

# Appendix

## The Kegworth Air Accident (1989)

### Introduction

The Kegworth air accident is used to illustrate several points in this book. We chose this particular accident because it is well known and has been widely analyzed over the years (e.g., see Besnard et al. 2004). The full accident report is very comprehensive, and covers all aspects of the accident as well as the human factors issues. It is available from the web site of the UK's Air Accidents Investigation Branch (AAIB).<sup>1</sup> The AAIB are responsible for investigating accidents that occur within UK air space.

### Description of the Accident

On 8 January 1989 a British Midland Airways (BMA) Boeing 737-400 plane crashed into the embankment of the UK's M1 motorway close to the village of Kegworth in the East Midlands, during a flight from London Heathrow to Belfast. Of the 126 people on board, 47 lost their lives.

Both members of the flight crew were highly experienced. The Captain had logged over 13,000 flying hours, whilst the First Officer had logged over 3,200. Both pilots were rated for the B737-200, -300, and -400 series aircraft. They had a combined experience of 76 flight hours in the Boeing 737-400 series aircraft. Furthermore, they had not been trained on the new plane's controls, but had only received a 1-day audio-visual conversion course on the B737-400, which has a glass cockpit, i.e., the information is presented on digital displays rather than the vast array of analogue instruments and electro-mechanical displays that appeared in the cockpit of its predecessor, the B737-300. In addition, the B737-400 series was fitted with a newer variant of an engine which could generate slightly more thrust. The engine had been certified by the appropriate authorities after undergoing testing.

During the flight, a fan blade broke off in the #1 engine. This resulted in an increase in vibration above what is considered normal, and which was strong

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<sup>1</sup> [http://www.aaib.gov.uk/sites/aaib/publications/formal\\_reports/4\\_1990\\_g\\_obme.cfm](http://www.aaib.gov.uk/sites/aaib/publications/formal_reports/4_1990_g_obme.cfm)

enough to be felt by the crew. This happened shortly after 20:05 h. At the same time as the increase in vibration was felt, smoke and fumes were drawn into the aircraft through the air conditioning system. In their analysis of the problem, the flight crew mistakenly identified the right hand (#2) engine as being at fault and therefore reduced its power accordingly.

An analysis of the data from the cockpit voice recorder (CVR) showed that there had been a slight hesitancy in determining which of the engines was at fault. When the Captain (the senior officer on the flight deck) asked the First Officer which engine was faulty, he replied 'It's the le... it's the right one.' As a consequence, the power to the right hand (#2) engine was throttled back and the engine was eventually shut down.

The actions taken on the right hand engine coincided (as it later turned out) with a reduction in vibration, and the smoke and fumes emerging from the left (faulty) engine also stopped. The flight crew therefore decided, erroneously (again, as it later turned out), that the correct engine had been shut down. They decided to put in motion the plan to make an emergency landing at East Midlands Airport, which involved talking to Air Traffic Control (ATC) to make sure they could get the appropriate clearances to land. Although the left engine continued to show a higher than normal level of vibration for several minutes, the crew did not notice this at the time.

When the crew began their descent towards the airport they reduced the power to the left engine. This led to a further reduction in the vibration in that engine to the point where it was not much higher than what would normally be expected. About 10 min later the crew decided to increase the power to the left engine once more, in order to maintain the aircraft's altitude in the final stages of descent. The vibration levels increased once more to very high levels, power was lost in engine #1, and a fire warning sounded. At this point the crew tried to restart the #2 engine but did not manage to achieve this before the aircraft crashed into the ground 0.5 nautical miles short of the runway shortly after 20:12 h.

## **An Analysis of Possible Contributory Factors**

It is often very difficult to single out the exact causes of an accident after the fact. Where lives and machinery are lost, the best attempts involve a reconstruction of events based on the available evidence. In the case of aircraft accidents, this includes the information captured by the Flight Data Recorder, and the CVR. These are what you often hear referred to as "the Black Box" although they are usually a highly visible shade of orange!

In the Kegworth accident, the crash was ultimately attributed to the way that the flight crew managed a mechanical incident in the left (#1) engine. The events unfolded very quickly: from the vibration being detected to the crash took less than 7 min 30 s. As is often the case, there were several contributory events that happened which contributed to the accident. These occurred at different levels

within the system. We pick out examples of several types of these below. Rather than providing an exhaustive analysis (which you can find by reading the accident report in full, and consulting the many papers that have been published about the accident), our intention is to illustrate the points of particular interest. We start at a level that is some distance away from the point at which people are interacting with technology, as a way of highlighting the importance of understanding the wider context in which people make decisions and take actions. When you have finished reading the book, you should be able to come back to the accident description above and identify further examples (this is Exercise 14.4).

### ***Regulatory Level Issues***

The B737-400 was fitted with a new type of engine. As with all aircraft engines, it had to undergo extensive testing before it could be certified for operational use. The engine in this case was a variant of an existing engine (which is common practice in the aero-engine industry), and it was thoroughly tested on the ground before being certified by the FAA (and ratified by the CAA). The engine was not, however, tested either in an altitude test cell (which simulates the conditions of flying at high altitudes) or in flight. If it had been so tested, this may have highlighted the fact that there was a flaw in the design which led to a turbine blade failure under certain patterns of vibration. This scenario illustrates how decisions that are made at remote distance from the user interface in a system can have an impact on the way that the users behave. If the engine had still been certified, and both the airline and the flight crew had known that this was a potential (even if very rare) problem, they could have included a checklist to deal with it in the Quick Reference Handbook (QRH) that is used by all pilots to deal with known situations, such as smoke in the cockpit.

### ***Organizational Level Issues***

The B737-400 was what is known as a glass cockpit aircraft, in which the information is presented on digital displays rather than the vast array of analogue instruments and electro-mechanical displays that appeared in the cockpit of its predecessor, the B737-300. The airline (BMA) did not have a glass cockpit flight training simulator for the B737-400, so pilots could only gain experience in using the new glass cockpit when they were actually flying it (i.e., on the job). The only training the pilots were given about the B737-400 was a 1-day audio-visual conversion course.

ATC offered the pilots two places to land. On company instructions, they chose to land at East Midlands airport, which was on their flight path, and the closest airport. This reduced the amount of time that they had available to reflect fully on the decisions and actions taken so far to deal with the engine problems. While the pilots

were trying to get ready for descent and landing, they were also in receipt of regular communications from ATC, had to talk to the operating company (BMA), keep the passengers informed of the situation, and complete the appropriate checklist in preparation for landing with one engine. The problem was made worse by the fact that the First Officer struggled to reprogram the Flight Management System (FMS) successfully with the details needed for landing at East Midlands airport. The way they had to use the FMS was unusual and rarely practiced. This is another area where the lack of appropriate recurrent training contributed to the accident.

### *Flight Crew Level Issues*

During the flight the pilots announced to the crew and passengers that there had been some trouble with the right engine but it had now been shut down. While some passengers could see the evidence of an engine fire, they did not inform the pilots that they had shut down the wrong engine. This appears to be an example of the problem of social distance, where the passengers perceive the pilots as being highly trained professionals, so they *must* know what they are doing, which means that the passengers do not feel in a position to correct them. The smell of smoke had dissipated by the time the announcement was made, too, which may also have had an influence on the passengers' thinking.

Three members of the cabin crew also reported having seen evidence of the fire in the #1 engine but they did not report this to the pilots. This seems to have been a failure in what is called Crew Resource Management, a procedure designed to ensure that all the members of a flight crew (pilots and cabin crew) communicate with one another and work together as a team. So the cabin crew should not have felt that there was a large social distance between them and the pilots, and should have not felt intimidated about telling the pilots about what they had seen even though it appeared to contradict what the pilots had said. This could have been attributed to a lack of CRM training.

### *Cockpit Level Issues*

The first indication that there was a problem with the engines came when the flight crew felt excessive vibrations in the aircraft and detected smoke in the cockpit. When both pilots were interviewed after the accident, neither could recall having seen any indication of the abnormally high vibration levels on the Engine Instrument System (EIS). The Captain noted that he rarely scanned the vibration gauges because he had found them to be unreliable in other aircraft in the past. Experts, like pilots, have a highly developed mental model of the world in which they normally operate, and this helps them to perform the tasks they are supposed to. In pilots, this mental model will help guide where they need to look to find appropriate information about the current state of the aircraft. In this case, the

Captain appears to have eliminated the vibration gauges from his mental model, because he has found that they do not provide any useful information (because they are unreliable). If the captain had looked closely at the EIS, he may have observed information about the engines that would have changed how the flight crew dealt with the engine problems.

### ***Technology Issues***

The EIS which was fitted to the B737-400 used digital rather than analogue displays. A subsequent survey showed that nearly two-thirds of BMA pilots believed that the new EIS was not effective in drawing their attention to rapid changes in the engine parameters, and nearly three-quarters preferred the old EIS. Thus, the system designers of the EIS and the training could be deemed to have contributed to the accident. It appears that the pilots of BMA (at least) were not involved in carrying out any evaluation of the new EIS before they had to use it in flight.

### ***External Issues***

When the aircraft was in sight of the airport, the #1 engine finally failed completely. There was not enough time to restart the #2 engine, and the aircraft ended up landing on the M1 (one of the UK's main motorways). This road had had noise abatement embankments (small hills) put up to shelter the surrounding land from motorway noise. This caused the plane to bounce, and probably compounded the crash.

### **Summary**

The formal accident investigation attributed the cause of the accident to pilot error. As you look through the description of what happened, and the list of contributory events, you should start to appreciate that maybe it was a series of mistakes, errors, and bad luck from a wide range of people who were part of the broad system. During a normal flight there are several things happening at the same time at different levels within the air transport system, and the flight crew has to deal with many of them. In the vast majority of cases, all the tasks are performed successfully, and the flight arrives safely at its destination and in a timely manner. It is often only when things go wrong, however, that you really begin to understand just how complicated getting a plane full of passengers from its original airport to its destination can be.

### **Reference**

Besnard, D., Greathead, D., & Baxter, G. (2004). When mental models go wrong. Co-occurrences in dynamic, critical systems. *International Journal of Human-Computer Studies*, 60(60), 117–128.

# Glossary

**ABCS** Anthropometric, Behavior, Cognition, and Social factors: the high-level constructs which are useful for organizing the knowledge about people that is relevant to system design.

**ACT-R** A cognitive architecture used to model human cognition.

**Aesthetics** Relates to the characteristics of an object or system that make it pleasurable to use. Sometimes called Esthetics.

**Affordance** The intrinsic property of an object that suggests actions that can be performed with it, e.g., a handle affords grasping and pulling.

**Anthropometrics** The study of the shape of the body and how it influences what is designed. It takes into consideration the physical characteristics of intended users such their size and their muscular strength.

**Attention** A term that refers to the selective nature of perception which functions in such a way that at any given time a person focuses on some feature(s) of the environment to the exclusion of others.

**Attribution theory** Describes the tendency of people to attribute their own actions to external situational causes, whereas external observers attribute the same actions to causes that are internal to the person carrying out the actions.

**Availability bias** Arises because users tend to recall those items that are easier to recall even when they may not be most representative of a particular situation.

**Blunt end** The part of the system that is furthest away from where the user interacts with the technology. Normally refers to the level at which regulations and laws are applied. Often used in contrast to the sharp end.

**Closed loop behavior** A pattern of behavior in which users take some actions, and look for feedback on those actions before deciding how to proceed. Also referred to as feedback control.

**Cognitive architecture** A framework that supports the modeling of human information processing under different conditions. Cognitive architectures include mechanisms designed to help model human cognition.

- Cognitive dimensions (of notation)** A common ontology used to name specific aspects of design as well as the associated design trade-offs.
- Cognitive dissonance** Cognitive dissonance occurs when a person holds two or more beliefs that are in conflict at one time, as in when people do not get what they want.
- Cognitive modeling** Using computer programs to simulate human behavior, usually within the framework of a cognitive architecture.
- Cognitive task analysis (CTA)** An extension of traditional task analysis techniques to facilitate the collection of information about the mental processes that underpin observable task performance. Usually comprises several methods.
- Computer supported co-operative work (CSCW)** The study of how people work together using technology.
- Cones** A type of light receptor cell located on the retina. Cones are sensitive to color. See also Rods.
- Confirmation bias** Arises because users tend to look for information that confirms their understanding of a particular situation, and hence have difficulty seeing things that conflict with their understanding of the world.
- Content strategy** Content strategy relates to the planning for the creation, publication, and governance of content that are both useful and usable. It covers which content to publish as well as why. Mostly used when referring to the web, but applies to all media, platforms, and devices.
- Co-operative principle** Basically refers to trying to say the right thing at the right time—the co-operative principle can also be seen as a description of the way that people normally conduct conversations. See also Grice's maxims.
- CREAM (Cognitive reliability and error analysis method)** Method for iteratively modeling and analyzing erroneous performance in a prospective or retrospective manner. The CREAM assumes that the context is a major influence on human performance. See also THEA.
- Decibel** A logarithmic measure of sound pressure: a tenfold increase in sound pressure (e.g., 10–20 dB) sounds twice as loud.
- Declarative memory** A hypothesized store which holds facts or statement about the world, e.g., the earth is flat.
- Designers** People who design systems or technology.
- Diffusion of social responsibility** When a group of people are held jointly responsible for dealing with a particular situation, the responsibility diffuses across people: several people may decide not to do anything in the belief that someone else in the group will.

**Distributed learning** Learning that occurs when practice is distributed over time in such a way that there are gaps between practice sessions.

**Efficiency** A system property that can be measured through its use of resources such as processor time, memory, network access, system facilities, disk space, and so on.

**Einstellung** *Einstellung* is related to Functional Fixedness but refers to the situation where a person gets fixated on a strategy to solve a problem.

**Ergonomics** The field that is concerned with providing a good fit between people and their work or leisure environments. Often used interchangeably with human factors.

**Error** The part of the system state that may lead to a subsequent failure.

**Ethetics** Relates to the characteristics of an object or system that make it pleasurable to use.

**Event tree** An inductive method for analyzing errors using a graphical binary tree representation.

**Explicit memory** A hypothesized store of items that can be explicitly reported. Most declarative information can be explicitly reported. Often used in contrast to Implicit memory.

**Extrinsic motivation** Motivation that arises from factors outside the individual, such as being paid to do something.

**Eye-tracking** A method for recording where the user's eyes are looking using a dedicated device (an eye-tracker).

**Failure** Something that occurs when the service that is delivered by a system or component is judged to have deviated from its specification.

**Fault** The adjudged cause of an error within a system.

**Fault tree** A deductive method for analyzing the causal factors that contribute to an error or accident, using a graphical tree representation.

**Feeling of knowing** Refers to the feelings an individual has about their knowledge on a particular topic, and particularly whether or not that knowledge exists within memory. It normally relates to making judgments either prior to recalling the target item, or after failing to recall it. The focus is on whether an individual *feels* that they know the answer, rather than what the answer actually is. Often used in the context of metacognition.

**Field experiments** Field experiments are trials of technologies in real world settings.

**Field studies** Evaluations that are carried out in the field, that is, in real world settings.

**Figure and ground** Figure is the term used to refer to the objects being focused on; ground is the rest of the perceptual field.

**Fitts' law** A method used to predict the time it takes to move a pointer to a target.

**Flesch reading ease score** A calculated value that reflects the readability of a selected piece of text.

**Forcing function** A mechanism for physically constraining actions to prevent the user from proceeding to the next step in task performance. To start most cars, for example, you are forced to put the key into the ignition.

**Formative evaluation** A type of evaluation that is used to help designers refine and form their designs. The focus of formative evaluation is to identify problems and potential solutions.

**Fovea** A small area of the retina (covering about 2° of visual arc). This is the area of clearest vision.

**Framing effects** Refers to the fact that the way that potential outcomes of a particular situation are presented (framed) has a powerful influence on how users choose between alternatives.

**Functional fixedness** Functional fixedness occurs when a person becomes fixated on a particular use of an object.

**Functionality** What the system does. Usually specified by the functional requirements.

**Fundamental attribution error** The belief that our own behavior can be attributed to extrinsic factors in the environment, and that the behavior of others is attributable to their intrinsic properties (e.g., they are a bad person).

**Fundamental attribution error of design** The belief, held by designers, that users act and behave in the same way as designers when using technology.

**Generic error modeling system (GEMS)** An approach to modeling errors based on interpretation, planning, memory, and acting.

**Gestalt principles of visual grouping** Can be used to explain how groups of objects are interpreted. The principles were developed as a rebellion against the simplistic notion that perception could be structurally analyzed into its component parts, and that complex ideas were the result of associating together simpler ones.

**GOMS (Goals, operators, methods, and selection rules)** A method of task analysis that can be used to describe the details of error-free, expert task performance using Goals, Operators (actions), Methods (procedures), and Selection rules (to choose between methods).

**Grice's maxims** The four basic maxims underlying the co-operative principle. These maxims make strong suggestions about how people should communicate with other people. When these suggestions are followed, communication is more successful and more satisfying.

**GUI (Graphical user interface)** A user interface that is made up of graphical objects, such as icons.

**Gulf of evaluation** The gap between the concepts used in the physical system and the user's psychological representation of those concepts.

**Gulf of execution** The gap between the user's (psychological) goals and intentions and the physical actions they need to take to achieve those goals.

**Habituation** Becoming so used to a stimulus that it becomes unnoticeable. (This is very similar to desensitization.)

**Haptic devices** Devices which utilize touch and tactile feedback. Most haptic devices only support interaction using the hands or fingers, even though users could use any part of their body. There is a growing number of devices that support input using the feet.

**Hard mental operations** One of the cognitive dimensions. It relates to the fact that users find some kinds of operations harder to perform than others, so they prefer easier mental operations.

**HCI (Human-computer interaction)** The study of how people interact with technology. The abbreviation is also sometimes used to refer to Human-Computer Interface.

**Heuristic evaluation** A relatively informal way of analyzing the usability of an interface design in which a small select number of people are asked to judge the design based on a set of guidelines or principles together with their own knowledge.

**Hicks law** An equation that is used to describe the time to make a decision based on the number of available choices. Also called the Hick-Hyman Law.

**Hidden dependencies** One of the cognitive dimensions. They show how visible the relationships between design components are, describing the number and direction of those relationships.

**Hierarchical task analysis (HTA)** A method for analyzing in detail how tasks are performed by decomposing goals into subgoals. It is often described in terms of decomposing tasks into sub-tasks.

**Human factors** The field that is concerned with providing a good fit between people and their work or leisure environments. Often used interchangeably with Ergonomics.

**Human-centered design (HCD)** An expansion of the User-Centered Design approach which extends the focus from the user's interaction with the system to considering how human capabilities and characteristics are affected by the system beyond direct interaction with the interface or system itself.

**Iconic memory** A store where perceptual images are held for a short period of time. Visual iconic memory, for example, holds only a few items and these decay fairly quickly.

**Ill-structured problem** Some problems are more difficult than others because they are ill-structured, that is, they are not clearly defined in terms of states, goals, and actions that are available. Also called ill-defined or messy problems.

**Implicit memory** A hypothesized store of items that cannot be explicitly reported. Most procedural information cannot be explicitly reported. Often used in contrast to Explicit memory.

**Information** Information can be thought of as organized data.

**Information architecture** A term used to describe how on-line information is structured to support usability by both its creators and its users.

**Information scent** Information scent is what leads a user to spend more time exploring a web page (or menu item) to find what they are looking for because the content effectively smells like the thing they are looking for. The idea is to make sure that objects and links appear to smell like the content they contain and do not smell like content that they do not contain.

**Insight problems** A class of problems where novel behavior or understanding is required to solve them. Sometimes called "Aha" problems.

**Interaction design (IxD)** An approach to designing interactive products and systems to support the way that people interact and communicate.

**Intrinsic motivation** The motivation to do something that arises directly from a person's inherent needs and desires.

**Introspection** The examination of your own mental experiences. It can be a source of insight but has been proven to be unreliable in general.

**Just noticeable difference (JND)** The smallest change in a perceptual stimulus that is noticeable by a user.

**Keystroke level model (KLM)** A simplified version of GOMS. It provides a quick and approximate way to calculate how long users will take to perform a cognitively manageable (unit) task.

**Kinesthesia** Kinesthesia (or the kinesthetic sense) generates an awareness of static and dynamic body posture based on information coming from the muscles, joints, and skin, along with a copy of the signal sent to the motor system.

**KSA (knowledge, skills, and attitudes)** Individual (or team) competencies that influence behavior.

**Learnability** How easy it is to learn to use the system.

**Learning curve** A graphical representation of performance that is assumed to reflect the learning that has occurred through practice. The shape of the curve reflects how response time changes with practice on a task. The curve is often described by a power law function and sometimes as an exponential function.

**Loftus effect** Refers to the fact that when people are presented with misleading information between the encoding of another piece of information and its later recall, the recall of the original information is altered by misleading information. Often referred to as the (Loftus) misinformation effect.

**Long term memory** An unlimited capacity store for items that have been processed or interpreted and permanently encoded.

**Maintainability** How easy a system is to maintain and upgrade over its lifetime.

**Massed learning** Learning that occurs when the practice is relatively or completely located within a single time period.

**Mental model** A user's mental model is a representation of some part of the world that can include the structures of the world (the ontology of the relevant objects), how they interact, and how the user can interact with them.

**Metacognition** Literally cognition about cognition. It includes knowledge about when and how to use specific strategies for problem solving and learning. See also Feeling of knowing.

**Millisecond (ms)** Abbreviated ms, this is one thousandth of a second.

**Mistake** A failure in planning. Refers to an action that was performed correctly but in the wrong circumstances.

**Mnemonic** Mnemonics are techniques that help to increase the amount or quality of information that can be stored, or the speed at which can it be retrieved.

**Model human processor (MHP)** One of the first simple integrated descriptions of psychological knowledge relating to error-free human performance in HCI.

**Need for cognition** Refers to the fact that some users like to think, and seek out opportunities to think, problem solve, and learn.

**Normative behavior** A term used to describe what people *should* do, rather than what they really do.

**Open loop behavior** A pattern of behavior in which users anticipate what will happen next in a particular situation, and take actions on that basis. There is little or no need to monitor the results of the actions. Also described as feed-forward control.

**Operators** Generally used to refer to users who work in industrial settings such as nuclear power stations and chemical plants.

**Parafovea** The area of the retina that immediately surrounds the fovea. It provides a lower level of visual acuity than the fovea.

**Periphery** The area of the retina beyond the parafovea. Visual acuity is at its lowest in the periphery and vision is only in black and white.

**Pop-out (effect)** Refers to the effect that some stimuli appear to ‘pop out’ of a visual field based on color, size, shape, or other unique and easy to distinguish features.

**Post-completion errors** Errors that arise when the main goal for a task has been accomplished, but the goals of the subtasks have not.

**Power law of learning** A mathematical description of how learning takes place over time. Usually represented by an equation of the form  $RT = aP^{-b} + c$ , where  $RT$  is the response time for a particular trial,  $P$ , and  $a$ ,  $b$ , and  $c$  are all constants.

**PQ4R** A method of studying designed to help readers retain more from what they read. It stands for Preview, Question, Read, Reflect, Recite, Review.

**Premature commitment** One of the cognitive dimensions. It relates to the situation where design decisions have to be made before all of the required information is available.

**Primacy effect** Refers to the fact that the items presented at the start of a list of items to be learned are subsequently better recalled than items in the middle of the list in a free (unprimed) recall situation.

**Priming** Used with respect to learning to refer to the presentation of a particular experience which makes the responder more sensitive or responsive to a wide range of stimuli. Used with respect to memory to refer to the triggering of the recall of related items, e.g., “yellow” would prime the recall of “banana,” “custard,” and other items that are yellow in color.

**Problem solving** Problem solving essentially involves working out how to get from the current state of affairs to the goal that you are trying to achieve by taking appropriate actions. More formally, this can be described as applying operators to states to reach a goal.

**Procedural memory** A hypothesized store which holds procedures that encapsulate how to do a particular task, such as how to move a knight in chess.

**Programmable user models (PUMs)** A psychologically constrained architecture which an interface designer programs to simulate a user performing a range of tasks with a proposed interface.

**Recency effect** Refers to the fact that the items presented at the end of a list of items to be learned are subsequently better recalled than items in the middle of the list in a free (unprimed) recall situation.

**Recognition-primed decision making (RPDM)** An approach to decision making which suggests that experts do not do problem solving, but that they recognize the particular situation (through perception) which directly leads them to make decisions about the correct actions to take.

**Reliability** When referring to evaluation, reliability describes the ability of a particular measure to produce consistent results when the same things are measured under different conditions. Often used in the context of test–retest reliability. When referring to systems, it refers to a dynamic property of the eventual system which relates to the ability of the system to function under stated conditions for a specified period of time.

**Repetitive strain injury (RSI)** A condition arising from upper limb disorders.

**Retrieval biases** Describes the inherent biases within people that affect what they recall from memory. They include primary effects, recency effects, and the von Restorff effect.

**Rich pictures** A component part of Soft Systems Methodology. Used to represent graphically the work context based on the roles, responsibilities, and concerns of the system stakeholders.

**Risk-driven incremental commitment model** A revised version of the spiral model which encourages incremental development of systems in an ongoing spiral process comprising requirements specification, technical exploration, and stakeholder commitment. At each stage the system development is assessed for risks to the success of the overall system.

**Rods** A type of light receptor cell located on the retina. Rods are very sensitive to motion. See also Cones.

**Role-expressiveness** One of the cognitive dimensions. It describes the extent to which a system reveals the goals of the system designer to the user.

**Satisficing** A method that finds a reasonable solution taking into consideration the costs of finding a (better, more optimal) solution.

**Search engine optimization** The process of increasing the visibility of a web page or web site in a search engine's organic (unpaid) search results.

**Sensitivity** A term used to describe how much a particular measure will change as other factors change.

**Serial position curve** A graphical representation of how the position of an item in a list affects its recall from memory. Often used to help show primacy and recency effects.

**Sharp end** The part of the system where the user interacts with the technology. Sometimes used in contrast to the blunt end.

**Short term memory (STM)** A relatively limited capacity store for items that have received a limited amount of processing or interpretation. STM is somewhat analogous to the registers in a computer.

**Signal detection theory (SDT)** A mathematical theory of the detection of physical signals based on the assumption that sensitivity to a signal depends on its intensity, the amount of noise, the user's motivation, and the criterion set for registering responses to the signal. Sometimes referred to as the Theory of Signal Detection (TSD).

**Slip** A failure in the execution of an action. Refers to performing the wrong action in the right circumstances.

**Social capital** A concept that highlights the value of social relations and the role of cooperation and confidence in establishing trusts and norms to get collective results.

**Socio-technical systems** Systems that involve a complex interaction between humans, machines, and the environmental aspects of the work system. (Nowadays this description applies to most enterprise systems.)

**Soft systems methodology** Essentially an analytical approach, mostly focusing on organizational aspects of the system. It does not purport to support systems design.

**Spiral model** A model of the system development lifecycle, which uses an iterative development process.

**S–R (Stimulus–response) compatibility** Refers to the fact the response should be compatible with the stimulus that causes it. This is typically exploited in the way that physical aspects of an interface (e.g., buttons) and displays (e.g., GUIs) are mapped onto the world that they are representing. It also explains why the call buttons for elevators are situated with the “up” button above the “down” one.

**Stimulus–response mapping** The mapping between the stimulus that the users see to the responses that they produce. Mappings that are simple and similar to previous mappings lead to faster, less error-prone interactions.

**Subitizing** The ability to determine directly the number of objects the user is looking at without counting them. This only works for small numbers of objects.

**Summative evaluation** A type of evaluation used to assess the success of the finished system or product, summarizing its overall impact and effectiveness.

**Task-action mapping** Describes the relationship between the domain of the task and the domain of actions. Ideally there should be a simple and direct mapping between the two.

**THEA (Technique for human error assessment)** Method for analyzing erroneous performance using an iterative process. Like the CREAM it assumes that the context is a major influence on performance.

**THERP (Technique for human error rate prediction)** An approach to modeling errors in human performance. The probability of errors occurring is conditioned by performance shaping factors as a way of taking into account the context in which the error happens.

**Threshold** The smallest energy level in a stimulus that can be detected by a user.

**Tower of Hanoi** A task used to study problem solving. It has three pegs or posts, and disks, typically three to eight, but in theory there could be any number of disks.

**Transfer (of learning)** Where learning on one task has an effect (either positive or negative) on a task that is performed later.

**Upper limb disorders (ULD)** Aches, pains, tension, and disorders that involve any part of the arm from fingers to shoulder or neck. They include problems with the soft tissues, muscles, tendons, and ligaments, as well as with the circulatory and nerve supply to the limbs. Often caused or exacerbated by work and, particularly, repetitive work. They lead to conditions such as repetitive strain injuries.

**Usability** A multi-faceted concept used to represent how easy a system is to use, how easy it is to learn to use, how safe it is, how effective (and efficient) it is, and how satisfying it is to use.

**Usability testing** A term usually restricted to describe the evaluation of the usability of a system under controlled (laboratory) conditions.

**User experience (UX)** The user's perceptions and responses that result from the use or anticipated use of a product, system or service. Some people regard UX as representing a broader view than usability.

**User-centered design (UCD)** An approach that focuses on the user's needs, carrying out an activity/task analysis as well as general requirements analysis, performing early testing and evaluation and designing iteratively.

**Users** Generally refers to people who use artifacts (systems, devices, and so on). There are several types of user, including operators, pilots, and drivers.

**Validity** A term used to refer to whether the particular measure that you are using is really measuring what it is supposed to be measuring. There are several types of validity.

**Viscosity** One of the cognitive dimensions. It reflects how hard it is to change something within a system.

**von Restorff effect** Refers to the fact that a single item that is made distinctive in a list of otherwise similar items will be easier to learn and subsequently recall.

**WIMP (windows, icons, menus, and pointer)** A shorthand description for a type of graphical user interface, using the elements that appear in that interface. Sometimes used interchangeably with GUI, but, strictly speaking, not all GUIs are WIMPs.

**Working memory** A hypothesized temporary store (an audio or semantic scratchpad) with associated mechanisms for rehearsing, refreshing, and using the stored information. It also includes a mechanism of central or executive attention that regulates the contents of that store based on performing a task.

# Index

## Symbols

- $\beta$  Beta, threshold, from signal detection theory, 84, 85
- $\Theta$  theta,  $\lambda$  lambda, 84

## A

- Abbreviations, 126
- ABCS, v, xxv, xxvi, 3, 16, 23, 24, 277, 281, 386–391, 410
- Accessibility, 394
- Accident, 9, 13, 21, 46, 176, 281–283, 286, 287, 413–417
- Accountability, 240, 303
- Acoustical loop, 127
- Activity theory, 45, 326
- ACT-R, 23, 24, 43, 126, 134, 140, 392, 395–397
- Acuity, 86, 87, 92
- Adaptability, 46, 238, 290
- Aesthetic, 419. *See also* Esthetics
- Affordances, 19, 58, 59, 237, 347
- Aids to memory, 131, 336, 370, 371, 392, 393, 395, 397
- Aircraft, 9, 10, 13, 14, 18, 21, 22, 28, 49, 84, 111, 145, 153, 154, 160, 169, 176, 226, 283, 286–288, 301, 345, 405, 413–417
- Airport
  - Dulles, 173
  - London, 173
  - Philadelphia, 169, 170
- Air traffic controller(s) and control (ATC), 13, 22, 226, 283, 287
- Alarm, 44, 83–85, 112, 116, 319, 387
- Alerts, 111, 112
- Allocation of function, 39, 311
- Americans with Disabilities Act, 15
- Anthropometrics, 16, 18, 28, 50, 59, 76, 77, 343, 351, 386, 387, 389

- implications for system design, 17, 57, 82, 85, 91, 98, 111, 115, 136, 144, 155, 173
  - Apple design guidelines, 46
  - Arms, 18, 60, 67, 92
  - Arthritis, 58, 287
  - Assessment, 35, 47, 118, 217, 319, 388
  - Assessment of Repetitive Tasks (ART) tool, 60
  - Association for Computing Machinery (ACM), 45
  - Astronauts, 74, 267
  - Attention, 8, 9, 20, 22, 60, 85, 91, 113, 118, 123, 124, 137–141, 144, 146, 275, 276, 286, 287, 301, 318, 341, 343, 371, 388, 410
    - divided, 141
    - implications for system design, 85, 144
    - Wickens theory of attentional resources, 139
  - Attributions and attributional style, 230, 231
  - Attribution theory, 10, 38, 228, 230–232, 246
  - Audio, 362, 387
  - Audio–visual, 9, 362, 411, 413
  - Audition/auditory, 74, 75, 82, 106, 109, 119, 158
  - Auditory system, 82, 106
  - Authority figures, 236, 244, 246
  - Automatic usability inspection, 11
  - Automation, 21, 301
  - Automation deficit, 143, 144
  - Automobiles, *see* Car interfaces, driving
  - Availability bias, 189
  - Avatar, 255
  - Awareness, 38, 62, 95, 238, 286, 360, 389
- ## B
- Backtracking, 177
  - Behavioral approach, 204, 211, 214, 218, 246, 343, 408

- implications for system design, 85
- Better products, 11
- Biases, 84, 85, 124, 134, 151, 158, 166, 177, 188, 189, 193, 197, 198, 290, 291, 373, 389
- Biases in reasoning, 193, 195
- Blind, 8, 75, 90, 111
- Blind spot, 389
- Blunt end, 288, 302
- Bobby (web site testing tool), 394
- Breakout boxes, 181, 193–196
- Brightness, 91, 93, 95, 102
- Button, 5, 18, 20, 59, 65, 68, 70, 72, 75, 148, 151, 157, 171, 183–188, 201, 323, 339, 344, 354
- C**
- Calibrated, 171, 195, 198, 372
- Camera, eye like, 86, 88, 101, 117, 371
- Capabilities, 4, 13, 20, 33, 39, 46, 50, 57, 58, 76, 119, 171, 184, 196, 231, 385, 387, 390–392, 405, 407
- Car interfaces, 19, 289
- Categories, 50, 64, 69, 119, 124, 129, 185, 286, 292, 294, 362, 393
- Caterham Formula 1 team, 58
- Cause–effect, 359
- CD writer, 170
- Cell phone, 3, 8, 11, 138, 173, 303, 314, 354, 387
- Channels, 74, 82, 272
- Checklists, 9, 8, 22, 175
- CHI conference, 27
- Choice shift in decision making, 226
- Circuit schematic, 167
- Citeseer, 11
- Classical ergonomics/interface ergonomics, 37
- Classification, 28, 84, 150, 167, 292, 294, 328
- Clearview Hwy font, 206
- Closed loop behavior, 142, 153
- CMN-GOMS, *see* KLM GOMS
- Cockpits, 9, 58, 226, 287, 345
- Cockpit resource management, 226, 287, 415–417
- Cocktail-party effect, 139
- Cognitive, 16, 20, 21, 23, 24, 28, 39, 40, 42, 83, 100, 105, 125, 138, 145, 149, 159, 181, 213, 231, 242, 281, 288, 294, 311, 317, 320, 324, 325, 328, 329, 336, 343, 349, 350, 386, 388, 393, 395, 397
  - approach, 350
  - architecture, 23, 24, 42, 149, 193, 392, 395, 408
  - dimensions, 51, 335–343
    - hard mental operations, 337, 341, 342
    - hidden dependencies, 336, 337
    - premature commitment, 337, 340
    - role-expressiveness, 337, 339
    - turning cognitive dimensions into a methodology, 342
    - viscosity, 337, 338
    - what is omitted, 343
- Cognitive dissonance, 231
- Cognitive ergonomics/ systems engineering, 39, 145
- Cognitive modeling, 42, 52, 159, 326
- Cognitive reliability and error analysis method (CREAM), 294, 295, 297–300, 302
- Cognitive systems engineering (CSE), 39, 40, 410
- Cognitive task analysis (CTA), 317–319, 329
  - components, 317
  - example application, 318
- Cognitive walkthroughs, 318
- Coins, 7, 8, 101
- Collision, 284
- Color
  - blindness, 95
  - perception of, 95, 100
  - systems, 95, 96
  - vision, 94, 95
- Command-line, 33
- Commands, 7, 124, 131–132, 142, 151, 155, 157, 242, 277, 320, 321, 328, 344
- Common ground, 201, 243, 256
- Communicate, 9, 21, 22, 25, 26, 70, 72, 74, 201, 202, 204, 212, 218, 219, 226, 234, 237, 245, 246, 248, 253, 256, 262, 268, 270, 271, 287, 299, 318, 386, 406
- Communities, 43, 226, 240, 259, 268, 296
- Communities of practice, 268
- Competent/competencies, 153, 195, 234, 319, 329
- Complexity, 198, 347, 398, 408
- Comprehend, 133, 136, 205, 208, 209, 217, 218
- Computational model, 192, 204, 272–273, 276
- Computational models of social behavior, 272, 276
- Computer-based prototypes, 367
- Computer–Human Interaction, 45
- Computer–Human Interaction Special Interest Group of the Association for Computing Machinery (ACM-SIGCHI), 27
- Computer-mediated communication, 34, 219

- Computer-supported co-operative work (CSCW), 41, 219, 276, 248
  - Concurrency in system development, 402
  - Concurrent, 140, 370, 371, 401, 403
  - Cones [eye], 89, 91, 95, 207, 211, 217, 372
  - Confidence judgments, 171. *See also* Feeling of knowing
  - Confirmation bias, 189, 193
  - Confuse, 8, 20, 45, 48, 73, 111, 134, 173, 283, 301, 340
  - Conscious, 4, 139, 146, 348
  - Consciousness, 8, 152, 389
  - Considerations when choosing a TA method, 326
  - Consistency, 47, 135, 320, 329, 337, 339, 340, 348, 358, 365
  - Construct validity, 358, 359
  - Content
    - strategy, 315, 316
    - validity, 359
  - Context, 15, 25, 34, 40, 44, 45, 63, 85, 105, 115, 119, 127, 134, 136, 169, 193, 198, 211, 212, 218, 220, 225, 226, 235, 236, 244, 247, 264, 266, 267, 270, 281, 282, 286, 287, 291, 293, 299, 300, 309, 318, 319, 326, 327, 336, 349, 356, 360, 361, 363, 369, 374, 386, 388, 403, 404, 407–409
  - Contextual design, 266
  - Contrast, 92–94, 102, 207, 209
  - Controls, 5, 18, 37, 75, 187, 288, 322, 344, 347, 348, 387
  - Conversations, 108, 109, 139, 201, 203, 254, 256, 326, 361, 389
  - Co-operative
    - evaluation, 335, 366
    - principle, 203, 204
  - Co-pilot, 286, 287. *See also* Pilot
  - Correct rejections, 84, 120
  - Cost savings, 110
  - CPM-GOMS, 320, 322
  - Creating content, 216
  - CRM, *see* Cockpit resource management
  - Crosstalk journal, 406
  - CTA, *see* Cognitive task analysis
  - Cultural effects, 265, 275
  - Culture, 17, 22, 34, 45, 187, 218, 227, 235, 240, 247, 253, 264, 265, 267, 275, 303, 391, 406
- D**
- d' (dprime), 84
  - Danger, 13, 85, 118, 285, 302, 313, 339, 348, 391
  - da Vinci surgical system, 63
  - DBLP, 11
  - Decibels (dB), 108
  - Decision making, 9, 37, 122, 42, 133, 165, 176, 184, 188, 190–193, 197, 198, 206, 216, 225–228, 228, 233, 234, 245, 247, 274, 317, 389, 410
    - attributions and attributional style, 230, 231
    - implications for system design, 192
    - known influences on, 176, 188
    - majority and minority effects, 233
    - often not rational, 184
    - social effects on, 228
    - social responsibility effects, 228
  - Decision-support, 192, 318
  - Declarative memory/knowledge, 23, 128, 129, 140, 146, 151, 156, 267, 320, 328, 393
  - Delivering content, 215, 218
  - Dependability, 282, 318
  - Depth cues, 101, 102, 105
  - Descriptive behavior, 196
  - Descriptive social models, 267
  - Design, 4, 6, 7, 9, 10, 12, 15, 16, 18, 24–28, 33–35, 37, 38, 42, 44, 45, 47, 49, 57, 76, 124, 132, 136, 142, 144, 149, 155, 160, 167, 169, 171, 173, 179, 181, 183, 185, 187, 188, 192, 196, 197, 201, 204, 206, 211, 218, 231, 258, 261, 273, 287, 300, 313, 326, 335, 342, 344, 346, 349, 355, 359, 365, 368, 389, 391, 395, 406
  - Design of content, 215–218
    - content strategy, 215
    - creating content, 216
    - delivering content, 218
    - information architecture, 216
    - structuring content, 217
  - Design patterns, 406
  - Designer, 3–5, 8, 10, 11, 22, 24, 33, 34, 37, 42, 46, 47, 49, 57, 58, 65, 67, 74, 81, 93, 105, 112, 134, 166, 182, 192, 196, 309
  - Designers are stakeholders too, 405
  - Development, 4, 22, 33, 37, 39, 44, 46, 49, 60, 169, 188, 216, 238, 240, 244, 269, 301, 309, 317, 329, 348, 353–357, 364, 367, 377, 386, 390, 398–400, 402, 403, 405–407, 409
  - Devices, 10, 13, 19, 20, 28, 36, 59, 62, 63, 65, 66, 70, 75
    - cell phone, 314, 330
    - X-ray machine, 13
    - other, 72

- Diabetes, 74, 75  
 Diagnose, 13, 143, 166, 227, 365  
 Dialogues, 132, 142, 202, 371  
 Differences, individual, 34, 40, 127, 181  
 Diffusion of social responsibility, 228, 230, 246  
 Digital Equipment Corporation (DEC), 41  
 Disabilities, 17, 63  
 Disasters, 22, 28, 247, 284, 345, 346  
 Discriminate, 8, 86, 94, 95, 97, 111, 142, 370  
 Discriminating sounds, 111  
 Distinctive, 112, 125, 313, 319  
 Distinguish, 12, 62, 63, 150, 282, 310, 320, 370  
 Distracted, 22, 98, 145, 286, 287  
 Distributed learning/practice, 133, 152  
 Diversity, 26, 236, 238, 239, 366  
 Divided attention, 141  
 Driving, 70, 128, 139, 141, 146, 185, 310, 409  
 Dulles airport, 173  
 Dunbar number, 261, 262
- E**  
 Ear, 106–108, 110, 117  
 E-commerce, 213  
 Eclipse, 68, 77  
 Ecological validity, 290–292, 358, 360, 361  
 Effectiveness, 48, 357, 359  
 Effective technical and human implementation of computer-based systems (ETH-ICS), 41  
 Efficiency, 47–49, 225, 313, 365, 369  
   of a system, 48, 357  
 Efficient, 3, 10, 48–50, 52, 150, 178, 219  
 Effort, 4, 15, 20, 143, 145–147, 175–176, 189, 192, 218, 238, 326, 338, 344, 356, 372, 374–376, 400, 409  
 Einstellung effects, 177  
 Ejector seats, 18  
 Elbows, 10, 36, 142  
 Elderly, 8, 58, 59  
 Email, 10, 36, 142, 180, 188, 189, 218, 229, 232, 242, 246, 257, 261, 262, 276  
   why it has gone awry, 232  
 Emergencies, 228, 413–417  
 Emergent, 269, 301, 392  
 Emotions/feelings, 44, 373  
 Empirical, 313, 261, 392  
   evaluation, 353  
 Encoding effects, memory, 128, 134  
 Engineering, 225, 353, 385  
 Enjoyable, 3, 50  
 Entertainment, 181, 226  
 EPIC cognitive architecture, 396  
 Episodic memory, 140  
 Ergonomics, 17, 34, 35, 38, 46, 96, 284, 314, 319  
 Errors, 204, 208, 281–285, 288, 290, 292–297, 299, 320, 322, 324, 325, 341, 343, 347, 365, 369, 370, 375, 387, 388, 391, 392, 395, 397, 410  
   analyzing, 296, 300  
   archive data, 291  
   ergonomics, 38  
   event trees, 296  
   fault trees, 296  
   field-based observation, 290  
   implications for design, 142, 300  
   introduction to, 3, 281  
   keystroke rate, 324  
   laboratory-based experiments, 289  
   latent, 282  
   omissions, 292  
   post-completion, 180, 181  
   reduction, 287  
   selecting the most appropriate data collection method, 289–291  
   studying, 12, 288–292  
   taxonomies, 292  
   typing, 13, 64, 158, 160, 303, 395, 397  
   usability measure, 320, 370  
   what is, 282
- Esthetics, 26–28, 45, 46, 75, 365, 205, 207, 212, 419  
 Ethics, effective technical and human implementation of computer-based systems, 41  
 Ethics of evaluation, 376  
 Ethnography, 41, 267  
 Evaluate, 12, 21, 25, 34, 43–45, 50, 51, 196, 242, 262, 263, 270, 284, 292, 329, 337, 344–346, 348, 350, 354, 356, 358, 361, 362, 365–367, 369, 374, 376, 404  
 Evaluation methods  
   co-operative evaluation, 335, 366  
   heuristic (expert) evaluation, 365, 366  
   usability testing field studies and field experiments, 362, 364  
 Evaluation study, 356, 358, 360  
 Event tree, 296  
 E-voting system, 65  
 Exchange costs and benefits, 256  
 Experiments, 4, 5, 46, 101, 114, 119, 155, 158, 184, 228, 233, 242, 261, 289, 357, 364, 397  
 Expert, 12, 15, 20, 34, 37, 39, 45, 48, 64, 97, 131, 132, 145, 147, 154, 175, 211, 217, 246, 284, 290, 293, 301, 319,

- 324, 329, 359, 362, 365, 366, 371, 387
  - Expert (heuristic) evaluation, 362, 365, 366
  - Explicit memory, 129, 130
  - Exploration, 7, 25, 62, 66, 72, 76, 89, 135, 156, 198, 214, 234, 272, 336, 340, 392, 399, 400
  - External validity, 358, 360
  - Extrinsic motivation, 114, 115, 120, 243, 245, 246, 274
  - Eyes, 74, 86–93, 95, 97, 100, 101, 105, 117, 118, 207, 211, 217, 356, 372
    - smooth pursuit movements, 101, 226
  - Eye movements, 372
  - Eye-strain, 60
  - Eye-tests, 86
  - Eye-tracker, 88, 89, 372
  - Eyewitness, *see* Loftus effect
- F**
- Face validity, 289, 359
  - Factors affecting team performance, 234
    - authority figures, 235
    - implications for design, 243
    - mutual support and mutual surveillance, 235, 240
    - social distance, 235, 240
    - spatial distance, 235, 240
    - task attractiveness, 235
    - team competencies, 153
    - team processes and tasks, 269
    - team size, 236, 236
    - team structure and composition, 235, 237
  - Failure, 7–9, 14, 21, 26, 49, 124, 128, 131, 191, 231, 247, 260, 282, 284, 286, 293, 385, 407
  - False alarms, 84–86, 120
  - Fatigue, 38, 208, 288
  - Fault–error–failure model, 282
  - Faults, 175, 225, 282, 296, 354
  - Fault trees, 296, 303
  - Feedback, 13, 21, 26, 46, 48, 57, 63, 65, 66, 70, 72–75, 88, 141, 144, 343, 346, 348, 355, 377
  - Feedforward, 141
  - Feeling of knowing (FoK), 124, 171
  - Field-based observation, 290
  - Field experiments, 364, 368
  - Field of view, 93, 94, 101
  - Field studies, 362, 364
  - Figure and ground, 93, 103
  - Filter, 90, 110, 276
  - Final system, what to evaluate, 367
  - Fingers, 64, 65, 110, 60, 63, 67, 69, 70, 131
  - Fingertips, 74
  - Fire, 9, 155, 192, 296
  - Fire-fighting, 192
  - Fitting the man to the job and the job to the man (FMJ/FJM), 36
  - Fitts' law, 324, 325, 407
  - Fitts list, 19, 311
  - Fixated, 177, 179, 372
  - Fixation (eye), 211
  - Flesch–Kincaid reading index, 217
  - Flexibility, 47, 48, 363, 365
  - Flicker, 92, 96, 100
  - Flight, 9, 36, 38, 144, 176, 226, 227, 283, 286, 413–417
  - Focus, 25, 33, 34, 43, 44, 48, 91, 101, 166, 184, 202, 214, 225, 227, 270, 289, 299, 336, 340, 343, 366
  - Fonts, 20, 27, 148, 206, 207, 210, 218, 221, 335, 389
  - Foolishness, 195
  - Forcing function, 19, 20
  - Forgetting, 57, 128, 143, 208, 301, 338
  - Formative evaluation, 357, 370, 377
  - Formula 1, 58
  - Fourier transform, 106, 108
  - Fovea, 87, 88, 95, 389
  - Framing effects (in decision making), 190
  - Frequency, 11, 106–108, 110, 111, 331, 141, 205, 247, 290, 296, 357
  - Frustration, 155, 373, 375
  - Functional fixedness, 177, 178
  - Functionality, 4, 14, 15, 20, 26, 27, 47, 49, 62, 74, 165, 168, 177, 208, 364, 366, 367
  - Function allocation, 301
  - Fundamental attribution error, 10, 24, 231
    - of design, 10, 231
- G**
- Games, 22, 60, 74, 101, 116, 120, 141, 142, 151, 177, 180, 242, 249, 256–258, 313, 344, 359, 398, 410
  - Gaze, 66, 105, 118
  - Generalities of human behavior, 386–391
  - Generic Error Modeling System (GEMS), 293, 294
  - Geographic, 112, 240
  - Geometric, 112, 146, 193
  - Gestalt principles of visual grouping, 103–105, 138, 387
  - Glare, 19, 82
  - Glasses, 87

- Gloves, force feedback, 70
- Goal, 12, 23, 46, 147, 155, 156, 174, 175, 177, 180–182, 197, 226, 231, 236, 242, 244, 246, 256, 258, 269, 274, 299, 310, 314, 319, 320, 326, 336, 339, 340, 344–346, 358, 363
- Goal-driven, 238
- Goal-oriented, 326
- Goggles, 58, 90
- Golden rule, v
- GOMS (goals, operators, methods and selection rules), 12, 43, 318, 319, 322, 328, 335, 394, 395  
 components, 320  
 example application, 320
- GOMSL, 320
- GPS, 65, 320, 326
- Graphic design to help reading and scanning, 27, 205
- Graphical user interfaces (GUIs), 33, 34, 339
- Graphics, 27, 45, 104, 176, 218, 338
- Grice's maxims of conversation, 203–205, 219, 221, 339, 389
- Ground and figure, *see* Figure and ground
- Groups, 45, 119, 126, 131, 181, 214, 221, 225, 226, 228, 229, 233, 236, 238–240, 242, 247, 253, 260, 262, 264, 268, 272, 275, 360, 374, 387
- Groupthink, 233
- GUI, *see* Graphical user interface
- Guidelines, 8, 37, 45, 46, 241, 321, 347, 356, 365, 376, 394
- Gulf of evaluation, 11, 345–351
- Gulf of execution, 11, 172, 345–351
- Gulfs in practice, 345
- Gulfs of evaluation and execution  
 implications for design, 346–349  
 in practice, 345  
 limitations of, 349
- H**
- Habituate, 62, 83, 85
- Haptic, 57, 63, 70, 72, 75, 101  
 devices, 72  
 interfaces, advantages and disadvantages of, 72
- Hard mental operations (cognitive dimensions), 336, 337, 341–343, 351
- Harmonics, 108
- Hawthorne effect, 360, 390
- Hazards, 35, 287, 338
- Human–computer interaction (HCI), 14, 27, 45, 52, 70, 89, 230, 327, 354, 369, 403, 407, 410
- HCI bibliography project, [hcibib.org](http://hcibib.org), 27
- Head-mounted, 88, 117
- Health and safety executive (UK), 60, 61
- Hearing, 23, 46, 62, 64, 81, 82, 86, 106, 108, 112, 117, 127, 139, 141, 227, 301, 387
- Heuristic evaluation, 365, 366
- Heuristics, 350, 365
- Hick–Hyman Law/Hicks law, 68, 182
- Hidden dependencies (cognitive dimensions), 335–337, 342
- Hierarchical task analysis (HTA), 299, 314–317, 329  
 components, 314  
 example application, 315
- Higher level visual perception, 100  
 implications for system design, 105
- Hindsight, 283, 295, 302
- Hits, 27, 83, 85, 292
- Hospitals, 227, 270, 318, 410
- How to encourage cooperation, 258
- Hue, 94
- Human-centered, 43, 50, 378, 405
- Human-centered design (HCD), 43
- Human-centered systems design (HCSD), 33
- Human–computer interface(s)  
 (HCI), 4, 14, 27, 33, 45, 52, 89, 184, 225, 230, 327, 369, 395, 410
- Human error rate prediction, 38, 292
- Human error, *see* Error
- Human factors, 17, 26, 27, 34, 35, 39, 45, 52, 76, 192, 276, 284, 314, 341, 369, 385, 408, 409
- Human–Human communication, 34, 201
- Human information behavior, 213
- Human–information seeking behavior, 213  
 implications for system design, 214
- Human–information systems, 23
- Human–machine systems, 40
- Human–robot interaction, 397
- Human–system integration, 407
- I**
- Iconic memory, 125
- Icons, 33, 59, 72, 93, 120, 142, 188, 203, 205, 218
- Identifying the dependent and independent variables, 357
- Ill-structured problems, 181, 182

- Illuminate, 72, 88, 91, 92, 210  
 Images, 86, 91, 96, 101, 105, 125, 274, 340, 395  
 Immersion, 70, 74  
 Immersive reality, 71  
 Impaired, 11, 75, 82, 111, 136, 387  
 Implications for system design, 82, 92, 142, 183, 192, 204, 211, 214, 218, 273, 300, 387  
     social and organizational aspects, 82, 92  
 Implicit memory, 129, 130  
 IMPRINT, 394  
 Incidents, 319, 364, 409  
 Incompetence, 193, 194, 196  
 Incubation in problem solving, 143  
 Index of difficulty, 67  
 Indicator, 47, 85  
 Individual differences, 34, 40, 127, 181  
 Informatics, 41  
 Information  
     architecture, 215, 216, 220  
     processing model of attention, 140  
     scent, 214, 219  
     seeking behavior, 201, 212–215  
 Information, 212  
 Infrared, 90  
 Input glove, 16  
 Insight problems, 179, 180  
 Instruction, 133, 135, 156, 204, 319, 324, 328, 347, 363  
     implications for, 133, 135, 136  
 Instructional, 156, 177  
 Instrument validity, 358  
 Intelligence, 13, 24, 43, 134, 171, 358  
 Interaction design (IxD), 33, 366, 378  
 Interface  
     design, 12, 13, 26, 28, 45, 97, 119, 131, 155, 160, 171, 173, 204, 214, 220, 311, 313, 329, 343, 365  
     ergonomics, 37  
 Interference in memory, 124  
 Internal validity, 358, 359, 361  
 International Standards Organization (ISO), 44, 48, 76, 98  
 Inter-rater reliability, 361  
 Interruptions, 21, 22, 137, 142, 143, 144, 286, 325, 361, 364  
 Interviews, 310, 318, 326  
 Interviews and focus groups, 190, 242, 270, 374  
 Intrinsic motivation, 325, 343, 345  
     implications for system design, 115, 116  
 Introspection, 4, 151, 370  
 Intuitions, 365, 390  
 iPod, 72, 109, 189, 343  
 Ironies of automation, 301  
**J**  
 Joysticks, 317, 322  
 Judgments, *see* Decision making  
 Just noticeable differences (JNDs), 82, 83, 85  
**K**  
 Kegworth air disaster, 9–10, 22, 281, 345, 346, 413–417  
 Key bindings, 151, 152, 155  
 Keyboards/keypads, 60, 63, 64, 69, 74, 77, 151, 324, 365, 387, 397  
 Key, *see* Keystroke  
 Keystroke logger, 303, 375  
 Keystroke level model (KLM), 43, 320, 322  
     description of components, 324  
     example application, 325  
 Keystrokes, 64, 130, 132, 149, 155, 157, 322, 324  
 Keystroke shortcuts, 132, 325  
 Kinesthetic information, 62, 63  
 Kiosks, 65, 172, 210  
 Kitchen, 52  
 Klaxons, 112  
 Knees, 18  
 Kneecaps, 18  
 Knobs, 6, 18, 19, 37, 182, 322  
 Knowledge  
     declarative, 128, 146, 328  
     procedural, 140, 328  
     skills and attitudes (KSA), 234, 265  
 Knowledge-based, 153, 156, 234, 293, 326  
 Knowledge-level, 153  
**L**  
 Laboratory-based experiments, 289, 368  
 Language, 17, 33, 40, 42, 127, 129, 155, 181, 197, 201–204, 219, 326, 335–338, 341, 389, 392, 394, 408  
     implications for system design, 33, 127, 156, 204  
 Lapses, 286, 293  
 Laptops, 18, 57, 208  
 Latent errors, 282  
 Leadership, 195, 238, 242, 245, 260, 390  
 Learnability, 47, 48, 320  
 Learner, 48, 131, 133, 145, 217, 242  
 Learning, 202, 217, 220, 246, 258, 264, 273, 274, 283, 284, 290, 309, 311, 326,

- 326, 338–340, 351, 369, 388, 389, 391, 398, 402, 403, 407, 408
- implications for interface design, 155–158
- implications for system design, 204, 214, 244, 402, 408, 409
- improvements from, 147–150
- process of, 145–147
- Rasmussen's theory of knowledge, 284, 293, 348
- stages of, 399
- transfer of, 407
- types of, 130, 150, 151, 157
- Learning and skilled behavior, 144–157
- Learning curve, 148–152, 205
- Learning within and between projects, 406, 407
- Legal, 303, 386
- Legibility, 206, 219
- Levers, 317, 387
- Lights, 327, 369, 388, 390
- Light waves, 206, 208, 290
- Likeability, 48
- Likelihood, 240, 245, 247, 296
- Limb, 387
- Line between success and failure, 284, 286
- Linguistics, 202, 256
- Listening, 202, 287
- Lists, 322, 408
- Load bearing, 62
- Localizing sound, 387
- Loftus effect, 135–136
- London airport, 173
- London ambulance dispatching system, 22
- Long-term memory (LTM), 158, 321, 395, 397
- Loudness, 370
- Low-level visual perception, 92, 100, 103
  - implications for system design, 98–100
- Luminance, 208
  
- M**
- MABA–MABA, 301
- Maintenance, 201, 219, 238, 262, 367, 388, 389
- Majority and minority effects, 233
- Man–computer, 354
- Man–machine, 40
- Massed learning, massed practice, 11, 13, 152
- Mastery, 245, 246, 274
- Means (average), 357
- Means-ends analysis (MEA), 176
- Meaning-making, 202, 203, 283
- Measurement of light, 92
- Measuring usability, 359, 369, 379
- errors, 370
- eye movement tracking, 372
- interviews and focus groups, 374
- patterns of usage, 375
- questionnaires and surveys, 373
- task time, 369
- user experience, 376
- verbal protocols, 370
- video protocols, 371
- workload measures, 374, 375
- Medicine, 214, 272, 287
- Memorability, 64, 125
- Memorable, 126
- Memories, 8, 20, 124, 127–129, 133, 134, 136, 140, 141, 145, 151, 156, 190, 217, 388, 395
- Memorize, 7, 28, 124, 167
- Memory
  - aids, 135, 395
  - biases, 133
  - declarative, 129
  - encoding effects, 134
  - episodic, 124, 140
  - iconic, 124
  - implications for system design, 156
  - interference in, 134
  - priming, 135
  - procedural, 129, 151
  - prospective, 131
  - recognition, 132, 151
  - representation, 136
  - retention, 331
  - retrieval, 124, 125, 128, 134, 135, 160, 189, 193
  - retrospective, 131
  - short term, 20, 124–128
  - types of, 124
- Mental model, 21, 165, 166, 169–171, 173, 176, 183, 188, 192, 196, 197, 217, 256, 287, 301, 345, 349, 348, 489
- Mental models, of users, 348, 389
- Mental representation, 166
  - implications for design, 173
  - simple representations, 167
- Menu bar, 67, 68, 160
- Menus, 7, 8, 28, 33, 68, 77, 159, 172, 182, 185
- Metacognition, 194, 196
- Metaphor, 138, 177, 187
- Method of loci, 131
- Micro-saccades, 88
- Misinterpretation, 135, 217, 289
- Mismatch, 71, 171, 187
- Misses, 84, 85
- Mistake, 12, 13, 28, 143, 153, 155, 194

- Misunderstanding, 22
- Mnemonics, 19, 131, 132, 136
- Mobile phone, 18, 69, 72, 75
- Modalities, 67, 74, 76, 144, 158
- Mode, 12, 37, 75
- Model human processor (MHP), 43, 392, 395–397
- Modeling, 23, 42, 43, 52, 159
- Models, 9, 12, 14, 21, 23, 24, 38, 42, 43, 49, 51, 64, 68, 131, 140, 165, 166, 168–171, 173, 176, 178, 192, 196, 272, 376  
     of social processes, 266–269  
     of users, 23, 391–399
- Monitoring, 39, 138, 141, 142
- Monochromats, 95
- Monochrome, 95
- Motivation, 4, 5, 17, 21
- Motor, 16, 23, 62, 74, 75, 138, 141
- Mouse, 59, 66–68, 72, 75, 77
- Mouth, 63
- Movement perception, 87, 101
- Movements, 16, 52, 57, 66–71, 146, 174, 295, 372
- MS word, 28
- Multimodal, 133
- Multi-tasking, 12, 158
- Multi-touch, 63
- Muscle, 16, 17
- Music, 72, 108, 189
- Mutual support and mutual surveillance, 235, 240
- Mythical man-month, 235, 238
- Myths, 159, 187
- N**
- NASA's Aviation Safety Reporting System (ASRS), 286
- NASA-TLX (task load index), 375
- Nash equilibrium point, 257
- Naturalistic, 192
- Navigation, 65, 364, 372
- Near misses, 22
- Need for cognition, 180, 181, 295
- Negotiation toolset, vi
- Neonatal, 270, 271, 318
- Nepal, 125, 128, 132, 135
- Networks, 48, 132, 173, 213, 235, 253, 260, 261, 262, 264, 343  
     leadership in, 260
- Networks lead to better work, 262
- NGOMSL, 320
- Norm, 236, 241, 327
- Normal curve, 388
- Norman's seven stages of action, 343–345
- Normative behavior/norms, 265, 310
- Novice, 21, 28, 48, 64, 147, 156, 157, 173, 175, 177, 188, 191, 217, 326, 328, 329, 357, 387
- NYNEX, 11–12
- O**
- Observer, 184, 188, 228, 231, 291, 303, 363, 370
- Old, 12, 70, 75, 176, 180, 187, 261, 287, 338, 340. *See also* Elderly
- Omissions  
     error of, 64, 295
- Open loop behavior/control, 141, 142
- Operate, 9, 12, 63, 64, 62, 75, 131, 152, 153, 166, 176, 227, 244, 247, 302, 345, 389, 393
- Operators, 11, 12, 37, 43, 143, 153, 174, 176, 177, 181–183, 187, 227, 238, 286, 288, 290, 291, 301, 313, 320, 321, 324, 329, 346
- Optical, 86, 87, 91, 105
- Optimization, 18, 34, 37, 48, 184, 204, 206, 219, 238, 262, 274
- Organization, 22, 26, 34, 36, 40, 41, 43, 44, 60, 76, 211, 216, 225, 227, 235–240, 243, 249, 259, 253, 265, 274–276, 302, 311, 357, 362, 376, 386, 409
- Organizational and cultural levels, 264
- Organizational effects, 265
- Organizing what we have learnt about users, 386
- Overview of vision, 86
- P**
- Paper-based reading, vs. screen-based reading, 208
- Parafovea, 87, 90
- Parallax, 19, 101
- Participants, 230, 242, 258, 259, 319, 360, 361, 373, 376, 377, 379
- Participation in an activity, 240
- Participation outside work settings, 116, 253  
     implications for system design, 136
- Passwords, 129, 136, 145, 160
- Patterns of usage, 368, 375, 376
- Payoffs, 235, 242, 254, 256, 257, 259, 274
- Peer-to-peer, 241
- Pencil and paper prototypes, 367

- Penny, knowledge in the head vs. in the world, 7, 8, 28, 347
- Perceive-decide-act cycle, 345
- Perception, 44, 95, 124, 236, 284
- Perceptual-motor, 124, 213, 320, 324
- Performance assurance, 311
- Performance shaping factors (PSFs), 293
- Periphery [eye], 50, 90, 91, 95, 101, 181
- Philadelphia airport, 169, 170
- Phones, 8, 14, 65, 70, 74, 77, 112, 159, 173, 182, 198, 219, 221, 242, 246, 253, 303, 320, 376, 387
- Photoreceptor, 90
- Physical, 17, 18, 20, 36, 52, 58, 63, 110, 120, 149, 171, 235, 267, 270, 286, 319, 322, 327, 343–345, 375, 386, 409
- Physical aspects of interaction, 59
- Physical keyboard, 63
- Physiology, 33, 81, 103, 113, 211, 281, 287, 294, 386
- Physiology of vision, 86
  - implications for system design, 91
- Pilots, 9, 13, 21, 22, 74, 153, 176, 226, 266, 283, 286, 287, 313, 346, 373, 410
- Planning, 138, 146, 153, 195, 246, 284, 293–295, 299, 315, 339, 377
- Planning your evaluation study, 356–362
- Platinum rule, v
- Play, 18, 22, 60, 74, 84, 108, 113, 141, 142, 151, 174, 191–192, 249, 257–259, 326, 327
- Pleasurable, 26, 27
- Pluralistic ignorance, 228, 230, 248
- Pointing devices, 66
- Policy, 26, 29, 198, 266, 273
- Pop-out effects, 92, 97–100, 116
- Post-completion error, 180, 181
- Postures, 60, 76, 17, 59, 60, 63, 387, 389
- Power law of learning, 148, 149
- Poynter Institute, 119
- PQ4R, 133
- Practice, *see* Learning
- Practitioners, 15, 34, 45, 154, 403
- Predictability, 8, 26, 38, 40, 67, 142, 143, 149, 155, 156, 188, 211, 241, 285, 288, 290, 313, 320, 385, 392, 394, 397
- Prediction, 5, 38, 269, 272, 292, 313, 314, 324, 392, 395, 397
- Preferences, 44, 96, 112, 338
- Premature babies, *see* Neonatal
- Premature commitment (cognitive dimensions), 341
- Prescriptions/prescriptive, 37, 46, 214, 265, 310, 405
- Primacy and recency, 189
- Primacy effect, 125–127, 134
- Priming, of memory, 134
- Principles, 37, 41, 46, 103, 105, 145, 204, 348, 355, 356, 365, 389, 395, 398
- Prisoner's dilemma (PD), 256–260
  - how to do well, 258
  - suggestions for how to promote cooperation, 258
- Problem solving, 40, 42, 145, 146, 152, 165, 166, 174–177, 180, 181, 183, 184, 192, 196–198, 202, 213, 239, 265, 293, 344, 345, 389
  - examples of, 175
  - implications for system design, 192
  - known influences on, 176
  - the importance of, 175
- Procedural memory, 129
- Procedures, 9, 19, 38, 41, 129, 151, 176, 265, 375
- Process of learning, 145
- Programmable User Models (PUMs), 43
- Programmer, 48, 143, 340, 343, 397
- Programming, 33, 48, 51, 129, 143, 160, 336, 338, 341, 392, 408
- Project lifecycle, 355, 404
- Propositional representation, 167
- Proprioception, 42
- Prospective memory, 131, 158
- Prototype, 4, 45, 101, 363, 364, 366–368, 395
- Proximal, 81, 115
- Psycholinguistics, 89
- Psychological science in the public interest, 198
- Psychology, 4, 10, 26, 34–36, 40, 76, 82, 103, 115, 117, 119, 145, 151, 158, 159, 166, 184, 192, 197, 202, 226, 228, 237, 349, 360, 389, 395, 397
- Psychology/design of everyday things*, 27, 350
- Psychometric, 15
- Psycho-physiology, 103, 281
- Psychotherapy, 281
- 8 puzzle, 130, 157
- Q**
- Questionnaires and surveys, 373
- R**
- Radiation, *see* X-ray
- Rarefaction, 106, 108
- Rasmussen's theory of knowledge, 284, 293, 348
- Ratings, 373, 375

- Rationality, 184, 192, 193, 291
  - RD-ICM, risk-driven incremental commitment (concurrent) model, 399–408
  - Reaction time, 64, 67, 387
  - Readability measures, 207, 217
  - Reading, 4, 20, 25, 60, 70, 72, 88, 97, 100, 125, 155, 158, 160, 197, 201, 204, 206–209, 216–218, 220, 221, 266, 302, 330, 389, 393, 410
    - factors affecting, 205
    - implications for system design, 136
    - paper-based reading, vs. screen-based reading, 208
    - scanning, 27
  - Reading from the screen, 208, 219
  - Reading index, 217
  - Reasoning, 8, 23, 42, 134, 145–147, 389
  - Recall, 7–9, 112, 128, 132, 135, 136, 157, 160
  - Recallable, 136
  - Recency effect, 126
  - Recency of memory, 134
  - Receptor, 62, 86, 87, 89, 91
  - Recognition memory, 132
  - Recognition-primed decision making (RPDM), 191, 192
  - Red–green color differences, 91, 95
  - Redundancy, 47, 100, 336, 344
  - Regression to the mean, 189
  - Regulatory, 21, 247, 274, 288, 415
  - Rehearse, 135
  - Reliability, 4, 14, 47, 49, 50, 108, 186, 284, 290, 294, 358, 361, 371
    - of user testing, 355
  - Remember/remembering, 8, 20, 50, 111, 125, 128, 135, 158, 159, 189, 192, 208, 226, 274, 276, 310, 353, 369, 371, 388, 389, 392
  - Reminders, 70, 136, 350
  - Repetition of stimuli, 132
  - Repetitive strain injury (RSI), 60
  - Representation in memory, 151
  - Requirements, 43, 44, 50, 115, 289, 313, 343, 354, 368, 399, 405, 407
  - Respiratory distress syndrome (RDS), 318
  - Retention, memory, 331
  - Retina, 87–89, 95, 101, 104
  - Retrieval biases, 134
  - Retrieval from memory, 125, 132, 134, 189, 193
  - Retrospective memory, 297, 370, 371
  - Rich pictures, 267, 270–272, 318, 319
  - Risk-averse, 193
  - Risk-driven incremental commitment (concurrent) model, 341, 385, 399
    - descriptive as well as prescriptive, 404
    - designers are stakeholders too, 405
    - learning within and between projects, 406
    - provides a way to organize user related knowledge and ways of knowing, 403
  - Risks, 14–16, 60, 66, 190, 234, 245, 266, 342, 385, 399, 400, 403, 409
  - Risk-taking, 234
  - Road, 70, 206, 228, 310
  - Robot-assisted surgery, *see* da Vinci
  - Rods [eye], 83, 89, 91, 95
  - Role-expressiveness (cognitive dimensions), 337, 339, 340
  - Role of tasks and environments, 390
  - Rubin vase, 94
  - Rule-based behavior/rule-level, 153
  - Rules, 14, 27, 115, 145, 147, 149, 153, 158, 166, 193, 226, 259, 283, 321, 322, 341, 365
- S**
- Saccades, 87
  - Safer systems, 10, 13
  - Safety, 13, 15, 22, 35, 38, 49, 60, 64, 100, 115, 287, 296, 303, 310, 314, 339
  - Safety-critical systems, 21, 364
  - Saliency, 83, 86, 95
  - Sample size effects, 189
  - Samsung TicToc mp3 player, 72
  - Satisfaction, 116, 148, 357, 359, 369
  - Satisficing, 407
  - Scanning, 118, 202, 206, 209, 211, 212, 218, 219
  - Scanning displays and menus, 209
  - Scenario-based, 299, 363, 364, 415
  - Scenarios, 9, 296, 299, 363, 369
  - Screen layouts, 81
  - Screens, 65, 72, 85, 98, 100, 104, 105, 206, 208, 210, 218–220, 317, 363, 371, 375
  - Screenshot, 187, 212
  - Scrolling, 59, 65, 72, 150, 185, 321
  - Searching, 11, 19, 27, 40, 84, 97, 120, 147, 150, 151, 172, 173, 184, 192, 202, 205, 206, 212–215, 231, 273, 276, 321, 327, 389
  - Search engine optimization (SEO), 215
  - Seats, 88
  - Second Life, 258, 277
  - Seeing, 83, 84, 88, 95, 103, 105, 138, 146, 289
  - Seeking, 104, 131, 190, 201, 212, 213, 219, 220, 231, 389

- Selecting a hypothesis, 356
- Selecting the most appropriate data collection method for error study, 289, 291
- Self-determination theory (SDT), 113
- Semantics, 127, 140, 188, 202, 203, 208
- Semi-structured interviews, 270, 318, 374
- Sensation, 74, 81, 89, 94, 107
- Senses, 19, 23, 25, 48, 49, 57, 60, 62, 63, 74, 81–83, 88, 90, 106, 114, 117, 176, 195, 202, 208, 239–241, 284, 303, 311, 355, 365, 366, 372, 386, 405
- Sensitivity, 74, 83, 84, 88, 90, 91, 94, 108, 117, 358, 361
  - of user testing, 361
- Sensors, 34, 395
- Sensory threshold, 83
- Sensory-motor, 386
- Serial position curve, 126
- Serifs, 210
- Shapes, 103, 104, 205
- Shared representations, 407, 408
- Sharp end, 288, 302
- Shortcuts, keystroke, 132
- Short-term memory (STM), 125
- Sight, *see* Vision
- Signal, 62, 74, 84, 85, 375
- Signal detection theory (SDT), 82–85, 120, 185
- Simple decisions, *see* Hicks law and speed-accuracy trade-offs
- Simulating humans, x, 23
- Simulation, 42, 267, 272, 273, 290, 359, 393, 394, 398, 406
- Simulator, 9, 290–292, 303
- Situation awareness (SA), vii, 138, 202, 238, 302, 371
- Skill-based/skilled, 12, 15, 141, 146, 153, 293, 348
- Skilled behavior in complex environments, 153
- Slack, 284, 293
- Slip, 284, 293, 370
- Slips of actions, 19, 141, 142
- Small world phenomena, 260
- Smartphones, 77, 242, 249
- Smell, 81, 82, 88, 134, 214, 219
- Smooth pursuit eye movements, 101
- Soar, 43, 129, 159, 232, 393, 395, 397
- Soccer, 249
- Social and organizational aspects, implications for system design, 204
- Social capital, 260
- Social distance, 236, 239, 240, 246, 274
- Social effects on decision making, xv, 228
- Social issues, 9
- Social networks lead to better work, 262
- Social responsibility effects, vi, 228
- Social theories and models, 253
  - cultural effects, 275
  - exchange costs and benefits, 256
  - good personal social networks lead to better work, 262
  - implications for system design, 273
  - informal, pairwise analyses, 254
  - networks, 260
  - organizational and cultural levels, 264
  - organizational effects, 265
- Sociology, 273, 276
- Socio-technical system design (STSD) methods, 41, 226, 273, 301
- Socio-technical systems, 329
- Soft systems methodology (SSM), 267, 269, 270
- Sound, 19, 34, 46, 82, 83, 85, 106, 108, 110–112, 117, 134, 203, 363, 387
  - localizing, 110, 387
  - measuring, 108, 109, 239
  - theoretical description of, 106
  - implications for system design, 111, 204
- Sounds discriminating, 111
- Spam, 232, 275, 277
- Spatial distance, 236, 241
- Spatial perception, 101
- Special interest group (SIG) on computer-human interaction (SIGCHI), 45
- Specification, 282, 320, 322, 358, 359, 391
- Spectrum, 90–92
- Speech, 72, 157, 247, 368, 387
- Speed-accuracy trade-offs, 185
- Spelling mistakes, 97
- Spiral model, *see* RD-ICM
- S–R (Stimulus–response) compatibility, *see* Stimulus–response compatibility
- Stages of learning, 146, 149
- Stakeholders, vi, 269–271, 362, 399–407, 427
- Standard, 37, 46, 50, 62, 76, 96, 106, 108, 269, 347, 365, 376
- Stereoscopic vision, 102
- Stimuli, 5, 63, 81–83, 85, 97, 101, 108, 119, 132, 171, 186, 360
- Stimulus–response compatibility, 5, 171–173, 186, 187
  - for decisions, 186
  - for mental models, 171
- Stimulus–response mapping, 427
- Storage, 42, 123, 131, 270, 293, 338, 397
- Store, 19, 38, 124, 125, 127, 129–131, 321, 323, 395
- Stories, vii, 155, 228
- Storyboarding, 4, 367

Stove-top mappings, 6  
 Strategy, 8, 21, 147, 149, 150, 171, 178, 192, 215, 216, 258, 259, 361, 395  
 Stress/stressors, 46, 241, 293  
 Structured, 131, 182, 201, 211, 215–217, 219, 244, 299, 374  
 Structure of the eye, 86, 211  
 Structuring content, 217  
 Styles, 19, 20, 51, 64, 146, 159, 187  
 Subgoals, 313–316, 321, 323, 325, 422  
 Subitizing, 102  
 Sub-tasks, 149, 315, 422  
 Summaries of users, 23, 385  
 Summative evaluation, 357, 368, 369, 427  
 Supervisory control, 39  
 Supporting participation outside work settings, 375  
 Surface fidelity, 290, 367  
 Surgery, 70, 74, 75  
 Surprises, 165, 197  
 Surveillance, 240, 241  
 Survey, 9, 62, 150, 160  
 Switches and lights, 5  
 Symbol, 20, 42, 202, 242  
 Syntax, 39, 139  
 System fidelity, 4  
 Systems ergonomics, 39  
 System usability scale (SUS), 373

## T

Tactics, 158, 213, 366  
 Tactile, 57, 63, 72, 74  
 Talking, 127, 138, 256, 286, 366, 371, 414  
 Task-action mapping, 187  
 Task analysis (TA), 12, 248, 309, 311, 313–314  
   considerations when choosing a method, 326  
   uses of task analysis, 12, 311–314  
   where to apply, 310  
 Task and interface design, 26, 311, 313  
 Task attractiveness, 236  
 Task-centered user interface design, 26, 119, 329  
 Task time, 156, 326, 330, 369  
 Taste, 82, 189  
 Taxonomies, 142, 292–293, 303  
 Team-building, 327  
 Team competencies, 236  
 Team processes and tasks, 236  
 Teams, 12, 49, 113, 225–227, 234  
 Team size, 236  
 Team structure and composition, 236

Teamwork, 234–235, 239, 248, 253, 258  
 Technique for human error assessment (THEA), 299, 428  
 Technique for human error rate prediction (THERP), 38  
 Ted Williams, 18  
 Telephone, 11, 70, 111, 264, 313, 323, 361, 364  
 Telepresence, 74  
 Tests, 136, 151  
 Text-based virtual environments, 253  
 Text-editing, 321, 325  
 Texture, 72, 94, 102  
 Theremin, 202, 203  
 Three letter acronyms, TLAs, 126  
 Three Mile Island accident, 282, 284  
 Threshold, 357, 369  
   sensory, 83  
 Thumbs, 77, 98, 111  
 Time-and-motion, 325  
 Time-constrained, 286  
 Time-sensitive, 313  
 Tolerances, 17, 88, 358  
 Tones, 106–108, 110, 111  
 Touch-based, 65, 72  
 Touch screen, 65  
 Touch, *see* Haptic  
 Touch-typing, 397  
 Tower of Hanoi, 174  
 Tracker ball, 75  
 Trade-offs, 64, 77, 132, 143, 155, 157, 186, 205, 212, 257, 327, 329, 330, 335, 339, 341, 343, 347, 350, 351, 367  
 Training, 5, 9, 19, 35–36, 39, 117, 120, 155, 286–287, 293, 295, 301, 314, 319, 347, 404, 407  
 Transfer, of knowledge, 48, 155  
 Troubleshooting, 147, 166, 169  
 Trust, 136, 147, 213, 244  
 Type of data: qualitative or quantitative, 195, 354, 356  
 Type of evaluation: formative or summative, 357  
 Types of memory, 123, 124, 129, 150  
 Types of user models, 393  
 Typing, 13, 64, 141, 303, 324, 367–368, 397  
 Typing errors, 303  
 Typist model, 64

## U

Ultraviolet, 90  
 Unified theories of cognition, 42, 159  
 University department web sites, 52, 160, 312

- Unsafe, 266, 283
  - Unusable, 266, 353
  - Upper limb disorders (ULD), 18, 35, 60, 61, 387
  - Usability, 11, 14, 18, 26, 43–44, 47–48, 57, 76, 136, 160, 172–173, 211, 216, 320, 336, 343, 357–358, 362–366, 369, 372–373, 378, 390, 403, 409
    - usability, testing, 362
  - User experience (UX), 33, 44, 216, 218, 369, 376
  - User manuals, 60, 314
  - User testing, 335, 353–355, 368
    - identifying the dependent and independent variables, 357
    - planning your evaluation study, 356
    - selecting a hypothesis, 356
    - type of evaluation: formative or summative, 357
    - when to carry out, 355
    - why needed, 354
  - User-based evaluation, 357
  - User-centered design (UCD), 33–35, 39, 43, 50–51
  - Users, 1–412
  - Users' bodies, *see* Anthropometrics
  - Users, how they read, 216
  - User, senses of the user, 81–121
  - User's mental models, 165, 168, 196
  - Users, why don't users do what they should, 194
  - Uses of task analysis, 12, 311–314
    - allocation of function, 311
    - performance assurance, 311
    - task and interface design, 313
- V**
- Validation, 353
  - Validity, 289, 291, 353, 358
    - construct, 358
    - content, 359
    - ecological, 360
    - external, 360
    - face, 359
    - instrument, 358
    - internal, 359
    - of user testing, 358–361
  - Verbal protocol, 365, 370, 372
  - Verification and validation, 353
  - Video games, 70. *See also* Games
  - Video protocol, 70, 185, 371
  - Vigilance, 84, 85
  - Violations, 265, 283, 370
  - Virtual reality systems 3.3.5, 63, 70
  - Viscosity (cognitive dimensions), 337–338, 341
  - Visibility, 337, 346–347, 405
  - Vision, 23, 34, 62, 75, 211, 286, 338, 355, 371, 375, 387, 392–393, 395
    - implications for system design, 91
  - Vocabulary tutor, 340, 343
  - Voice, 106, 111, 112, 144, 173, 414
  - Voice output(s), 144
  - Von Restorff effect, 125, 132, 134
- W**
- Warnings, 288
  - Wason reasoning task, 194
  - Waterfall model, 404
  - Waveform/waves, 86, 90, 106–108, 110, 112
  - Wave-length, 90, 91, 94, 95, 110
  - Ways email has gone awry, 232
  - Webbly, 11
  - Web content usability guidelines, 394
  - Websites, 37, 38, 78, 277, 312, 329
  - What is omitted by the cognitive dimensions, 343
  - What to evaluate, 367
  - When not to study the user, *see* Risk driven spiral model
  - Why don't users do what they should, 194
  - Wickens theory of attentional resources, 139
  - WIMP interfaces (windows, interfaces, menus, pointer), 33
  - Windows in childhood home, 371
  - Windows (OS), 68, 371
  - Windows in childhood home, 371
  - Win-win requirements negotiation tools, vi
  - Wizard of Oz (WoO) technique, 367
  - Workarounds, 47, 50, 376
  - Workers, 38, 263, 329
  - Working memory, 127, 151, 388, 395
  - Workload, 301
  - Workload measures, 374
  - Workspaces, 37, 330
  - Workstation, 12, 60
  - Writing, the importance of, 125, 211
- X**
- X-ray machine, 13
- Y**
- Yellow–blue color, 95
  - Yellow–green light, 95