychotic drugs. This evidence suggests that a functioning thalamus is necessary, but not sufficient, for human consciousness.

Neurophysiological studies in awake, behaving monkeys point to advanced cortical areas in prefrontal cortex and temporal lobes as carriers of neuronal correlates of consciousness. Christof Koch and Francis Crick argue that neuronal mechanisms of consciousness are intricately related to prefrontal cortex — cortical areas involved in higher cognitive function, affect, behavioral control, and planning. Rodolfo Llinas proposes that consciousness results from recurrent thalamo-cortical resonance where the specific thalamocortical systems (content) and the non-specific (centromedial thalamus) thalamocortical systems (context) interact in the gamma band frequency via time coincidence. According to this view the "I" represents a global predictive function required for intentionality. Experimental work of Steven Wise, Mikhail Lebedev and their colleagues supports this view. They demonstrated that activity of prefrontal cortex neurons reflects illusory perceptions of movements of visual stimuli. Nikos Logothetis and colleagues made similar observations on visually responsive neurons in the temporal lobe. These neurons reflect the visual perception in the situation when conflicting visual images are presented to different eyes (i.e., bistable percepts during binocular rivalry). The studies of blindsight — vision without awareness after lesions to parts of the visual system such as the primary visual cortex — performed by Lawrence Weiskrantz and David P. Carey provided important insights on how conscious perception arises in the brain.

In recent years the theory of two visual streams, vision for perception versus vision for action has been refined by Melvyn Goodale, David Milner and others. According to this theory, visual perception arises as the result of processing of visual

information by the ventral stream areas (located mostly in the temporal lobe), whereas the dorsal stream areas (located mostly in the parietal lobe) process visual information unconsciously. For example, catching a ball quickly would engage the dorsal stream areas, whereas viewing a painting would engage the ventral stream. Overall, these studies show that conscious versus unconscious behaviors can be linked to specific brain areas and patterns of neuronal activation.

Consciousness can be viewed from the standpoints of **evolutionary psychology** or evolutionary biology approach as an adaptation because it is a trait that increases fitness. Consciousness also adheres to John Alcock's theory of animal behavioral adaptations because it possesses both proximate and ultimate causes.

The proximate causes for consciousness, i.e. how consciousness evolved in animals, is a subject considered by Sir John C. Eccles in his paper "Evolution of consciousness." He argues that special anatomical and physical properties of the mammalian cerebral cortex gave rise to consciousness. Budiansky, by contrast, limits consciousness to humans, proposing that human consciousness may have evolved as an adaptation to anticipate and counter social stratagems of other humans, predators, and prey. Alternatively, it has been argued that the recursive circuitry underwriting consciousness is much more primitive, having evolved initially in pre-mammalian species because it improves the capacity for interaction with both social and natural environments by providing an energy-saving "neutral" gear in an otherwise energy-expensive motor output machine. Another theory, proposed by Shaun Nichols and Todd Grantham, proposes that it is unnecessary to trace the exact evolutionary or causal role of phenomenal consciousness because the complexity of phenomenal consciousness alone implies that it is an adaptation. Once in place, this recursive circuitry may well have provided a basis for the subsequent development of many of the functions which consciousness facilitates in higher organisms, as outlined by Bernard J. Baars. Konrad Lorenz sees the roots of consciousness in the process of

self-exploration of an organism that sees itself acting and learns a lifetime. *Behind the Mirror: A Search for a Natural History of Human Knowledge.*

Many of us attribute consciousness to higher-order animals such as dolphins and primates ; academic research is investigating the extent to which animals are conscious. This suggests the hypothesis that consciousness has co-evolved with life, which would require it to have some sort of added value, especially survival value. People have therefore looked for specific *functions* and benefits of consciousness. Bernard Baars (1997), for instance, states that "consciousness is a supremely functional adaptation" and suggests a variety of functions in which consciousness plays an important, if not essential, role: prioritization of alternatives, problem solving, decision making, brain processes recruiting, action control, error detection, planning, learning, adaptation, context creation, and access to information. Antonio Damasio (1999) regards consciousness as part of an organism's *survival kit*, allowing planned rather than instinctual responses. He also points out that awareness of self allows a concern for one's own survival, which increases the drive to survive, although how far consciousness is involved in behaviour is an actively debated issue. Many psychologists, such as radical behaviorists, and many philosophers, such as those that support Ryle's approach, would maintain that behavior can be explained by non-conscious processes akin to artificial intelligence, and might consider consciousness to be epiphenomenal or only weakly related to function.

Regarding the primary function of conscious processing, a recurring idea in recent theories is that phenomenal states somehow integrate neural activities and information-processing that would otherwise be independent (see review in Baars, 2002). This has been called the *integration consensus*. However, it has remained unspecified which kinds of information are integrated in a conscious manner and which kinds can be integrated without consciousness. Obviously not all kinds of information are capable of being disseminated consciously (e.g., neural activity related to vegetative functions, reflexes,

unconscious motor programs, low-level perceptual analyses, etc.) and many kinds can be disseminated and combined with other kinds without consciousness, as in intersensory interactions such as the ventriloquism effect (cf., Morsella, 2005).


Ervin László argues that self-awareness, the ability to make observations of oneself, evolved. Émile Durkheim formulated the concept of so called collective consciousness, which is essential for organization of human, social relations. The accelerating drive of human race to explorations, cognition, understanding and technological progress can be explained by some features of collective consciousness (collective self - concepts) and collective intelligence.

Though often thought of as a test for consciousness, the Turing test (named after computer scientist Alan Turing, who first proposed it) is actually a test to determine whether or not a computer satisfied his operational definition of "intelligent" (which is not synonymous with consciousness and self-awareness). This test is commonly cited in discussion of artificial intelligence. The essence of the test is based on "the Imitation Game", in which a human experimenter attempts to converse, via computer keyboards, with two others. One of the others is a human (who, it is assumed, is conscious) while the other is a computer. Because all of the conversation is via keyboards (teletypes, in Turing's original conception) no cues such as voice, prosody, or appearance will be available to indicate which is the human and which is the computer. If the human is unable to determine which of the conversants is human, and which is a computer, the computer is said to have "passed" the Turing test (satisfied Turing's operational definition of "intelligent").

The Turing test has generated a great deal of research and philosophical debate. For example, Daniel Dennett and Douglas Hofstadter argue that anything capable of passing the Turing test is necessarily conscious, while David Chalmers, argues that a philosophical zombie could pass the test, yet fail to be conscious.

It has been argued that the question itself is excessively anthropomorphic. Edsger Dijkstra commented that "The question of whether a computer can think is no more interesting than the question of whether a submarine can swim", expressing the view that different words are appropriate for the workings of a machine to those of animals even if they produce similar results, just as submarines are not normally said to swim.

Philosopher John Searle developed a thought experiment, the Chinese room argument, which is intended to show problems with the Turing Test. Searle asks the reader to imagine a non-Chinese speaker in a room in which there are stored a very large number of Chinese symbols and rule books. Questions are passed to the person in the form of written Chinese symbols via a slot, and the person responds by looking up the symbols and the correct replies in the rule books. Based on the purely input-output operations, the "Chinese room" gives the appearance of understanding Chinese. However, the person in the room understands no Chinese at all. This argument has been the subject of intense philosophical debate since it was introduced in 1980, even leading to edited volumes on this topic alone.



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