WHAT YOU DON'T KNOW CAN HELP YOU:

INTUITIVE PROCESSING OF INCOMPLETE VISUAL STIMULI

by

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Intuition is an innate ability through which human beings acquire knowledge about the world around them. Throughout history people have speculated about how intuition operates and about the accuracy and usefulness of intuitively derived conclusions, but there have been few attempts at empirical investigation primarily due to the fact that a person using intuition does not appear to be doing anything at all. In fact, clinical lore suggests that that trying too hard may actually impede progress toward achieving an intuitively derived solution.

As source of knowledge or understanding, intuition appears to stand somewhere between perception and reason. Phenomenologically, intuitively derived solutions resemble perceptions, in that both are experienced as "given," however unlike perception intuition involves no discernable physiological pathway leading from sensory stimulation to the conscious awareness of some thing. Functionally, intuition has similarities to the process of reasoning, in that both can provide useful information about the world to consciousness. In use, however, intuition differs from reasoning, which takes place through explicit, observable intermediates between the recognition of a problem in need of a solution and the achievement of a successful solution. Intuition involves no such intermediates. Thus, intuition appears to be a function with neither pathway nor process.

The set of studies discussed in Part A of this thesis was designed to examine the notion that, rather than an abrupt and disjunctive "change of state," intuition is an incremental, accumulative process through which implicit and increasingly complete intermediates, or states of "partial knowledge" are generated prior to the achievement of a solution in consciousness. In Part A, it was demonstrated that unsuccessful attempts to identify objects portrayed in difficult visual gestalts significantly facilitated participants' performance on a related partial-word solution task. When the unrecognized stimulus items were incoherent, i.e., altered so that the component parts were displaced and rotated relative to each other, the facilitation effect, while still significant, was less than when the unrecognized gestalt was coherent. This finding supports the idea that the amount of solution-relevant implicit knowledge generated in an unsuccessful attempt to solve a problem varies with the quality of information present in the problem situation.

The set of studies in Part B examined the effect of inserting "dead air" interval between the visual gestalt and the related partial-word in the partial-word solution phase. Against prediction, coherent partial-word facilitation did not decrease at any interval condition, while incoherent partial-word increased at the longest interval condition. Overall, the findings are best explained by a bi-directional, dual-processing model in which the organization of visual stimuli and the symbolic labeling of sub-components within the visual stimuli are processed independently. Such a model could provide some context for the dispute between proponents of reorganization vs. forgetting in the debate about mechanism underlying incubation effects.

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I would like to dedicate this thesis to the memory of my parents, Vaughn and Clarice. More than anything I wish you could have been here to see this.

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Chapter 1 - Introduction

> "[U]nderstanding consists in reducing one type of reality to another…the true reality is never the most obvious… the nature of truth is already indicated by the care it takes to remain elusive…. to reach reality one has first to reject experience, and then subsequently to reintegrate it into an objective synthesis." (Lévi-Strauss, 1992, p. 57-58)

> "It takes a lot of time to be a genius, you have to sit around so much doing nothing, really doing nothing." (Stein, 1973, p. 70)

Intuition is an intriguing, but ephemeral and poorly understood concept. It is likely that almost everyone has at some time had the experience of struggling to solve a problem without success, only to have the desired solution appear suddenly and unexpectedly in consciousness. Often the solution appears while the person is engaged in some other activity and is no longer consciously thinking about the problem. The arrival of the solution in consciousness is sometimes accompanied by what has been described as an "aha" experience, in that the desired solution appears in the problem-solver's consciousness suddenly, without warning, and seemingly without effort.

Perhaps you have had the experience of trying in vain to find your car keys while rushing around the house getting ready to leave for work. After searching all the usual places and struggling unsuccessfully for some time to remember where you last saw them, you get caught up in your other morning activities, perhaps making your lunch or letting the dog out, only to have a sudden, unanticipated realization that you put your keys down by the computer last night while checking your email. Or, perhaps you have had the experience of meeting an acquaintance unexpectedly and struggling, with some embarrassment, to recall that person's name. Later, while out for a walk, the desired name flashes into awareness without warning, apparently "out of the blue."

Artists typically hold intuition in high regard and it has often been reported that artistic inspiration arrives "out-of-the-blue" and seemingly without conscious effort. Writer Robert Graves described intuition as "a sort of supra-logic that cuts out all the routine processes of thought and leaps straight from the problem to the answer" (Carter, 1989, p. 147). Similarly, author Antoine de Saint-Exupéry (1982, p. 8) stated that a "theoretician believes in logic and believes that he despises dreams, intuition, and poetry…. He does not know that he owes his greatest discoveries to them." According to British novelist Arnold Bennett (Flower, 1932, p. 36) "the artist is sometimes granted a sudden, transient insight…. A flash, and where previously the brain held a dead fact, the soul grasps a living truth! At moments we are all artists."

These sorts of sudden "aha" experiences have also been reported in the process of scientific discovery. In a frequently cited example, Kekulé, a 19th century chemist, after extended and unproductive attempts to discover the structure of a peculiar organic molecule, reportedly went home after a day of frustration in the lab, fell asleep, and dreamed of a ring of snakes, each biting the tail of the next. When he awoke he realized that the ring was the exact structure he was seeking. As Evelyn Monsay (1997) has noted, the sudden and unexpected achievement of an insightful solution after a long, fruitless struggle with a puzzling problem is an experience that has been reported frequently by researchers. According to Monsay, creative scientific discoveries are often seen to follow a two-phased pattern, in which a period of intense engagement with a particular problem is followed by a period in which the problem-solver is no longer consciously engaged with the problem. It is during this latter period, often referred to as an "incubation" period, that insightful solutions are likely to occur. When such a solution does arrive in consciousness it is often reported to have come without warning, and seemingly without connection to the current contents of the problem-solver's conscious mind. Physicist Fritjof Capra (2000, p. 31) noted that: "During these periods of relaxation after concentrated intellectual activity, the intuitive mind seems to take over and can produce the sudden clarifying insights."

The examples above from everyday life, from artists, and from researchers illustrate a type of problem-solving that, while informed by the problem-solver's prior conscious efforts to solve the problem, is experienced as unconnected to those conscious efforts. In their discussion of the intuitive generation of ideas Harman and Rheingold (1984) refer to Poincaré's observation that "…the idea came to me, without anything in my former thoughts seeming to have paved the way for it…. The idea came to me with … brevity, suddenness and immediate certainty" (Poincaré, 1946, p. 387-388). Arvidson (Floyd-Davis & Arvidson, 1997, p. 43) further describes the sudden appearance of an intuitively generated solution in consciousness as "comprehensive and immediately given as true, as a perfect fit," and experienced phenomenologically as "utterly different…than solving the problem of how to construct a child's bicycle by following step-by-step instructions." Monsay, in an essay tracing the impact of intuition on the theory and practice of science, provides a quote from mathematician Harald Cramér that aptly describes the experience of achieving an intuitively derived solution:

> "When no further progress is within sight, a strangely interesting phenomenon will often appear. The concentrated efforts of the conscious part of the mind … seem to have set some wheels going on a deeper level, and the subconscious mind takes over the work …. And then there is so to

> speak a “knock at the door” of the conscious mind, the intuitively attained result is presented, and left … to be verified and rigorously proved by conscious work” (Davis-Floyd & Arvidson, 1997, p. 110).

Whether the problem is as mundane as a search for a name in memory, or as extraordinary as an attempt to discover universal laws, for which, as Einstein has remarked, “There is no logical path leading to these…laws. They can only be reached by intuition, based on something like an intellectual love (“*Einfuhlung*”) of the objects of experience” (Popper, 1992, p. 32). Similarly, Stephen Hawking (1994) has stated that “there is no prescribed route to follow to arrive at a new idea. You have to make the intuitive leap…. Once you’ve made the intuitive leap you have to justify it by filling in the intermediate steps.”

As a result of the unique phenomenological characteristics of intuitively generated solutions, including suddenness, comprehensiveness, and certainty, many theorists have come to the conclusion that the “operations” of intuition are qualitatively different from those of conscious problem-solving procedures, and that the generative phenomena we refer to as intuition occurs outside of consciousness. It is precisely the “subconscious work” of intuition that occurs prior to the “knock at the door” of consciousness that is the object of investigation in this set of studies. In following sections I will discuss prior philosophical attempts to describe and explain intuition, similarities and differences between intuition and reason, similarities and differences between intuition and perception, the relation between intuition and concepts such as subliminal/implicit perception and memory, priming, and spreading activation. Each of these discussions will provide information for the task of answering the central questions that prompted this research project, i.e., “Are intuitively derived solutions to problems generated whole in a single, qualitative change of state or, instead, through a gradual process in which knowledge about the solution accumulates incrementally?" and, if the latter, "how might such a process operate?"

A very brief history of the concept of intuition

As noted above, many have recognized intuition as an important tool that human beings can use to generate knowledge about the nature of the world around them, a tool which is particularly useful when all other methods fail. Bastick (1982) has offered the opinion that intuition is a universal natural ability. While practically everyone would acknowledge having had some experience that they would describe as intuition, there is no consensus about exactly what should be held up as an example of intuition, nor is there agreement about how intuition operates. Some might reserve the term intuition for examples similar to those discussed above, in which desired solutions to puzzling problems appear in consciousness suddenly and seemingly without effort. Others might use the term intuitive to describe a precocious talent, for example a so-called musical prodigy who appears able to understand and generate music directly without having engaged in systematic study and practice. For still others, the term intuition implies something mysterious, like magic or voodoo, as Shirley and Langan-Fox (1996) note. The latter understanding has led to colloquial usage of the term intuition to describe the mechanism underlying such dubious phenomena as prescience, premonition, and prophecy. Since by definition each of these latter phenomena operates through supernatural or magical means rather than through a native human ability, they should properly be considered to be examples of divination, rather than of intuition. Even if one accepts that such things are in fact possible, any information truly given at the whim of a supernatural being or force would presuppose the generative mechanism to be fully external to the human mind, with the mind serving only as a passive receiver.

Throughout history there have been shifts in the understanding of intuition that are perhaps more revealing of cultural beliefs and concerns than of intuition itself, but because investigators have been forced to speculate backward from visible product to invisible generative process this is perhaps to be expected. According to the second edition of the Compact Edition of the Oxford English Dictionary (OED) (1971), intuition can be defined as the action of mentally looking at, or contemplating, i.e., achieving a mental view of some thing. The Latin root of intuition, *intueri*, conveys a similar meaning, i.e., "to look upon, consider, contemplate." In fact, *intueri* may be deconstructed to yield the Latin word *in*, a preposition indicating "motion or direction from a point outside to one within limits … now ordinarily expressed by the compound in-to," and the Latin word for sensory vision, *tueri*, which means "to look." Thus, taken as a whole, the Latin word *intueri* means a view, or understanding of the "inner workings" of reality obtained through mental operations.

Clearly, for Latin thinkers intuition was understood to be something akin to sensory vision, but distinct from sensory vision in that the knowledge provided by intuition "goes beyond" that provided by sensory vision to the "inner workings" of reality that underlie surface appearances. As well, for Latin thinkers intuition differs from sensory vision in that it involves no "intuitive organs" and is a purely mental, or cognitive phenomenon, similar to reason. Thus, Latin thinkers understood intuition to be a native human ability standing in some position "in-between" perception and reason, through which meaningful patterns and relationships *not* given by surface appearances can be known.

Scholastic philosophers of the medieval period, from the 9th to the 15th century (Radical Academy, 2002-3) also understood intuition as having characteristics similar to visual perception, and also agreed that through the use of intuition observers could "go beyond" the information provided by visual perception and come to know the inner workings of the perceived world. According to the Radical Academy (2002-3), however, Scholastic philosophers understood knowledge to be "a gift of God" and believed that "as the eyes have need of the light of the sun in order to see sensible objects, so the intellect needs the light of God to know the world of intelligible beings." The Scholastics understood "any method of knowledge which bypasses sense experience and is based on intuition" to be true "if based on an actual supernatural gift."

Thus, where Latin thinkers understood intuition to be a native ability fully situated within the human mind, the Scholastics, under the influence of St. Augustine's notion of "illumination," appeared to consider intuition to be some form of complex interaction between mortal and spiritual planes that allowed human intellect to operate momentarily at a superhuman level in order to provide "glimpses" of the internal workings of reality (OED, 1971). In other words, through the use of intuition humans can briefly tap in to some higher form of consciousness in which "seeing is knowing," temporarily elevating human intellect to the level of the divine.

It is likely that such an explanation grew up in part as an attempt to explain failures of intuition. Despite the fact that intuition can provide human beings with knowledge whose immediacy, comprehensiveness, and certainty resembles that of a visual perception, it can not provide the same sort of “on demand” reliability that is characteristic of sensory vision. By locating the mechanism of intuition partly in the human mind and partly in the spiritual realm, Scholastic thinkers could explain failures of intuition as a lack of connection or misalignment between the two.

The view of intuition expressed by most modern thinkers is much closer to the Latin conception of intuition than to that of the Scholastics. Most modern theorists accept intuition as a native human ability, as an alternative, non-rational source of knowledge, and recognize the phenomenological similarities between intuition and sensory vision. According to J. Dolhenty (n.d.), modern philosophical approaches define intuition as “the process by which insights or bits of knowledge emerge into consciousness from the subconscious or as the direct apprehension of knowledge which is not the result of conscious reasoning or immediate sense perception.” Dolhenty notes that, like the Scholastics, modern philosophers regard intuition as a source of knowledge that is similar to revelation in that neither can be verified or subjected to any public test, but modern philosophers do make explicit a distinction between intuition, which is understood to be a native human ability situated within the human mind, and revelation, which is understood to be a process through which knowledge is passively received from an external, supernatural source.

In a similar way, the OED (1971) states that modern philosophers understand intuition to be a mental tool, like reason, that human beings can use to acquire knowledge and understanding of the world around them. Despite a functional similarity to reason, however, the way that objects are presented to the mind by intuition is quite dis-similar to the way objects are presented by the process of reasoning, and instead the products of intuition resemble those of sensory apprehension, i.e., presented whole and complete. The OED definition suggests that intuition occupies a position somewhere "in-between" reason and perception, as a native human ability through which knowledge about the world is acquired, with similarities to reason and to perception but also with important differences from each, which will be discussed further in later sections.

It should be noted that some important thinkers have accorded a very high place for intuition amongst human abilities. In his *Opus Majus* (Bacon, 1267, p. 583) Roger Bacon (1928) stated that "there are two modes of acquiring knowledge, namely by reasoning and experience. Reasoning draws a conclusion and makes us grant the conclusion, but does not make the conclusion certain, nor does it remove doubt so that the mind may rest in the intuition of truth, unless the mind discovers it by the path of experience." In *An Essay Concerning Human Understanding* (1690, Chapter II, ¶ 1) Locke wrote that intuitive knowledge, which is immediately known to be true, is the "most sure" type of knowledge, and stated that, "[t]his part of knowledge … like bright sunshine, forces itself immediately to be perceived, as soon as the mind turns its view that way" (The Chinese University of Hong Kong, 1999). In *Rules for the Direction of Mind*, Descartes (1961) stated that that all acquisition of knowledge depends on only two mental operations, intuition and deduction. Kant, in the *Critique of Pure Reason*, (Kant, 1781, p. 65) stated that "all thought must, directly or indirectly… relate ultimately to intuitions… because in no other way can an object be given to us." Monsay (Davis-Floyd & Arvidson, 1997, p. 117) noted Wescott's (1968) observation that many theorists, including Bergson, Spinoza, and Croce, have recognized intuition as the path to "true and perfect knowledge." (Davis-Floyd & Arvidson, 1997, p. 117).

Intuition *vs*. Insight

> "[I]ntuitions give the appearance of miraculous flashes, or short-circuits of reasoning…. they may be likened to an immersed chain, of which only the beginning and the end are visible above the surface of consciousness. The diver vanishes at one end of the chain and comes up at the other end, guided by invisible links." (Koestler, 1990, p. 211)

Before proceeding, it should be pointed out that there has been a confusing tendency to apply the terms intuition and insight interchangeably in the literature. As an indication of how well entrenched this confusion has become, in the OED (1971) intuition is defined as both process, i.e., the mental act through which direct, immediate knowledge of an object is generated, and product, i.e., the appearance of a completed solution in consciousness.

Shirley and Langan-Fox (1996, p. 564) acknowledge the tendency to confuse intuition with insight, and attempt to clarify the situation by asserting that intuition is "a feeling of knowing with certitude on the basis of inadequate information and without conscious awareness of rational thinking" and is not "the sudden realizations that occur after the incubation of thoughts." This is in contrast to insight, which they define as becoming "instantly aware of something." Unfortunately, this definition also leads to some confusion due to the fact that "feeling of knowing" has taken on a specific meaning within psychological literature, i.e., an anticipation that a solution is imminent. The attempt by Shirley and Langan-Fox to clarify the definition of intuition, while still somewhat confused, points toward an important distinction between intuition, which is a generative process that takes place outside of consciousness, and insight, which is the sudden appearance of a solution, answer, or understanding in consciousness. Common to the examples of intuition discussed so far is the idea that intuition operates somewhere “outside” of conscious awareness with the purpose of supplying consciousness with insightful solutions to puzzling problems, thereby providing the problem-solver with a “glimpse” of otherwise invisible characteristics of the environment and the relationships amongst those characteristics.

In their discussion of intuitive processes, Bowers, Farvolden, and Mermigis (1995) described two conceptually distinct stages in the achievement of a solution to an insight-type problem, an intuitive stage and an insight stage. Activities in the intuitive stage involve the generation of potential solutions, or hunches, and “trial-fit” of these with the available elements of the problem. When a hunch is discovered that does have some degree of “fit” to the elements of the problem it may be passed along to the insight stage for further testing. Any hunch “promoted” to the insight stage may then be rigorously tested as a solution, and, if recognized as a potentially viable solution to the problem at hand, ushered into conscious awareness.

Bowers *et al* (1995) state that the activities involved in the intuitive generation of a potential solution must necessarily take place outside of consciousness. With the recognition of a problem in need of a solution, these activities are engaged automatically and operate independently of conscious awareness. Because all of the activities in the intuitive stage occur outside of conscious awareness, there will be nothing to signal to the problem-solver that progress toward a potential solution has been made until very late in the process. Perhaps the first opportunity for conscious awareness that a potential solution has been generated occurs at the junction between the intuitive and insight stages. If a hunch, or potential solution is promoted from the intuitive stage to the insight stage for further testing, some form of “alarm” may be set off alerting the problem-solver that a potential solution has been discovered. Thus, in broad strokes, Bowers posited that when a problem-solver's initial conscious attempts fail to deliver a satisfying solution to a problem the task of discovering a potential solution is taken up by unconscious processes in which potential solutions are generated in the intuitive stage and "handed off" to the insight stage to be tested for viability as a solution, prior to appearing as in consciousness an insightful solution.

It should be noted that Bowers' stage model of intuitive problem-solving has parallels in the work of several other theorists. As discussed earlier, Monsay (1997) observed that scientific discovery often follows a course in which a stage of intense conscious effort is followed by a stage of disengagement during which the problem-solver is no longer consciously engaged with the problem, at which time a solution may appear in consciousness as an "aha" experience. It is Monsay's stage of disengagement that Bowers would further subdivide into intuitive and insightful stages. In his discussion of the creative process, Bastick (1982) also described two distinct stages, a non-conscious intuitive stage and a verification stage. Bastick maintained that the intuitive stage is a necessary precursor to all creative insight, from great scientific discoveries to hunches about solutions to everyday problems.

In *The Art of Thought,* Wallas (1926) also described problem-solving as a progression through stages: a preparatory stage in which there is conscious recognition of a problem in need of a solution and some preliminary attempts to find a solution, an incubation stage in which the problem-solver disengages from conscious attempts to solve the problem, an illumination stage in which a solution appears in consciousness, and a verification stage in which the validity of the solution is consciously tested.

Wallas' incubation stage appears analogous to Bowers' intuitive stage, and his illumination stage can be considered equivalent to Bowers' insight stage.

As Dorfman, Shames, and Kihlstrom (1996) note, Wallas' stages of incubation and illumination can be thought of as examples of implicit thought, occurring outside of conscious awareness. Wallas (1926) stated that in the incubation stage "a series of unconscious and involuntary … mental events may take place …. a successful train of association … which has probably been preceded by a series of tentative and unsuccessful trains" (pp. 93-94). With respect to the role of consciousness throughout the incubation and illumination stages, Wallas noted that the problem-solver may experience some vague awareness that a solution is about to enter consciousness only in the illumination stage, very close to the actual arrival of that solution in consciousness.

For the purpose of this dissertation, intuition will be considered to be a phenomenon that: a) is engaged automatically upon the perception of a problem in need of solution, b) occurs outside of consciousness, and c) is responsible for generating and optimizing "hunches," or potential solutions to the perceived problem. Insight, on the other hand, will be considered to be a process through which: a) each hunch generated by intuition is judged as a potential solution to the problem at hand, and b) a hunch recognized as a viable solution is promoted to conscious awareness.

The relationship between intuition and reason

As noted earlier, by definition intuition and reason have a functional similarity, in that both are tools that human beings can use to acquire knowledge and to understand the world around them (OED, 1971). This being said, the experience of using intuition to acquire knowledge is very different than that of using reason. First, acquiring knowledge or understanding through intuition does not involve any conscious mediating process. Reason, on the other hand, must operate through the mediation of conscious and explicit inference, i.e., passing from one explicit statement, or proposition, that is held to be true, to a second explicit statement, whose truth is believed to follow from the first. A second difference lies in the dis-similar experiential qualities of intuition and reason. As noted earlier, knowledge acquired through the use of intuition is experienced by the user as something akin to a sensory perception, i.e., as sudden, complete, and effortless, while knowledge acquired through rational processes is experienced as a sequence of purely conscious, cognitive events, without the "given" quality that is characteristic of perceptions or intuitively derived insights.

Despite these differences, I will argue for a further similarity between intuition and reason in that both may operate in either a "part-to-whole" or "whole-to-part" fashion. It is well established that reason may be used in a "part-to-whole" fashion to induce a higher order concept from specific instances, or in a "whole-to-part" fashion to deduce conclusions about specific instances from a higher-order concept, but to date this sort of bi-directionality has not been suggested as an important characteristic in the operation of intuition. The idea to be developed throughout this thesis is that intuition may also be used in "inductive" (part-to-whole) and "deductive" (whole-to-part) ways. This is speculative with regard to intuition, but evidence pointing toward such a bi-directional mode of operation will be presented and discussed. This sort of bi-directionality may also underlie the operation of visual perception, and may be the norm in human information gathering and processing. In the following section, I will discuss the bi-directional nature of reason, and in subsequent sections I will discuss the ongoing tension between "part-to-whole" and "whole-to-part" theories in the study of visual perception, before addressing the possible relevance of bi-directionality to the phenomenon of intuition.

Forms of reason: Induction *vs*. deduction.

As noted, reason can take one of two general forms: "part-to-whole" induction or "whole-to-part" deduction. Inductive reasoning is a "bottom up" process in which a person repeatedly observes specific instances and then infers a broad generalization, conclusion, or theory that describes a pattern of regularity common to all of the observed instances. For example, when one looks at the question of mortality all individual human beings studied so far have had a limited lifespan. This leads us to infer a general conclusion about human beings, i.e., all humans are mortal. This does not mean that we have data for every single human being who has ever lived, and so the possibility exists that there are some immortals among us who have escaped our notice, but, on the basis of the evidence so far we accept as true that all humans are mortal. In this way, conclusions reached through inductive reasoning may "go beyond the information given" thereby allowing us to make predictions about specific instances that have not actually been studied, and which may not actually exist at this point in time.

A person employing deductive reasoning, on the other hand, starts from a general statement about regularities that exist amongst a specific set of instances and then infers a conclusion about a specific instance, or a subset of instances, from that set. This commonly takes the form of the syllogism, e.g., "all virtues are laudable; patience is a virtue; patience is laudable." Unlike the conclusions reached through inductive reasoning, conclusions reached through deductive reasoning do not go beyond what is contained in the premises. Thus, if the statements that make up the premises correspond with reality, and the conclusion follows logically from these premises, the conclusion must also correspond with reality.

There are two issues of particular relevance to the discussion of intuition that should be noted. First, as discussed above, reason may be used to infer knowledge about general regularities from the observation of specific instances, or to infer knowledge about a specific instance from the abstract, general regularities that apply to the set of instances to which that instance belongs. It may be that intuition is similarly bi-directional, allowing for the generation of knowledge in "part-to-whole" and "whole-to-part" ways, a point which will be developed in a later section.

A second point of relevance illustrates a very important difference between reason and intuition. A rational problem-solver must move from puzzlement to solution through a set of explicit intermediate steps. Should a rational problem-solver arrive at a faulty conclusion the process of reasoning may be traced backward to identify and correct either faulty premises, e.g., "All humans are ducks; Socrates is a human; Socrates is a duck," or faulty steps in logic, e.g., "All collies are dogs; Lassie is a collie; All dogs are Lassie." Thus, a problem-solver using reason will necessarily move through a series of explicit intermediate statements on the way to a solution, and the process and contents will open for inspection and revision at every step.

An intuitive problem-solver, on the other hand, appears to jump directly from puzzlement to solution without apparent intermediate stages. Most experiences that we identify as intuitive involve a subjective sense of immediacy, in which the desired solution appears in consciousness whole and complete, unanticipated and seemingly without effort. Because this sort of experience does not involve any observable intermediate stages, most historical views of intuition have foreclosed on the idea that there is no intuitive process *per se*. The fact that intuition does not involve explicit intermediates does not mean, however, that one can conclusively rule out the possibility that intuition is a process that operates through implicit intermediate stages. As will be discussed throughout this thesis, a demonstration of the presence of implicit intermediate stages in intuitive problem-solving would provide strong support for the idea that intuition operates as an incremental process, one in which implicit, increasingly complete "partial states of knowledge" are generated prior to the entry of a whole and complete solution into consciousness. If it is the case that intuition operates through implicit intermediates, the noted operational difference between intuition and reason would be lessened, lending some support to the notion that intuition, like reason, can operate in a bi-directional manner.

Neisser (1967) described two distinct forms of mental organization, which can be broadly described as either rational or intuitive. A rational procedure would be characterized as deliberate, logical, reality oriented, and processed in a serial manner, while an intuitive procedure would be characterized as automatic, prelogical, autistic, and processed in a parallel manner. In a similar vein, Anderson (1982) and Schneider and Shiffrin (1977) have noted that unlike rational procedures, which are conscious and volitional, some mental procedures are automatically engaged by inputs not represented in the current contents of the person's consciousness, and once engaged, operate independent of awareness or voluntary control.

If intuition does operate through automatic, associative, and parallel procedures, it may be that successive rounds of parallel processing do generate intermediates between puzzlement and solution, but these intermediates would be unlikely to exist in any form that could enter consciousness. As Rumelhart, McClelland *et al* (1986) have noted, the contents of a parallel process are simply too complex to be represented in consciousness. In fact, once the intuitive problem-solving mechanism has been set to work it may be only at a very late stage in the intuitive process, once a potential solution has been generated, that a “representative” of that complex solution may be presented to consciousness. At such a point, the problem-solver may, or may not, experience a sense that a solution is imminent, and the potential solution may then enter consciousness as a flash of insight.

The relationship between intuition and sensory vision

Despite the fact that intuition has been recognized throughout history as a unique and valuable source of knowledge, the lack of any visible mechanism of operation and the unexpectedness and immediacy of its products have hindered attempts at investigation. As a result, the literature addressing the question of how intuition operates is scanty and mostly speculative, and there is little clarity about what mechanism, or mechanisms, might be at work in the achievement of intuitively derived knowledge.

As has been noted, the experience of achieving an insightful solution to a puzzling problem through the use of intuition has frequently been compared to the experience of sensory vision because both share the phenomenological quality of “given-ness.” In the same way that we turn our gaze onto some scene and, without apparent further effort, acquire visual perceptions complete and whole, we also turn our thoughts toward some problem and, albeit after a seemingly fruitless conscious search for a solution, suddenly and effortlessly acquire an insightful solution. In both cases, once set in motion, our experience of "looking" or "intuiting" provides us with the sense of achieving the desired result without doing anything at all, i.e., without effort. Jung (1968) has explicitly referred to intuition as a form of perception operating through the unconscious.

Despite the noted similarities, there are also some very real differences between intuition and visual perception. Most significantly, because no "intuitive organ" or "intuitive nerve," or "intuitive cortex" within the brain has been identified, it is not clear what, if anything, is going on at a physiological level during intuitive problem-solving. The lack of evidence that intuition is systematically related to some localized physiological process has left investigators with few options for direct empirical study of the supposed processes underlying intuition. As a result, theorists have largely foreclosed on the notion that intuition operates through a singular change of state.

In the study of visual perception, on the other hand, information about physiological processes is readily available. Despite this availability, there has been little agreement about the mechanism underlying visual perception, and it may be useful to briefly review attempts to explain how the objects of visual perception appear in consciousness, particularly with respect to the "whole-to-part"/"part-to-whole" bidirectionality discussed in relation to reason.

<u>Theories of visual perception</u>

In very broad terms, theorists in this area tend to be either "whole-to-part" or "part-to-whole" in their orientation. For the purpose of this paper, it is unnecessary to provide a comprehensive account of all theories of visual perception, so I will primarily focus my discussion on the Gestalt approach, as a representative of the "whole-to-part" orientation and the Feature Analysis approach, as a representative of the "part-to-whole" orientation.

The Gestalt approach to visual perception.

One of the most influential "whole-to-part" approaches has been that of the Gestalt theorists of the early 20th century, whose central tenet was that the "whole" of a stimulus is more than a simple summation of its parts and that the whole must necessarily be perceived before perception of its parts. Gestalt theories grew out of dissatisfaction with the Structuralist approach to visual perception of the late 19th and early 20th centuries, as exemplified by the work of Wundt, who held that visual perception provided "products" to consciousness through the construction of visual percepts from common "building blocks," i.e., discrete basal component parts. From this point of view, a visual percept was built up incrementally, and accordingly "more work should be rewarded with more products and greater success" (Smith, Ward, & Finke, 1995).

Gestalt theorists objected from the start to the Structuralist assumption that every perception must be built up from "bits" of sensory data sent from the sensory organs to the brain. Instead, Gestalt theorists began from the *naïve* assumption that visual perception must first of all be the perception of something meaningful, i.e., perception of a whole, arguing that perception of a meaningful whole could never occur on the basis of a simple accretion of meaningless sensory "bits."

Gestalt theorists maintained that visual perception could not be an "arbitrary piecemeal … summation of events, but is a process in which characteristics of the whole play a major determining role" (Wertheimer, 1958). According to Eysenck & Keane

(1990), theorists such as Kohler, Koffka, and Wertheimer were adamant that recognition of meaningful patterns could not be achieved by sequentially focusing attention on the individual "features" of a stimulus item. From this perspective, the individual features that can be discerned within a larger pattern do not operate independently of that pattern as a whole (Wertheimer, 1923). Gestalt theorists maintained that analysis must begin with an understanding of the overall configuration, or *gestalt* of the stimulus item and from this understanding subsequent recognition of individual features or components could be achieved. Thus, from the Gestalt perspective, whether or not recognition of the whole actually reaches consciousness, at some level the whole must necessarily be perceived before any of the features and the inter-relationships amongst features, all of which draw their meaning from the whole, can be perceived.

Gestalt theorists proposed that in order to rapidly organize and make the best use of the potentially overwhelming flood of information available from a visual stimulus, the perceptual system has evolved to rapidly and automatically extract meaningful wholes and promote these to conscious awareness. Gestalt theorists maintained that this automatic extraction procedure ensured that the perceiver is provided with useful information in the most stable, consistent, and simple form possible, i.e., as a meaningful object (Coren, Ward, & Enns, 1994). According to the Gestalt law of *pragnanz*, the visual perceptual system is designed precisely to extract the wholeness, or "essence" of objects in the real world for the perceiver.

There has been support for the Gestalt approach. Using figures in which large outlines in the shapes of letters were constructed using smaller component letters, Navon (1977) demonstrated that when the same letter was represented in the large outline and the smaller component, as in Figure 1, performance was facilitated for that letter on a subsequent auditory discrimination task.

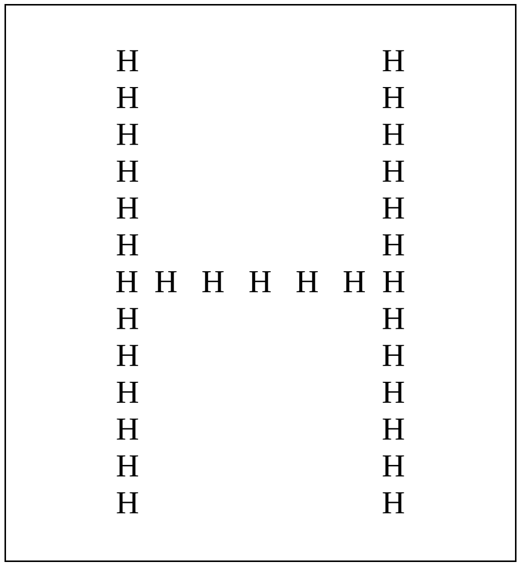

Figure 1. Gestalt whole and component parts represent the same letter

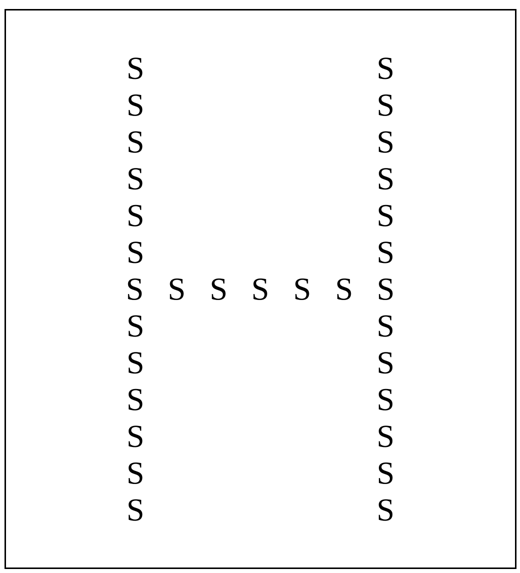

Figure 2. Gestalt whole and component parts represent different letters

On the other hand, when the outline and the component represented different letters, as in Figure 2, participants’ performance on the subsequent auditory discrimination task was worse for trials in which the letter corresponded to the component, e.g., “S,” indicating interference. No such interference occurred on the auditory discrimination task when participants responded to the letter corresponding to the larger outline, e.g., "H." As would be predicted by the Gestalt approach, Navon's participants were responding preferentially to wholes, i.e., the larger letter-shape outlines, over features of the wholes, i.e., the smaller component letters.

In a second study using the same stimulus materials, Navon (1977) asked participants to simply identify the letter corresponding to either the outline or the component as rapidly as possible. Results showed that decision speed in identifying letters corresponding to outlines was unaffected by the status of the component letter. It made no difference whether the component letter was the same or different than the one represented by the outline. In stark contrast, decision speed in identifying component letters was strongly affected by the status of the letter represented by the outline. Participants took significantly longer to identify component letters when they differed from the ones represented by outlines than when they were the same. Once again, participants appeared to be responding preferentially to the overall shape of the visual stimulus over features of that stimulus, a result that would be predicted by Gestalt theorists.

The Feature Analysis approach to visual perception.

Feature Analysis has its philosophical roots in Structuralism, and retains the Structuralist assumption that perceptions are constructions, built up from the raw data sent from sensory organs to the brain. In contrast to the "whole-to-part" Gestalt approach proponents of Feature Analysis maintain that movement must be in the direction of part-to-whole, and that perception of the whole can take place only after completion of a process of identification and summation of simple stimulus features.

Template and Prototype theories of visual perception, which preceded Feature Analysis, both presumed that the unit of analysis must be a representation, and that what was sent from the retina to the brain was a largely unprocessed copy of the retinal image. Upon arrival at some “comparison station” of the brain this copy of the current retinal image would be directly compared to copies of other images stored in memory. According to the Template approach, visual perception resulted when the copy of the current retinal image exactly matched a stored copy of a previous retinal image, or template. The first problem with such an approach is that an infinite number of stored retinal patterns would be required to account for all possible variations in orientation, size, interposition, etc., of any particular object to be perceived. Second, even if one could accumulate and store such an exhaustive library of templates in memory the search for an exact match would be prohibitively slow. These difficulties led to the development of the Prototype approach, in which it was proposed that visual perception occurred as a result of a match between features of the visual stimulus and the key features of some stored prototypic form. According to Moates and Schumacher (1980), what is held in memory for any specific object is the prototype for its general category, i.e., a form representing the key features of that category, plus a list of acceptable variations specific to that object. When an object enters the visual field whose features match the key features of a prototype, it is recognized as another instance of that category.

Thus, while both Template and Prototype approaches rely on representational forms in the comparison process, in the Prototype approach features of the retinal image must match key elements of simplified general categorical forms, rather than exactly match a copy of some stored retinal image. With the adoption of a generalized representation as the unit of analysis, demands on memory and search processes are reduced, and as Moates and Schumacher (1980) note, there has been some support for this approach (Posner & Keele, 1968; Reed, 1972; Lindsay and Norman, 1977). Where Prototype theories run into difficulty, however, is in specifying how particular features become key to a prototype, how many key features are required for recognition, and what role, if any, the arrangement and organization of those key features play in recognition.

Feature Analysis goes a step further in simplifying the unit of analysis by discarding the notion of imagistic representation altogether. Feature Analysis theorists proposed that visual perception takes place through extraction of meaning-free perceptual characteristics, or features from the stimulus, and assembly of these extracted features into a set of criteria. The sorts of features extracted would be those things that are detected by specific cells in the nervous system, e.g., lines, slits, edges, length, movement, and changes in speed of movement. According to Selfridge (1959), recognition of a visual stimulus occurs when the set of features extracted from the stimulus matches a set of features associated with a particular concept stored in memory. As noted by Leahey & Harris (1993), this approach is not affected by the organization or orientation of features, and it allows for an almost unlimited number of feature combinations.

There has been support for the Feature Analysis approach. Neisser (1964) demonstrated that participants could detect target letters amongst lists of six-letter strings more quickly when distractor letters shared fewer features with the target letter, an indication that participants were paying attention to and processing the features of letters. As well, Gibson, Shapiro, and Yonas (1968) demonstrated that as letter pairs shared more features participants took longer to decide whether the letters in each pair were different, suggesting that participants were paying close attention to the individual features of the letters.

According to Eysenck & Keane (1990), despite research evidence in support of the Feature Analysis approach there are several persistent problems with this model. They note that Feature Analysis theorists tend to downplay the importance of context and interrelationships amongst features in pattern recognition, and thus may seriously underestimate the difficulty of using a Feature Analysis approach with highly complex real world stimuli. As an example of the impact of context, Weisstein & Harris (1974) demonstrated that participants were able to detect a target line more frequently when it was embedded in a coherent three-dimensional form than when it was embedded in a less coherent form, which would not be the case if participants were simply scanning for the presence of line features. Eysenck and Keane (1990) also point out that the Feature Analysis approach cannot account for evidence that overall shape often appears more important to pattern recognition than the presence or absence of any individual features.

To quickly recap, for Gestalt theorists visual perception begins with a singular, immediate recognition of a meaningful "whole." This recognition may be implicit, but it must occur prior to achieving awareness of any part of the whole. For Gestalt theorists explicit recognition of a part can only occur as a result of the meaning bestowed on that part by the whole. In contrast, Feature Analysis theorists contend that visual perception must begin with the extraction of meaningless component features from the visual array, followed by summation of those component features into a feature set and subsequent comparison of the summed feature set with feature sets of meaningful objects stored in memory.

This brief section was not intended as a full discussion of the area of visual perception, but rather as an illustration of a particular tension, i.e., “whole-to-part” vs. “part-to-whole,” that has persisted in the attempt to explain how visual perception works, and which may be useful in the following discussion of possible mechanisms of intuition. I have neglected other important approaches, such as Marr’s computational approach and Gibson’s ecological approach; however a lengthier discussion of these would not add appreciably to the exploration of intuitive operating mechanisms.

<u>The psychological investigation of intuition</u>

Turning once again to the examination of intuition, like visual perceptions of the external world the flashes of insight we attribute to intuition appear in consciousness “whole,” seemingly without effort and without discernable intermediate states. Conceptually, the traditional understanding of intuition as a singular mental act of knowing is closer in spirit to the Gestalt description of visual perception as an immediate apprehension of “wholes” than it is to the incremental, “part-to-whole” Feature Analysis description. In fact, there does not appear to be a “part-to-whole” conception of intuition analogous to the Feature Analysis approach to visual perception.

As has been noted, it has been possible to identify and directly investigate the physiological processes underlying visual perception, which has led many investigators of visual perception to adopt a "part-to-whole" approach, taking as their object of study the processing of "bits" of information provided to the nervous system by sensory organs. This tendency has been particularly attractive since the advent of digital technology. The temptation to model visual perception by analogy to the operation of a computer constructing larger, meaningful patterns from "bits" of input data has led to the development of many "data-driven" approaches. In the investigation of intuition, however, there is no similar option. There are no intuitive "organs," and it is not possible to investigate the passage of input data through the nervous system to the brain. Thus, with neither physiological pathways nor explicit intermediates to examine, most theorists have foreclosed on the "all-or-nothing" singular act as the operating mechanism underlying intuition.

As Bowers (1995) has pointed out, despite the lack of an observable physiological process or of observable intermediate stages between the onset of problem-solving and the achievement of an intuitively derived solution, the psychological perspective on intuition has diverged from the philosophically based view of intuition as a singular act. Bowers notes that the psychological view of intuition has largely concerned itself with the study of "cognitive processes that antedate and generate insight," and that this investigation has largely taken place in the arenas of judgment/decision-making under conditions of uncertainty and of insight in problem solving. For the most part, however, the literature in this area has had little favourable to say about intuition. In particular, studies of decision-making (Tversky & Kahneman, 1974; Kahneman, Slovic, & Tversky,

1982) have repeatedly demonstrated that participants preferentially rely on error-inducing implicit cognitive "shortcuts" in making judgments about probability, even when more useful predictive information, such as a base rate, is readily available. As Bowers (1995) points out, as a result of the findings of authors such as Kahneman *et al* (1973, 1982), Ross (1977), and Nisbett & Ross (1980), intuition has come to be seen as a systematic and persistent source of error in human judgment.

Goldstein and Gigerenzer have noted that over the past 30 years it has become apparent that human problem-solving procedures do not follow accepted rules of reasoning, which has led many investigators to conclude that human reasoning operates as a weak approximation of an idealized statistical tool. With this conclusion, the term heuristic, which had previously understood to mean "useful and indispensable cognitive processes for solving problems that cannot be handled by logic and probability theory" (Goldstein & Gigerenzer, 2002, p. 75), instead became a pejorative term indicating a defective mental process generating outcomes that differ from those of an optimal rational strategy.

Goldstein and Gigerenzer argue that the heuristics that humans use to solve problems are not simply lesser versions of an optimized, all-purpose statistical reasoning tool, but instead are designed to respond to and exploit information as it exists in the environment, i.e., they are "ecologically rational" (Goldstein & Gigerenzer, 2002, p. 75). Goldstein and Gigerenzer note Simon's observation that models of human information processing must take into account that the mind has evolved in particular environments, and that human information processing should be understood as models of bounded, rather than classical rationality. From this perspective, human information processing is a satisficing, rather than an optimizing procedure (Simon, 1956, 1982), in which the first object discovered that satisfies the current requirements will be chosen, without the need for processing all possible options and "estimating probabilities and utilities for the possible outcomes associated with each alternative, calculating expected utilities, and choosing the alternative that scores highest" (Gigerenzer & Goldstein, 1996, p. 651). Goldstein and Gigerenzer make the case for "fast and frugal" heuristics that are highly effective in problem-solving when time, knowledge, and "computational might" (Goldstein & Gigerenzer, 2002, p.75) are limited, reporting empirical support for the validity of these "fast and frugal" heuristics as effective problem-solving strategies (Gigerenzer & Goldstein, 1996).

Bowers (1990) has also argued that the general pessimism about the use value of intuition is unwarranted and has come about largely because the type of task employed in studies by Kahneman and others predisposes participants to make errors from the outset. As noted by Mayer (1991), in an example of the sort of problem typically used in this area of research, Tversky and Kahneman (1974, p. 1124-1125) asked participants to estimate the probability that an individual, chosen randomly from a group, would be an engineer. In the first part of the experiment, participants were given no information about the individual. Half of the participants were told that the group consisted of 100 individuals, of whom 70 were engineers and 30 were lawyers, while the other half of the participants were told that the group consisted of 100 individuals, of whom 30 were engineers and 70 were lawyers. Participants who had been told that 70 of the 100 individuals were engineers correctly estimated a .70 probability that a randomly chosen individual would be an engineer, while participants told that 30 of the 100 individuals were engineers correctly estimated a .30 probability that a randomly chosen individual would be an engineer, demonstrating that participants were able to make use of base rates in judging probability.

In the second part of the experiment the same participants were asked to estimate the probability that another individual, also chosen at random from the same group, would be an engineer. For this individual, participants were give personal information about the chosen individual. Participants were told that his name is Jack; he is 45-years of age and married with four children; he is generally conservative, careful, and ambitious; he shows no interest in political and social issues; he spends most of his free time on his many hobbies, which include home carpentry, sailing, and mathematical puzzles. In this case the personal information was chosen to be biased with respect to profession, engaging the stereotype of engineers, but not of lawyers. Unlike participants in the first part of the experiment who had used base rate information to judge the probability that the chosen individual would be an engineer, participants in the second part of the experiment ignored the available base rate information altogether. In the second part of the experiment, both groups incorrectly estimated the probability of the second individual being an engineer to be .90.

In the third part of the experiment the same participants were asked to estimate the probability that a third individual, also chosen at random from the same group, would be an engineer. For this individual, participants were told his name is Dick; he is 30-years of age; he is married with no children; he has high ability, is highly motivated, and promises to be quite successful in his field; he is well-liked by colleagues. In this case the personal information was chosen to be generic and neutral with respect to profession, engaging stereotypes of neither engineers nor lawyers. Participants again ignored the available base rate information, and both groups incorrectly estimated the probability of the third individual being an engineer to be .50. From the results of these and other similar studies, the use of intuition in problem-solving has, for the most part, come into general disrepute as a kind of "mental laziness" or willful disregard of truly predictive variables, i.e., a strategy that leads to error more often than not.

It should be pointed out that successful solution of the type of problem employed by Tversky & Kahneman and others typically demands that participants employ a particular problem-solving strategy, and focus on particular types of predictor variables within the problem-situation. As Mayer (1991) notes, participants in the 1974 Tversky & Kahneman study were obviously familiar with the use of statistical inference in decision-making and they were able to make good use of base rate information when no personal information about the chosen individual was available. On the other hand, when given information that appeared to match preconceptions about the personal characteristics an engineer should possess and a lawyer should not possess, or even when given neutral information that did not match preconceptions about the personal characteristics of either engineers or lawyers, participants chose to base their predictions on information about personal characteristics while ignoring base rate information altogether. Thus, participants did not appear able to judge the relative importance of the predictive information available to them within the problem situation, which led them to preferentially choose less predictive, but more familiar and subjectively more salient personal characteristics over base rate information as the basis for their predictions.

On the other hand, as Mayer (1991) notes, when probability problems are restated in terms of frequency of occurrence the biasing of predictions observed in the above studies does not occur. For example, Kahneman, Slovic, & Tversky (1982, p. 496) posed the following problem to participants:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with the issues of discrimination and social justice and also participated in anti-nuclear demonstrations.
>
> Based on this information, which of the following two alternatives is more probable: a) Linda is a bank teller, or b) Linda is a bank teller and is active in the feminist movement?

Kahneman *et al* found that most participants (77%) chose the second alternative, despite the fact that the probability of a single fact being true is greater than the probability of that fact plus another fact both being true. Participants again chose to base their prediction on information about personal characteristics and ignored base rate information. This tendency disappeared, however, when Fiedler (1988, p. 345) restated the question in the following way:

> There are 100 persons who fit the description above. How many of them are:
>
> a) Bank tellers
> b) Bank tellers and active in the feminist movement

With the question rephrased in this way the majority of participants (73%) were able to correctly state that of 100 persons fewer would be both bank tellers and active in the feminist movement.

In another example, Kahneman, Slovic, & Tversky (1982) report that Casscells, Schoenberger, and Grayboys (1978, p. 999) asked faculty and students at Harvard Medical School the following question:

> If a test to detect a disease whose prevalence is 1/1000 has a false positive rate of 5%, what is the chance that a person found to have a positive result actually has the disease, assuming you know nothing about the person's symptoms or signs?

In actuality, 1000 tests would yield one true positive and 50 false positives; thus any individual positive test should have a likelihood of being a true positive of 1 out of 51, or just under 2%. Only 18% of respondents were able to state the correct 2% likelihood that the person had the disease, while 45% stated a 95% likelihood, ignoring base rate information and focusing exclusively on the reported false positive rate. Mayer (1991) notes that Cosmides and Tooby rephrased the problem statement in the following way: How many people who test positive for the disease will actually have the disease? ____ out of ____. With the question rephrased in this way the majority (76%) of participants were able to generate the correct answer (Cosmides & Tooby, 1996, p. 62). It may be that people are simply more comfortable and familiar with a problem that is stated "how often does event X happen?" than with one stated "how probable is event X?" In any case when restated in terms of frequency participants did not ignore base rate information.

From the discussion above, when participants are asked to solve problems whose solution requires them to use strategies that are well-known, frequently used, and perhaps over-learned, conclusions about the viability and usefulness of intuitively derived solutions may be very different than those that have arisen from the findings of Kahneman *et al* and others. When one thinks about situations in which successful solutions have been achieved through the use of intuition, generally the intuitive problem-solver is very familiar with the elements of the problem situation. As Monsay (1997) notes, the correctness of an intuitively derived solution is highly dependent on the background knowledge of the intuitive problem-solver. Kekulé, for example, had expert knowledge of known chemical structures and chemical reactions prior to his intuitive discovery of the novel structure of benzene. Thus, the use of intuitive methods is more likely to generate successful solutions when tasks are posed in areas in which the problem-solver has much prior experience and has expert knowledge of the variables within the problem situation.

With this in mind, Bowers proposed that a fitting task for the examination of intuition would be one within what Reichenbach (1938, p. 6-7) referred to as the "context of discovery," rather than one within the "context of justification." The sort of task envisioned by Bowers would allow examination of the process through which hunches are generated that implicitly point the problem-solver toward a viable solution. From this perspective, Bowers described intuition as a heightened sensitivity to the presence of some underlying "coherence," or tacit pattern of regularity within the problem space. This is not a dissimilar position from that of Einstein (1932, p. 10), who described his search for elemental laws governing the universe as necessarily relying on "intuition… helped by a feeling for the order lying behind the appearance." While not represented in consciousness, this sensitivity to underlying coherence can guide the problem-solver toward a "hunch or hypothesis about the nature of the coherence in question" (Bowers, 1990). Thus, for Bowers intuition was, simply put, a very sensitive attunement to patterns of regularity that human beings use to navigate, investigate, and generate knowledge about their environment.

Other theorists have expressed similar notions about the intuitive process operating through an implicit processing of problem elements with the goal of discovering tacit patterns of regularity that may be passed along to consciousness. Goldberg (1989) has proposed that the mind is automatically and simultaneously set in operation on many levels at the onset of problem-solving. Only one of these levels may be attended to in conscious awareness at any given time. Outside of consciousness, however, there may be many different levels simultaneously engaged in generating solutions. Goldberg referred to this process of unconscious generation of solutions as incubation, but he did not comment directly on how such a process of incubation might operate.

Bastick (1982) proposed that intuition is an emotionally directed process in which implicit progress toward a viable solution results in a lessening of the anxiety, or cognitive dissonance aroused by the encounter with a puzzling problem. Through intuition, primary process associative thinking is directed outward from the initial problem state. The outward spread of associative thinking is guided toward a solution by decreases in anxiety that occur when the problem-solver implicitly follows a line of thought that leads toward a solution, with a final, relatively large decrease in anxiety accompanying the entry of a solution into consciousness. Unfortunately, while such a theory might explain a subjective feeling of having a hunch, or of being on the right track, or of having the answer "on the tip of the tongue" that sometimes accompanies the intuitive process, it really does not help us to understand how particular directions in thought become associated with the lessening of anxiety. Logically, one would have to have some sense of where the solution resides in the first place in order to judge whether a particular direction in thought is bringing you closer to that target solution.

Agor (1989) and Rowan (1989) have presented the idea that intuitive problem-solving relies on retrieval of "chunks," i.e., perceptions, experiences, and relationships stored as meaningful patterns, from long-term memory. Upon retrieval, these patterns may then be used to guide our thoughts toward a desired outcome without triggering conscious awareness of the process of retrieval and guidance. While there is some appeal to this idea, how one goes about meaningfully chunking material for storage or how one retrieves the appropriate chunks is left unanswered.

As noted earlier, there has been little empirical research in the area of possible processes underlying intuition, but there have been investigations of processes operating outside of conscious awareness in the area of implicit memory (Dorfman *et al*, 1996; Shimamura, 1994; Graf, Squire, & Mandler, 1984; Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982). One line of research in this area that is particularly relevant for the discussion of intuition is the investigation of semantic priming effects. Tulving *et al* (1982) defined priming as the facilitative effect of an encounter with a stimulus on subsequent processing of either the same stimulus (direct priming) or a related stimulus (indirect priming). As noted by Burton (2004), studies of semantic priming typically expose participants to prime stimuli and then ask for simple judgments about subsequent target stimuli, e.g., a word/non-word lexical decision task. Semantic priming is judged to have occurred when target judgments are facilitated.

As an example of priming using semantic stimuli, Marcel (1983) presented participants with stimulus words, or primes, followed by a pattern mask so that participants reported seeing the primes on less than 60% of trials. Following each prime presentation, participants were given a lexical decision task in which they were presented with a string of letters and asked to decide whether the string of letters was an actual word or not. Marcel found that participants' decision speed for actual target words was faster when the prime was a word associated with the target word than when the prime was not associated with the target.

Cheeseman & Merikle (1984, 1985) have pointed out that participants in this type of study are able to perform at above-chance levels in guessing the identity of the prime, despite claiming no conscious awareness of the prime. This has led to an explicit distinction between an objective threshold, at and below which participants would guess the identity of primes at chance levels, and a subjective threshold, at which participants would guess the identity of primes at above-chance levels while still claiming no conscious awareness of the primes. As Eysenck and Keane (1990) have noted, it is possible for participants to report no conscious awareness of prime stimuli and to nonetheless guess the identity of primes at above chance levels and show facilitation on subsequent, related criterion tasks. Both of these phenomena may be explained by reference to patterns of residual energy generated by spreading activation, which will be discussed in more detail in the following section.

Compared to intuition, which is the use of implicit procedures to generate a novel solution to a problem, priming appears to be similar but a less complex phenomenon in that it involves the use of a familiar prime stimulus, whether consciously recognized or not, to speed a known and likely response. Both, however, involve a pattern of engagement with problem stimuli followed by facilitated performance on a related criterion task. Because priming and intuition do appear to follow a similar pattern, for the purpose of investigating the process of intuition, it may be illustrative to examine the most common explanation of the mechanism of priming, i.e., spreading activation.

<u>Priming and spreading activation.</u>

Priming effects have most often been explained through reference to the spreading activation model (e.g., Collins & Loftus, 1975; Anderson, 1983, 1993). In very simple terms, according to the spreading activation model information is stored in memory in clusters of associatively interconnected nodes or terminals. Each of these nodes would stand for some facet of understanding, a concept, a verbal label, an image, a feeling, a sensation, etc. When a concept, verbal label, etc. becomes associated with another concept, verbal label, etc., an associative link is formed between their respective nodes. As the degree of association increases, the number of linkages back-and-forth between nodes for the associated concepts also increases. This degree of association, and the corresponding number of linkages, may change over time as the person has additional experiences involving associated concepts.

For example, the concept "horse" would be highly associated with the word "horse," and there will be many links between their nodes. The concept "horse" will also be associated with images of horses, and perhaps with emotions such as pleasure or fear. As well, the concept "horse" will be associated with other concepts, such as "mammal," "buggy," or "saddle." The number of associations between these and the concept "horse" will differ from person to person, depending on their experience and expertise with horses. With only simple exposure to Western movies and television programs, it is likely that for most people in North America the concept "horse" will be associated with concepts such as "cowboy," "ranch," or "stagecoach," and will be associated through these concepts with their respective verbal labels, images, sensory experiences, and emotional tones. With more extensive experience with horses, concepts such as "sorrel," "Arabian," and "tack" may become highly associated with the concept "horse."

As an example of how experience can alter the strength of associations, a person wishing to overcome a fear of horses might decide to spend a summer learning to take care of horses. The person may experience enjoyment in a number of activities related to caring for horses, so that many horse-related nodes become linked, and perhaps multiply linked, with pleasure nodes. The net effect of these positive experiences with horses is that the person comes to more strongly associate horses and activities involving horses with enjoyment than with fear. In addition to changing the strength of existing associations, new experiences may also lead to the creation of new nodes and new associative linkages in the associative network. For the person trying to overcome a fear of horses, reading about horses may result in the creation of many new horse-related nodes and linkages. The person might discover that there are many words used to describe differences in the coat and color of horses, e.g., a sorrel is solid red, yellowish-red, or reddish-brown, without black on the mane, tail, or lower legs, while a bay is reddish-brown, with black on the mane, tail, and lower legs (Casa de Whatever, 2004). In learning that some horses are called sorrels, the person has altered his/her associative network by creating/assigning a new "sorrel" concept node and a new "sorrel" verbal label node, each linked to the other and to nodes for the concept "horse," the verbal label "horse," the concepts "red," "yellowish-red," and "reddish-brown," the verbal labels for these colors, images of sorrel horses, etc..

When a person wants to bring a particular concept to consciousness, s/he must focus attention on the relevant concept and in so doing provides activation energy to the node for that concept, raising the level of residual energy at the target node from the resting state to the threshold level at which the concept enters consciousness. As activation energy is provided to the target node, some portion will drain off even as it is being added, spreading outward along associative links between the target node and other nodes whose concepts are closely associated with the target concept. From these close associate nodes energy will spread to other nodes that are associatively linked with them. As the spread of activation energy proceeds "outward" from node to node, some of the activation energy will be retained at each node in the form of residual energy, and some will be passed along links to nodes for associated concepts. Despite this ongoing "leakage," if the person persists in attempting to bring a particular concept into consciousness, barring a failure of memory, the level of residual energy at the target node will continue to increase until it exceeds the level required for the desired concept to enter consciousness.

Nodes for closely associated concepts, which will be multiply interlinked with the target node and with each other, will have received energy directly from the target node and also from other close-associate nodes in the spread of energy from the target node. Nodes for things that are associatively closest to the target concept will accumulate relatively high, but still sub-threshold levels of residual energy. Examples might be nodes for specific images, semantic labels, and affective valences associated with the target concept. At nodes for things less closely associated with the target concept the accumulation of residual energy will be less, while at nodes for things not associated with the target concept there will be no accumulation of residual energy. See Figure 3. Thus, as the person brings a concept to consciousness, a pattern of residual energy is created within the person's associative network in which the level of residual energy held at nodes will vary from the resting state to just below the threshold.

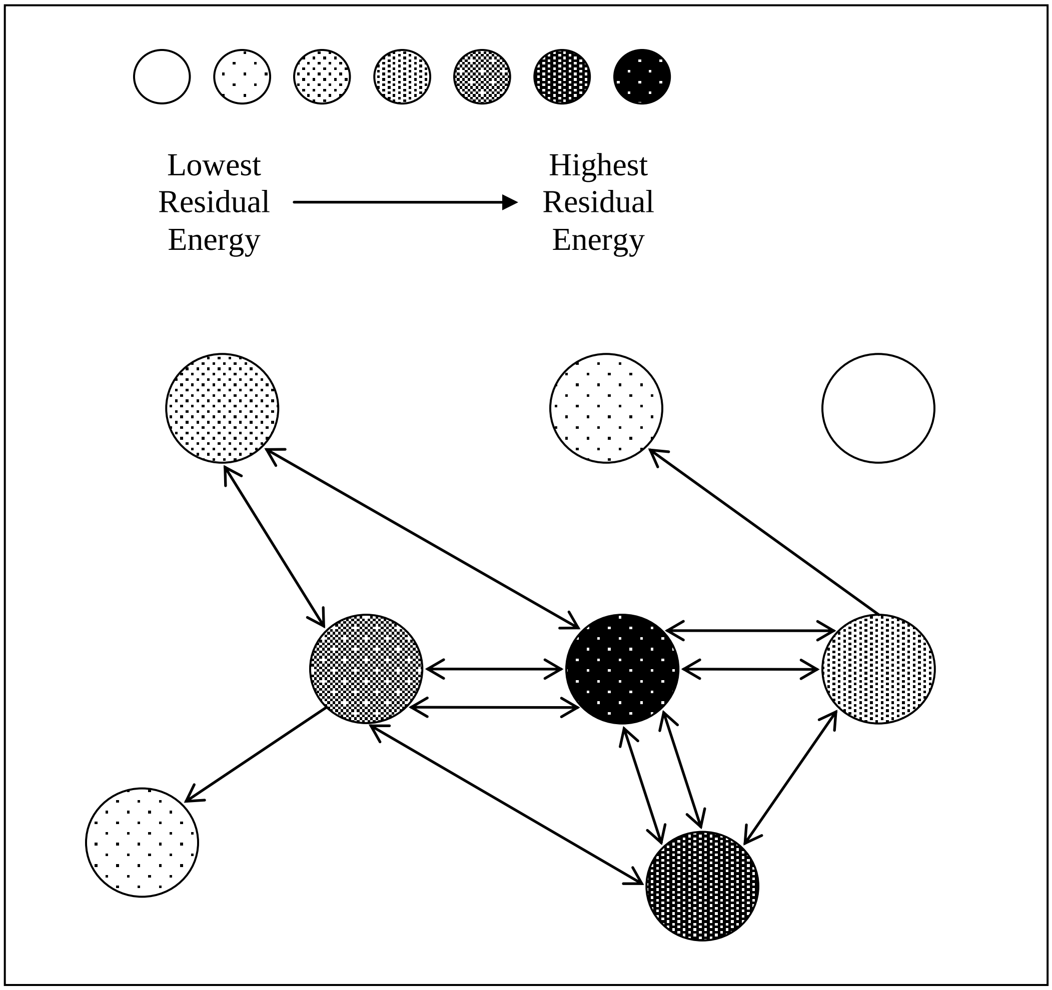

Figure 3. Residual energy at nodes within the associative network following activation of a concept to consciousness

For as long as the target concept is held in consciousness, energy will continue to flow through the associative network, maintaining the established pattern of residual energy. Nodes for close associates of the target concept will maintain a level of residual energy very close to the threshold, allowing the concept, word, image, affective tone, etc.

corresponding to any one of these close associate nodes to be brought to consciousness quickly with the addition of very little activation energy. In terms of an evolutionary advantage, this arrangement makes sense because it would be advantageous in many, if not most situations to be able to rapidly bring to consciousness concepts, names, images, etc., that are closely associated with the concept currently in consciousness, e.g., bear $\rightarrow$ danger, bear $\rightarrow$ escape, bear $\rightarrow$ climb tree, bear $\rightarrow$ get weapon, bear $\rightarrow$ make noise, etc.

Nodes for concepts that are only distant associates of the target concept, on the other hand, will have accumulated a very low level of residual energy, and each of these will require the addition of a great deal of activation energy for its concept, word, image, etc to enter consciousness. This also makes sense from an evolutionary perspective, because being able to rapidly bring such a concept to consciousness would be unlikely to provide any advantage, e.g., bear $\rightarrow$ belly-dancing, food $\rightarrow$ escape.

It should be noted that spreading activation is a parallel process, and in the spread of activation from a target node, more than one node will receive activation energy simultaneously. Consciousness, on the other hand, operates as a serial process in which one conscious thought gives way to the next. Because a parallel process involves the simultaneous processing of multiple pieces of information, a parallel search for relevant information can be much more rapid and will employ far fewer mental resources than a serial search process, which, by definition, must move sequentially from one piece of information to the next.

In the case of a semantic priming task, a person attempting to memorize a word will focus attention on that word and rehearse it in consciousness, thereby raising the level of activation at the node for that word and, through the outward spread of activation, at nodes for closely associated words/concepts. Due to the limited and serial nature of consciousness, however, only the target node will accumulate enough residual energy to breach the threshold. In the priming task, as the person transfers his/her attention from the first word to the next on the list to be memorized, the level of residual energy at the node for the first word will drop below the threshold as the residual energy at the node for the next word rises above the threshold. The decrease in the level of residual energy at the first word node occurs because no further activation energy is being provided to the node, but energy continues to spread outward from the node to its associates. Through rehearsal techniques a person may continue to provide enough activation energy to keep the residual energy level very close to the threshold at several nodes, but this will quickly reach a limit for most people.

Disregarding rehearsal effects, as the first word is replaced in consciousness the residual energy at its node will drop below the threshold level, but further decreases are likely to be gradual because most non-trivial problems require that a problem-solver shift attention back and forth quickly between different aspects of the problem to reach a solution that can incorporate all of the elements of that problem. This being the case, it would be advantageous for the level of residual energy at a node whose concept is being replaced in consciousness to decay slowly so that a rapid return to consciousness could be achieved with the addition of only a small amount of energy. The notion of shifting attention back-and-forth amongst different elements of the problem will be discussed further in a later section as “alternating activation.”

If, on the other hand, following the exit of the first word from consciousness the level of residual energy at its node was allowed to drop to the resting state, a large input of activation energy would be required to reach the threshold again, meaning that a return of the first word to consciousness would take more effort and would take longer. If one thinks of this process as a play and each of the concepts as actors, having each of the actors remain onstage and "primed" to deliver their lines would result in a performance that would be much more coherent and intelligible to the audience than one in which each actor, upon receiving a cue, had to start from home, travel to the theater, deliver a line, and then go home to await the call to deliver his/her next line. It is likely that the audience would not find the latter performance engaging and they would rapidly tire of trying to make sense of such a disjointed and incoherent play.

In a similar way, when a person engaged in a priming task focuses on a memorizing a new word, the residual energy at the node of the previously memorized word will decrease, but will remain at a level somewhere between the resting state and the threshold. When the person is later tested for recall of the memorized words, only those whose nodes retain a level of residual energy very close to threshold should be recalled. Words whose nodes retain lower levels of residual energy will not be accessible to recall, but the residual energy held at these nodes may still have an impact on participants' behaviour on implicit learning tasks, such as word-nonword recognition, which are more sensitive to low levels of residual energy than direct recall tasks. With a word-nonword recognition task it can be shown that despite the fact that some of the previously memorized words are inaccessible to recall, they are recognized as real words more quickly than words that were not previously memorized because the level of residual energy at the nodes for these words, although too low to promote direct recall, will be higher than the level of residual energy at the node for a new word. The previously memorized word will be recognized as a word more quickly because less activation energy will need to be provided at its node to reach the threshold of consciousness than at the node for the new word. This can be likened to a race between two equally fast runners, but one runner, the new word, must start at the starting line while the other runner, the previously memorized word, gets to start at a point midway to the finish line. Clearly the previously memorized word will arrive at the finish line more quickly and with less effort.

In a 1987 study of verbal priming, Yaniv and Meyer demonstrated that participants' unsuccessful attempts to produce words corresponding to provided definitions could have the effect of speeding the recognition of those words on a subsequent lexical decision task and also the correct recognition of those words as "old" on a subsequent old-new judgment task, despite the fact that the latter judgment took place 30 minutes after the initial definition task. Yaniv and Meyer gave participants definitions of rare words and following each definition asked participants to produce the word corresponding to that definition. The rare words were organized two per item, so that for each item half the participants received the definition for word A and half received the definition for word B. If a participant received the A-version of an item as the target word, the B-version served as the control word, and *vice-versa*. When participants could not produce a response to a definition, they were asked if they felt the target word was "on the tip of their tongue" and to rate their "feeling of knowing" the word they were searching for. After each block of four items, participants performed a lexical discrimination task in which they were asked to indicate as quickly as possible whether a stimulus was a word or a non-word. For each item participants responded to six stimulus items: the target word, the control word, 1, 2, or 3 other words, and 1, 2, or 3 non-words. After completing 13 blocks participants were asked to make old-new judgments about the target and control words used in the study and an equal number of new words that participants had not encountered in the study.

Yaniv and Meyer found that for trials in which participants successfully produced the target word in response to definitions lexical decisions were more rapid for target words than for control words. For trials in which participants produced an incorrect word in response to the definition, lexical decision speed was essentially the same for target and control words. Of particular interest, for trials in which participants were unable to produce a response to the definition target, lexical decisions were more rapid as ratings of accessibility increased. For control words, however, there was no change in lexical decision speed as accessibility ratings increased.

In the old-new judgment task a similar pattern emerged. For trials in which participants were able to successfully produce the correct word in response to the definition, correct "old" judgments were more rapid for target words than for control words. On the other hand, for trials in which participants produced an incorrect word in response to the definition, correct "old" judgments were actually less rapid for target words than for control words, indicating an interference effect. For trials in which participants were unable to produce a response to the definition, correct "old" judgments were again more rapid for target words as ratings of accessibility increased. For control words there was no change in correct "old" judgment speed as accessibility ratings increased.

In their explanation of these results, Yaniv and Meyer note that several theorists (Collins & Loftus, 1975; McClelland and Rumelhart, 1981; Meyer & Schvaneveldt, 1971, 1976; Morton, 1969) have proposed that facilitation of lexical decisions in priming studies reflects changes to levels of residual energy held at nodes within the semantic network as a result of the operation of spreading activation in long-term memory. Yaniv and Meyer proposed that unsuccessful attempts to recall target words leads to a "memory-sensitization" effect, in which memory traces critical to the problem's solution are activated to sub-threshold levels. While these traces did not accumulate sufficient residual energy to allow the target word to reach consciousness in the recall task, their relatively high levels of residual energy facilitated recognition of the target word in a subsequent encounter in the environment. As Yaniv and Meyer note, when the semantic network is activated by a failure to reach solution, assimilation of new related stimuli will occur more efficiently and with a higher probability.

With respect to encounters between a sensitized problem-solver and solution-relevant environmental stimuli, Posner (1973) noted that a break introduced between the initial period of conscious engagement with a difficult problem and a subsequent period of conscious engagement often increases the likelihood that the problem will be successfully solved, a phenomenon he referred to as the incubation effect. Yaniv and Meyer (1987) noted that as the length of the break, or incubation period increases so too do opportunities for encounters with relevant stimuli, leading to an increased probability of achieving a solution; however, this depends on participants' ability to maintain residual activation at solution-critical traces for periods long enough to allow for such encounters. As noted above, Yaniv and Meyer have reported that participants have demonstrated word-nonword facilitation for as long as half an hour following failures to produce target words in response to definitions.

Yaniv and Meyer's memory sensitization hypothesis may also be useful in explaining the mechanism underlying problem-solving when achievement of a solution occurs as a flash of insight. An often cited example of this sort of problem is Maier's string problem (1931), in which participants were presented with two strings hanging from the ceiling and asked to tie the hanging ends of the string together. The strings were spaced so that no one could reach one string while holding the other. See Figure 4.

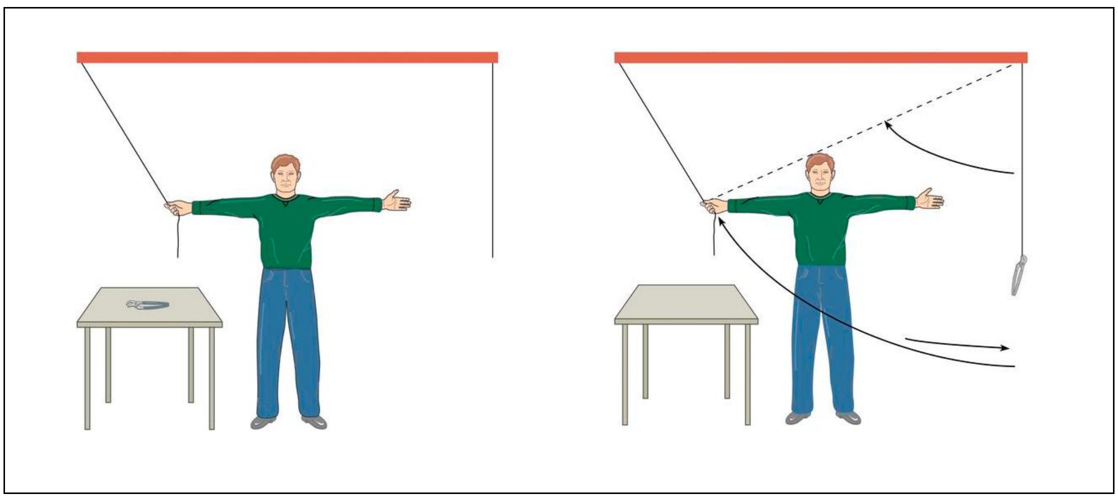

Figure 4. Maier's string problem (adapted from K. Stange, 2005, pp. 21-22).

Solving this problem required participants to recognize that a pair of pliers, which were in plain sight, could be used as a pendulum bob. By tying the pliers to one string and swinging it in an arc away from the second string, a participant could walk to the second string and grasp it, then, as the pliers swung back, the participant could catch them and tie the two strings together.

In Maier's experiment, only 39% of participants were able to solve the string problem correctly within the 10-minute time limit. Participants who had not solved the problem were then given an important clue. The experimenter "accidentally" nudged one of the strings, setting it in motion. After receiving this clue, 62% of the remaining participants solved the problem within 60 seconds. When interviewed later, however, none of these participants mentioned the clue as an important factor in solving the problem, and many reported having no memory of seeing the string move at all. Thus, despite being either not consciously aware of the movement of the string, or not aware that it was important in their solution of the problem, participants appeared to be making use of the clue. In other words, they were generating successful solution strategies based on information not consciously experienced as important, or not consciously experienced at all.

Maier's finding was replicated by Judson (1956), who substituted semantic priming for the "accidental" nudge of the string as the subtle clue. The priming effect is well-established in the context of memory-research, where the use of incidental, or implicit learning tasks is common. In Judson's study participants were first asked to memorize a list of words and then, after a period of time, to explicitly recall as many of those words as possible. The list of words participants were given to memorize included the words string, pendulum, and swing. Following the explicit recall test participants were given an implicit learning task, a word-nonword recognition task and a second implicit learning task, the string problem. As Judson had predicted, including the words string, pendulum, and swing on the memory task had the effect of facilitating participants' performance on both the word-nonword recognition task and the string problem. With respect to participants' awareness of the semantic priming clues, participants reported having no awareness of any connection between the stimulus words and their solution of the string problem.

In general terms, according to the spreading activation model, recognition of a problem in need of a solution sets in motion a search for a solution through outward spreads of activation in the problem solver's associative network from nodes which are in some way relevant to the problem at hand. When two problem-relevant elements (concepts, images, names, etc.) are considered by the problem-solver, there will be near-simultaneous spreads of activation from each of their nodes. If the two spreads of activation then intersect at nodes whose elements are associatively linked to both of the original elements, these points of intersection will receive energy from each of the originally activated nodes. If a third element is then considered, more intersections may occur, and residual energy will build up rapidly at these intersection nodes with associative links to each of the activated nodes. These intersection nodes are especially likely to be relevant to a solution, since a solution must, in some way, bring together and integrate all of the elements present in the problem in a coherent manner. As additional problem elements are juxtaposed, the level of residual energy at common intersection nodes builds until it exceeds the threshold of consciousness at one node, at which time the problem-solver experiences the "Aha!" of achieving a sudden insight into the solution.

It is likely that intermediate stages between the onset of puzzlement and the achievement of an insightful solution will exist only as complex patterns of residual energy in the problem-solver's associative network that cannot be represented in consciousness; however, one should be able to demonstrate the presence of partial, or intermediate states of knowledge at solution-relevant nodes. A problem-solver who is interrupted before achieving a solution will have generated a complex, but unfinished pattern of residual energy in which solution-relevant nodes, due to their multiple interconnections with nodes for problem elements, will be amongst the nodes with the highest levels of residual energy. If the problem-solver is on the right track, the pattern generated will resemble the one that would exist if the person had actually achieved a solution, i.e., the solution pattern, in which nodes for solution relevant concepts will hold the highest levels of residual energy. The nearer the problem-solver is to achieving a solution, the closer the resemblance will be between the pattern of residual energy generated and the solution pattern.

Since these complex patterns of residual energy, or intermediate states of partial knowledge cannot be represented in consciousness directly, one would need to employ indirect measures sensitive to the presence of residual energy to demonstrate the existence of partial knowledge. For example, a problem-solver interrupted before achieving a solution to a problem will have generated a pattern of residual energy in which the level of energy at solution-relevant nodes will be relatively high. If the problem-solver is subsequently asked to solve a second problem whose solution requires knowledge of the solution to the first problem, s/he should perform at a level somewhere between that expected from persons attempting the second problem without having attempted the first problem and that expected from persons who had actually solved the first problem. As well, a problem-solver near to solving the first problem at the point of interruption should perform at a higher level on the second problem than a problem-solver who is not near to solving the first problem at the point of interruption.

This is, in fact, the general notion underlying the set of studies included in this thesis. If intuition involves a movement from puzzlement to solution through a set of intermediate states of partial knowledge which take the form of increasingly-complete complex patterns of residual energy within the problem-solver's associative network, then one should be able to demonstrate that a problem-solver who attempts but fails to solve a problem will have generated partial knowledge of a solution, i.e., a pattern of residual energy in which a relatively high level is held at solution-relevant nodes that will facilitate performance on a related problem. This would be the case despite the fact that the intuitive problem-solver would have no conscious awareness of the solution to the first problem, or of having any knowledge about that solution.

Further, when the problem-solver is provided with enriched information in the first problem, s/he would have more potential sites for activation to work with than would a problem-solver working with impoverished information. The problem-solver working with enriched information should, therefore, generate a pattern of residual energy that more closely approximates the solution pattern, and should accumulate a level of residual energy at solution-relevant nodes that is nearer to the threshold of consciousness,

The discussion above is premised on the idea that the intuitive generation of a potential solution occurs through the creation of a pattern of residual energy that approximates the solution pattern, within which the highest accumulation of residual energy will occur at solution-relevant nodes. This will occur as a result of intersections in several simultaneous spreads of activation from solution-relevant nodes. It is, however, possible that once the problem-solver has activated some problem element nodes and generated a tentative pattern of residual energy in his/her associative network, the process of generating a potential solution could be sped up considerably by directly testing a potential solution by activating the node in the tentative pattern of residual activation that has accumulated the highest level of residual energy. In the following section I will discuss how such an activation of a potential solution node could be helpful in problem-solving.

<u>A possible model of organization within the associative network</u>

As discussed earlier, a person's associative network may be thought of as clusters of associatively interconnected nodes or terminals. As a heuristic, one can think of the associative network as a two-dimensional "plane" on which nodes for associated concepts are linked to each other by linkages, or "jumper wires." See Figure 5.

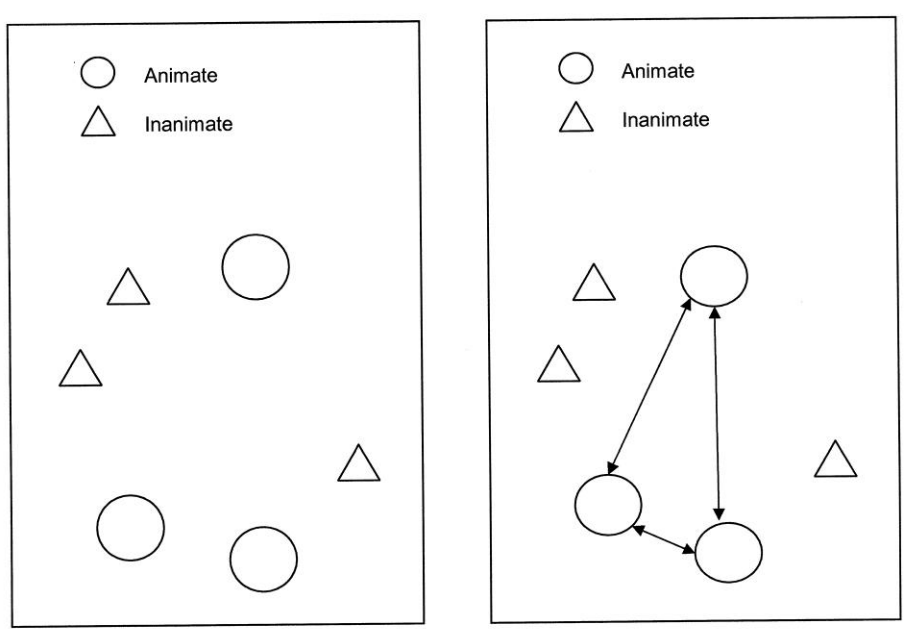

Figure 5. Associative linkage between nodes on the basal plane

As a person matures, his/her associative network develops and differentiates, with new nodes added to accommodate new concepts, words, images, etc., and new linkages formed between nodes to reflect newly developed understanding of the associations between different concepts, names, etc. In addition to expanding to accommodate newly experienced phenomena, the person's associative network also develops in a new way, with the creation of logical, meaningful categories that organize concepts into groupings on the basis of the presence of important shared characteristics, for example the presence of life. The "animate" category can be conceptualized as a new plane at a "higher level of abstraction," upon which nodes representing living things from the basal level can be represented. See Figure 6.

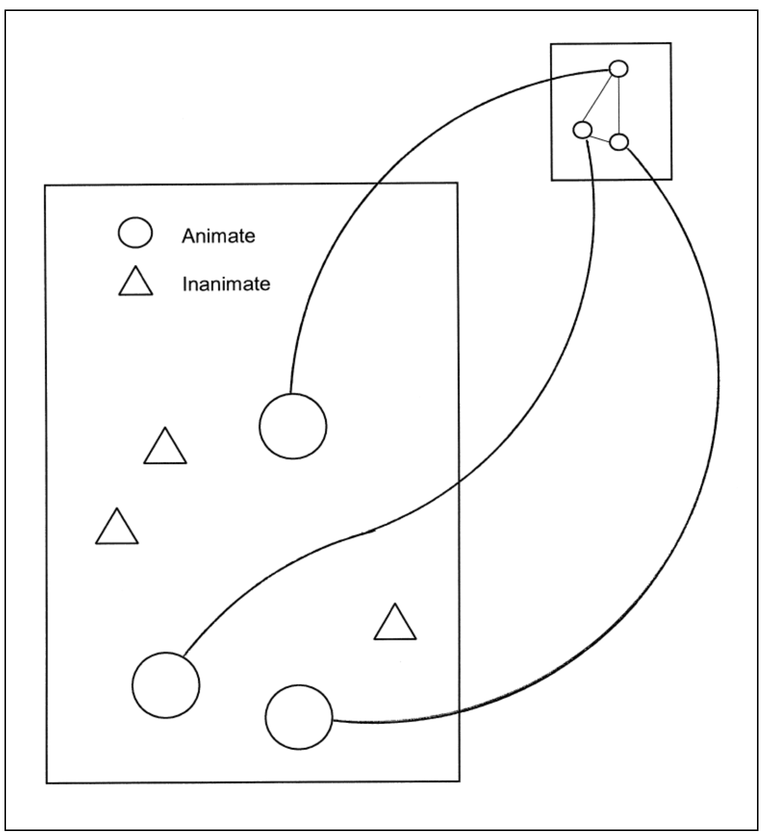

Figure 6. Linkage between basal nodes for living things and
the "animate" category on a higher level of abstraction

As a person's experience and expertise with a category grows, new planes of abstraction may be introduced between the basal level and the category level to reflect finer 'sub-categories" whose members all share a characteristic at the highest level of abstraction, e.g., they are all "animate," but all differ from members of other sub-categories on other important characteristics, e.g., "fish" vs. "bird" vs. "mammal." See Figures 7 and 8.

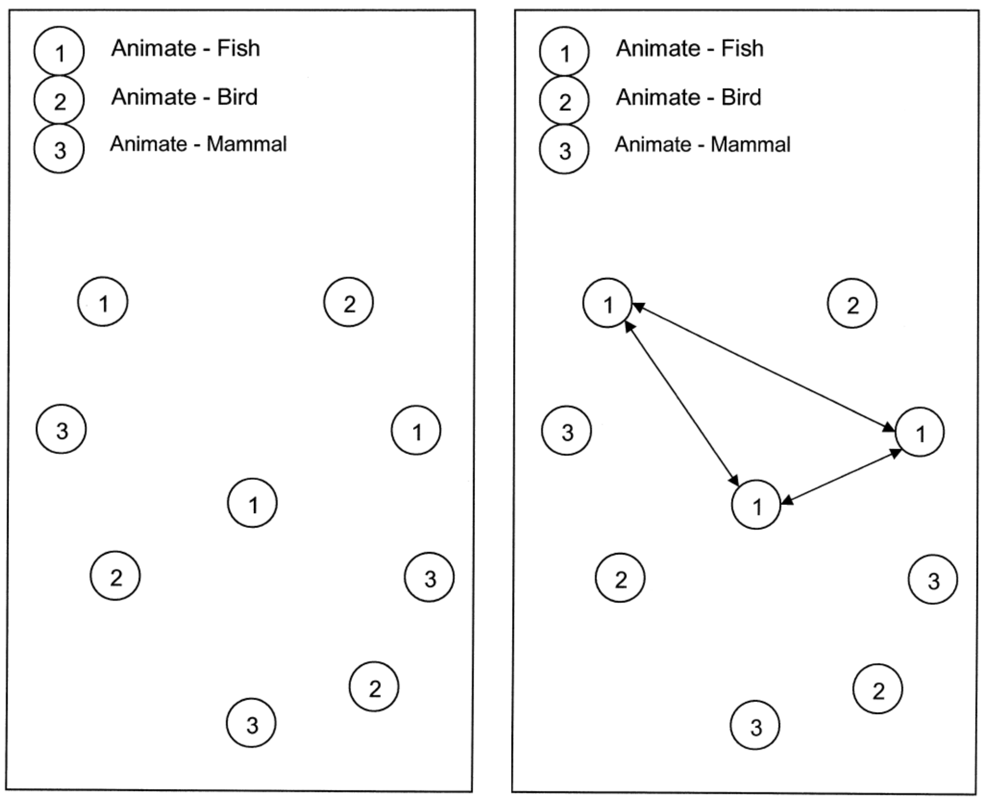

Figure 7. Linkage amongst basal nodes for a specific type of living thing

In a similar way, as one's expertise with a sub-category such as "bird" develops, finer sub-categories will be introduced between the basal level and the bird level, whose members all fit within the higher-level characteristic "bird," but all differ from members of other sub-categories on other important characteristics, e.g., “sparrow” vs. “hawk” vs. “duck.”

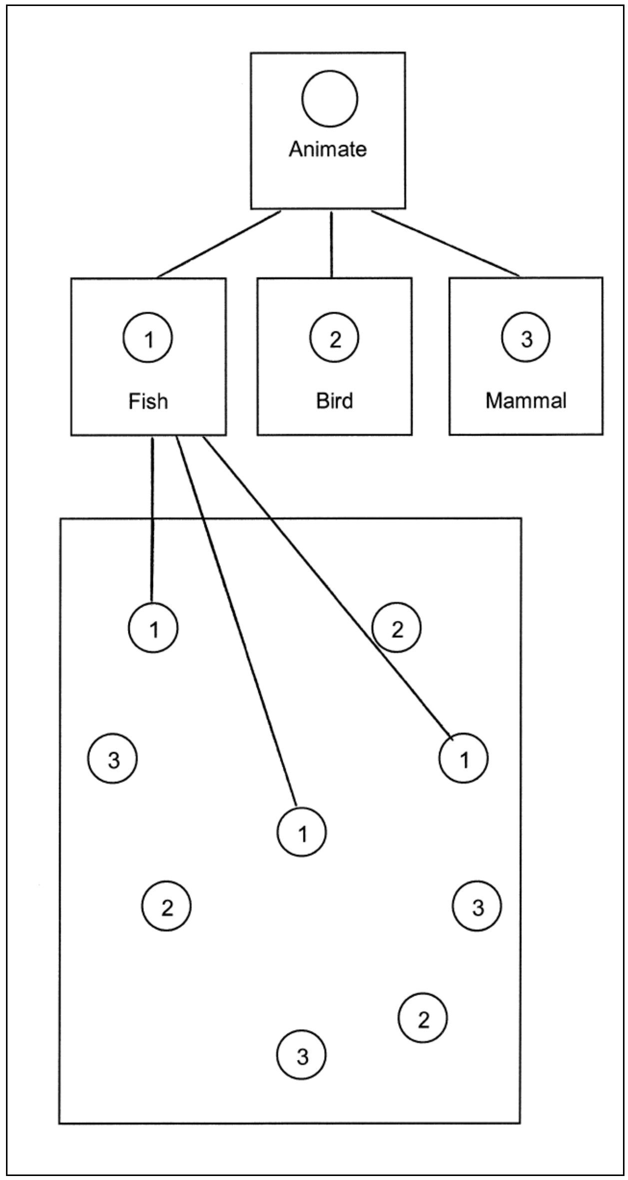

Figure 8. Linkage amongst nodes on basal, midlevel, and higher levels of abstraction.

In this way, one may go on creating sub-categories to organize members of a category on the basis of the presence or absence of important characteristics. For example, a person with expert knowledge of birds would have a highly differentiated category for birds in his/her associative network The expert's "bird" category will include sub-categories such as "hawk," "duck," and 'sparrow," and finer sub-categories such as "hawk characteristics," "duck characteristics," and 'sparrow characteristics." The number of levels of abstraction, the number of planes at a given level of abstraction, the number of nodes and the amount of interlinkage amongst those nodes on a given plane, and the complexity of the linkages between planes at different levels of abstraction would be entirely dependent on how much knowledge and experience the person has in a particular topic area. An expert in a particular area would likely have more levels of abstraction, more nodes and more interlinkages between the nodes on a given level, and more linkages between levels than would a beginner.

The obvious advantage of re-organizing the associative network in this way is that one may rapidly localize searches on the basis of the characteristics required to belong to a particular category, or to a particular sub-category within that category. A problem-solver employing a purely associative approach when searching for a desired solution would be forced to rely only on the strengths of the associative linkages between concepts established by personal experience, and would have no basis for inferring similarities across discrete experiences. Thus, a purely associative approach would involve a search through associations forged in past experiences in that particular situation. On the other hand, with the reorganization of the nodes in the associative network into a logical, categorical structure, problem-solvers have the opportunity to use a new and more efficient search process.

For example, activation of a specific "hawk beak" image node will send energy through the associative network in a particular way. A small amount of this energy will pass upward to "hawk characteristic" level, from there to the "bird characteristic" level, and from there outward to other nodes in the "bird system," but the majority will be retained at the "hawk" and "hawk characteristic" levels because of the complex pattern of multiple interlinkages amongst nodes on these levels with the "hawk beak" image node, for example, "hawk wings," "hawk tail," "hawk talons," "hawk size," "hawk feather," etc.. Thus, the majority of the energy introduced into the associative network by the initial activation of the "hawk beak" image node will recirculate amongst nodes within the "hawk system," resulting in a relative increase in residual energy held at nodes within the "hawk system," compared to nodes in other systems, such as the "sparrow system."

Thus, a person with a logical categorization scheme can create new categories of similarity that can meaningfully unite discrete experiences, and create new logical links amongst nodes for different things experienced at different times in different situations. For example, "dolphin," 'skunk," and "butterfly," all different and all experienced at different times in different contexts, can all be meaningfully subsumed under a purely mental category that can logically integrate those specific things, e.g., they are all "animate." Using this logical categorization scheme, problem-solvers can search in memory for desired solutions in either an inductive, "part-to-whole" manner or a deductive, "whole-to-part" manner. In an inductive search the problem-solver might activate nodes for specific things, e.g., "duck," "sparrow," and "hawk," and energy would flow "upward" from these through logical links to the node for a category that can integrate those things in a meaningful way, e.g., "bird." A deductive search, on the other hand, would involve activating a category level node, e.g., the node for the concept "horse" and sending a spread of energy "downward" through logical links to nodes for things that belong to that category, e.g., "bay," "quarter horse," and "thoroughbred." Further, the inductive and deductive search process may be integrated into what will be discussed throughout this thesis as the alternating activation hypothesis.

<u>The alternating activation search process</u>

> "He did not arrive at this conclusion by the decent process of quiet, logical deduction, nor yet by the blinding flash of glorious intuition, but by the shoddy, untidy process halfway between the two by which one usually gets to know things." (Allingham, 1942, p. 145)

Gigerenzer (1991) notes that there has been a tendency to too-strongly divide the context of discovery from the context of justification, with the assumption that the context of discovery exists as a discrete stage that simply precedes the stage in which justification procedures occur. Gigerenzer makes the point that checking and testing (justification procedures) are likely to take place in all stages of inquiry, as is the generation of new ideas (discovery processes). Gigerenzer further states that discovery is unlikely to occur through a process of pure induction from data, or of irrational guessing, but instead is likely to involve heuristics guided by "the tools of justification" (p. 264). It will be argued that intuition operates to generate potential solutions to puzzling problems through the process of alternating activation, in which inductive procedures alternate with deductive procedures throughout. As will be discussed, the latter involves checking and testing procedures, and these occur throughout what Bowers labeled the intuitive stage well prior to the appearance of a potential solution in the insight stage.

In the alternating activation model of intuitive processing, the intuitive search for a solution to a problem begins with a primary "inductive" activation event at the node for "something" experienced as relevant to a specific feature of the problem. Following this primary activation event, energy will spread along logical links to nodes at a higher level of abstraction, one of which may serve as a hunch or "potential owner" of the problem feature. At this point a reversal in the direction of activation occurs, and the higher level node that has accumulated the highest level of residual energy following primary activation will be selected as the hunch node, which will be the site for a secondary "deductive" activation event. Following the secondary activation event at the hunch node, energy spreads along logical links to nodes for the set of characteristics for that "potential owner." If the activated hunch node is in fact the correct solution, many of the expected characteristics may "match" actual features present in the gestalt, and because of the increase in residual energy held at expected characteristic nodes the likelihood of noticing a matching gestalt feature increases. When a match occurs between an expected characteristic and an actual feature, residual energy at the expected characteristic node will increase sharply. Because of this increase in residual energy, a matching characteristic node may become the site for a new primary inductive activation event. Each new primary activation event will send another spread of activation into the associative network, and wave after wave of activation energy will flow from matching characteristic nodes to the hunch category node.

For the beak/bird example discussed above, when a problem-solver responds to some aspect of a drawing as a beak, the initial activation event occurs at the node, or nodes, that would be activated had the problem-solver seen an actual beak. This in itself is not a trivial event in that it involves attempting to match some aspect of an incomplete and never-before-seen image with different, stored examples in memory, and so it is likely that this involves a speculative "trial-fit." Once a "beak" image node has been activated on a trial basis, however, the spread of activation energy from that node will generate a pattern of residual energy within the problem-solver's associative network.

At this point, the problem-solver could simply continue to attempt further primary inductive activations of nodes for characteristics that seem relevant to other data features. Once a pattern of residual energy has been established the search process may be more efficient if the problem-solver shifts from the "data" of the image to "things" at a higher level of abstraction most useful to solving the question at hand, i.e., "what is the thing that this beak belongs to?" If, following primary activation of the "beak" node, one such "potential owner" node has accumulated enough residual energy to set it apart from other nodes at its level of abstraction, that node may then serve as a hunch, i.e., the site for a secondary activation event. A secondary activation event at a hunch node will send a highly-focused spread of activation energy to nodes for characteristics closely associated with that particular "potential owner." See Figure 9.

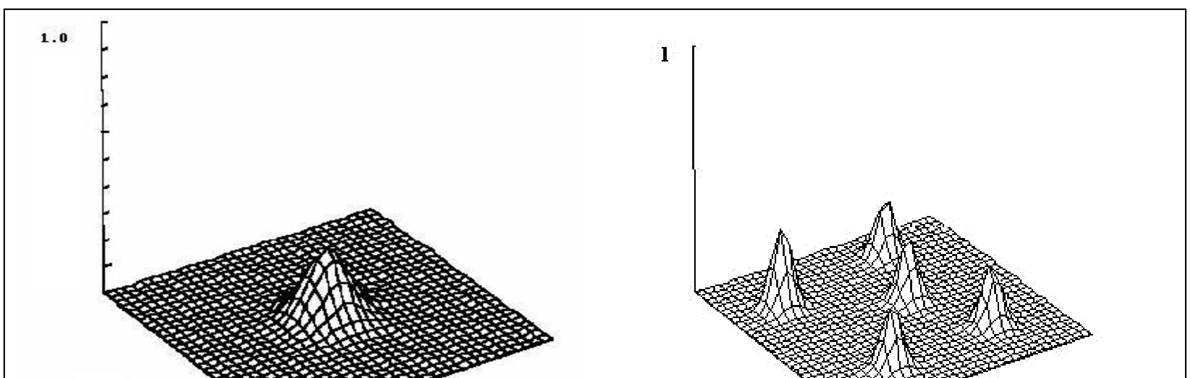

Figure 9. Deductive activation of a "hawk" node (left) leads to accumulations of residual energy at "hawk characteristic" nodes on a lower plane of abstraction (right).

Logically, if the activated hunch is in fact the correct solution, one would expect that characteristics associated with that "likely owner" would be present in the data as features of the image. In the case of the example given above, if “hawk” is the hunch identified in the spread of activation from the “beak” node, secondary activation of the “hawk” node will send a spread of activation energy to “hawk characteristics,” some of which should be present as features of the image if “hawk” is in fact the correct solution.

When an expected characteristic does correspond with an actual feature of the image, for example, “hawk eye,” the likelihood of its recognition is enhanced by the high level of residual energy at the expected characteristic node. Since the level of residual energy at the “hawk eye” characteristic node will already be part-way to the threshold of conscious recognition, little additional activation energy will be required to boost the level above the threshold, increasing the likelihood that the gestalt feature will match and be recognized as a hawk eye. The “match” characteristic node may then serve as the site for another primary inductive activation event, sending another spread of activation throughout the associative network and depositing additional energy at the “hawk” node.

With each match between an expected characteristic and an actual feature, another spread of activation energy will flow “upward” to the node for the “likely owner” of the matching characteristics. If a hunch node has been chosen that can serve as the “owner” of each of the activated image features, that node will receive energy from each of these activations and the residual energy at that node will accumulate rapidly to the threshold of consciousness at which point the problem-solver will become aware of the “owner” of the image, “Oh, it’s a hawk!” See Figure 10. Depending on the quality of information available and the problem-solver’s acuity with visual images, it may be that several cycles of inductive/deductive activation are necessary to accumulate sufficient residual energy in the “hawk system” to allow the problem-solver to become consciously aware of “hawk” as the correct solution.

It may be that the node chosen as the site for a secondary activation event is an incorrect hunch, for example the “duck” node, the subsequent accumulation of residual energy at “expected duck characteristic” nodes, for example nodes for “webbed foot,” “side-facing eyes” and “thin neck,” will not facilitate matches with actual features of the image. Without expected/actual matches there will be no new sites for primary activation events, and so no further additional energy will flow “upward” to the hunch node. Very quickly, the “duck” node will dead-end as hunch pointing the problem-solver toward the “likely owner” of the beak.

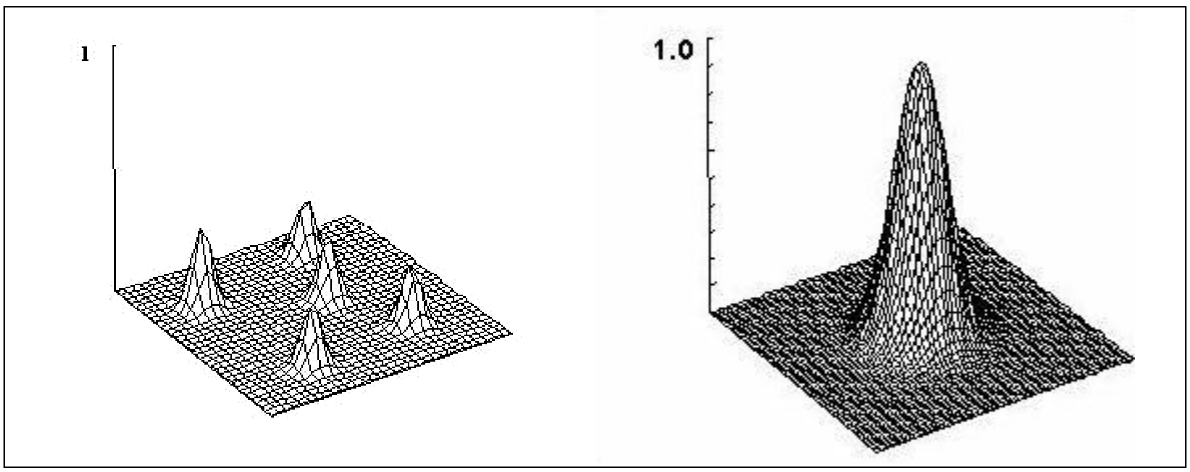

Figure 10. Inductive activation of expected characteristic/actual feature “match” nodes (left) leads to rapid accumulation of residual energy at the “hawk” node on a higher conceptual plane (right).

It should be pointed out that in the process of alternating activation it is not necessary that the problem-solver achieve conscious awareness of either the gestalt features or the hunch in order for their nodes to be used as sites for activation events. It is likely sufficient that, following primary activation, the accumulation of residual energy at a hunch node be greater than at other nodes at its level of abstraction, and that, following secondary activation and the matching process, the accumulation of residual energy at a characteristic node be significantly above the level of accumulation at other characteristic nodes.

The process of alternating activation allows a problem-solver to rapidly limit and localize the search area for “likely owners.” Using primary activation the problem-solver can move quickly from specific instances, i.e., the “data,” to a higher-level abstraction, i.e., a “hunch,” that can subsume and meaningfully integrate those specific instances. Using secondary activation the problem-solver can move from the “hunch” back toward the “data,” engaging in a matching process between actual gestalt features and the set of characteristics that would be expected for that “hunch” to be the correct solution. With many expected/actual matches, the level of residual energy at the “hunch” node will increase rapidly, until it reaches the level at which the problem-solver becomes aware of the hunch as the desired solution. As noted, the problem-solver could, of course, simply continue to activate different feature nodes serially in the hope of mechanically depositing sufficient residual energy at a solution node to bring its concept into consciousness, but it would be more efficient to *directly* test any higher-level node that has accumulated a sufficient level of residual energy to set it apart from others on its level as a potential solution.

In terms of evolution, there would be a distinct advantage to the model described above, in that a problem-solver who can maintain a large, associatively linked pattern of activation within his/her associative network through the conscious activation of a single thought would be able to rapidly bring to consciousness other information that is associatively related to the thought currently in consciousness. For example, to return to the example of “eagle,” if a problem-solver is currently thinking about a particular eagle, for example a bald eagle, and has some reason to want to know where a bald eagle lives, the activation provided to conceptual/semantic nodes for “bald eagle” in order to bring the concept of “bald eagle” to consciousness will have generated a pattern of residual energy amongst nodes associatively linked to the “bald eagle” node, one or several of which will represent “habitat of bald eagle.” Because a high level of residual energy will have accumulated at the “habitat of bald eagle” node(s) in the spread of activation from the “bald eagle” node while the person maintained bald eagle in consciousness, the problem-solver will be able to bring information about bald eagle habitat to consciousness rapidly with the input of a minimal amount of activation energy.

Had the problem-solver simply activated the highest-level “owner” node to consciousness, e.g., “bird,” bringing information about bald eagle habitat to consciousness would take longer and require the addition of more activation energy. This higher level of abstraction will include the required information about bald eagle habitat, but will also include information about the habitat of other species of birds known to the person, which would make access to information specific to the bald eagle much more difficult. It would simply not be an efficient strategy to go to a higher-than-necessary level of abstraction if the goal is to rapidly access information about something at a particular level of abstraction.

Note that activation of “bird” in response to seeing a bald eagle would correspond to a child’s unsophisticated understanding, reflecting a relatively undifferentiated associative network. With more experience and developing expertise with different types of birds the child’s associative network will become differentiated, with more associative linkages between nodes and an organization that includes more meaningful/useful levels of abstraction. For a person who has spent time studying bald eagles, "habitat of bald eagle" may be too abstract for the current situation, and s/he may instead activate a node for "winter habitat of western coastal bald eagle."

Bowers' previous studies

The studies included in this thesis have their conceptual roots in several studies performed by Ken Bowers in the 1990s. In these studies, intuition was understood to be a tacit perception of clues to coherence that activates and guides thinking toward discovery of the nature of that coherence. Using intuition, problem-solvers extract "something" from the problem situation that they can use to generate patterns of spreading activation relevant to the task of discovering a solution to the problem at hand. It is this process of extraction and generation that are at the core of Bowers' intuitive stage. Activation of a concept in long-term memory that is in some way relevant to "something" extracted from the problem situation sends a spread of activation energy through the problem-solver's associative network, generating a residual energy pattern in which relatively high levels of residual energy are held at nodes for concepts, words, images, etc. that may then serve as hunches or implicit hypotheses about the nature of the solution to the problem at hand. When a problem is very familiar, the problem-solver will likely accumulate a high level of residual energy at a hunch very rapidly, and that hunch will likely be correct and immediately relevant to all of the elements of the problem situation, so that movement from puzzlement to solution is rapid and glitch-free. When a problem is unfamiliar, however, movement from puzzlement to solution will take longer, but the intuitive process takes the same route, beginning with the activation of concepts experienced as similar *in some way* to elements within the problem situation.

Bowers maintained that one of the first and most important “somethings” that problem-solvers respond to in the problem situation is the presence of coherence within the stimuli. From the outset of problem-solving, identifying the presence of some form of coherence amongst elements in the problem situation would seem to be an efficient use of resources. If no general coherence can be discerned amongst the elements of the problem situation, it would be pointless to continue the attempt to discover any specific pattern of regularity, i.e., a solution. If some form of coherence can be discerned, however, it is likely to be related to the solution in some way, since the solution must logically integrate the elements of the problem situation. Thus, problem-solvers are likely to be very attuned to the presence or absence of coherences amongst challenging stimuli.

In the first of three 1990 studies by Bowers, Regehr, Balthazard, and Parker, stimuli were created based on items drawn from the Remote Associates Test (RAT) (Mednick and Mednick, 1967) and Arthur’s (1964) revision of the Kent-Rosanoff Word Association Test (Kent & Rosanoff, 1910). Sixty pairs of three-word items, or Dyads of Triads (DOT), were constructed so that each pair contained: a) a coherent triad, in which each of the three stimulus words was a remote associate of a fourth word, and, b) an incoherent triad, in which the three stimulus words did not have a common remote associate, barring loose, psychotic associations. In addition, each Dyad of Triads was constructed so that the most closely associated pair of words within the coherent triad and the most closely associated pair within the incoherent triad were similar in ratings of associative closeness. One DOT item with the remote associate for coherent triad A is illustrated in Figure 11.

A	B	Remote Associate
PLAYING	STILL	
CREDIT	PAGES	CARD
REPORT	MUSIC	

Figure 11. Sample DOT Item

Participants were given a brief exposure (8 or 12 s.) to each Dyad of Triads arranged as in Figure 11, without the remote associate word or any indication of which triad is coherent. Pairs of triads were counterbalanced with respect to left/right positioning of the coherent triad. Participants were asked to generate the remote associate word, or, failing that, to simply indicate which of the two triads was the coherent version, and then to provide a confidence rating that they had chosen the correct triad as coherent. Bowers *et al* found that amongst unsolved items the coherent Dyad was chosen at a rate significantly greater than chance, and higher confidence ratings were associated with increased likelihood of choosing the correct triad as coherent.

Coherent triads were then separated into convergent coherent triads, in which the common remote associate of the triad maintained the same meaning for each stimulus word, e.g., “goat-pass-green” are all associated with the same meaning of the word “mountain,” and divergent coherent triads, in which the common remote associate of the triad did not maintain the same meaning for each stimulus word, e.g., “strike-same-tennis” are associated with different meanings of the work “match.” Participants were asked to rate the convergence of each triad and the resulting average rating was correlated with the proportion of times that triad was chosen as the coherent triad in the first study when the item was not solved.

Bowers *et al* found that an increased rating of semantic convergence was significantly correlated with the likelihood of being correctly chosen as the coherent triad, indicating that participants were responding to the differing “quality” of information available within each coherent triad. As noted by Bowers *et al*, it was unlikely that participants in the first study were conscious of the degree of semantic convergence in each of the coherent triads while making decisions about which triad of each pair was coherent, and it was therefore argued that the influence of semantic convergence on decisions regarding coherence was implicit, taking place through the process of spreading activation, rather than through conscious analysis of the semantic properties of the triads.

In the second 1990 study, Bowers *et al* replaced verbal stimuli used in the first study with the Waterloo Visual Closure Task, i.e., difficult visual gestalts in the form of incomplete black-and-white representations of common objects. Students from the Fine Arts program at the University of Waterloo were asked to construct a set of ambiguous visual gestalt stimuli in which coherence was manipulated. Each item consisted of two versions of a black and white line drawing of a common object. In the coherent version some parts of the drawing had been removed forcing participants to mentally “fill in the blanks” to recognize the object portrayed. The incoherent version contained the same components that were present in the coherent version, but these were rotated and displaced on the page to disrupt the expected spatial relationships amongst them.

Participants were shown the visual gestalts in coherent/incoherent pairs and asked to identify the object portrayed and failing that to choose of the pair they believed to be coherent and rate their confidence that they had chosen correctly. Of the unsolved gestalt items, participants were able to choose the coherent gestalt 60% of the time, demonstrating their sensitivity to coherence. The average correlation between confidence ratings and the proportion of unsolved items in which the correct version of the gestalt was chosen as coherent was .23, indicating that while participants were able to successfully respond to coherence at an above-chance level, they had little sense of how well they were actually doing.

In the third of their 1990 studies, Bowers *et al* used items from Arthur's (1964) revision of the Kent-Rosanoff Word Association Test (Kent & Rosanoff, 1910) to create a finely gradiated version of the RAT, which they referred to as the Accumulated Clues Task (ACT). Each ACT item consisted of a list of 15 clue-words, each having a single common associate. For each item, the common associate was relatively remote from the first 12 clue-words, but relatively close to the last 3 clue-words on each list. One example of an ACT item is illustrated in Figure 12.

TIMES
INCH
DEAL
CORNER
PEG
HEAD
FOOT
DANCE
PERSON
TOWN
MATH
FOUR
BLOCK
TABLE
BOX

Solution: SQUARE

Figure 12. Sample ACT item

Beginning with the most remote clue-word, the list for each item was revealed one clue-word at a time. Each clue-word was revealed for 10s., after which the next clue-word was revealed. As each clue-word was revealed, participants were asked to write down an association to that particular word. As they wrote down their associations to the individual clue-words, participants were also asked to judge whether one of their responses was associated with each of the clue-words revealed so far for that item. When they discovered a common association, participants were to place a check mark beside that response and continue responding to subsequent clue-words. If a later, different response emerged as a more promising solution, participants were to place a check mark beside it as well. On the trial in which participants became absolutely sure that they had discovered the correct solution they were to place an “X” beside their response for that trial, and no further trials were conducted for that item.

Results indicated that it took participants an average of 10 clues to arrive at a hunch, and just under 2 more clues before they felt confident that they had arrived at the correct solution. In order to determine whether participants' associations were becoming gradually closer to the correct solution with successive clues, participants' responses for each ACT item were rated for associative closeness to the solution word by independent judges at four different clue-words. While participants differed in terms of how many clue-words were required before they indicated discovery of a potential solution, participants' responses demonstrated a pattern of increasing associative closeness to the correct solution as they responded to each of the clue-words for each item, supporting the notion that intuitive problem-solving proceeds through an accumulative, incremental process involving increasingly complete, implicit states of partial knowledge.

In a 1995 study, Bowers, Farvolden, and Mermigis returned to the visual gestalt stimuli employed in the second 1990 Bowers *et al* study. In this study, participants saw only one version of the gestalt for each item, with half of the items displayed in their coherent form and half in their incoherent form. Each gestalt was presented for 5 seconds, after which the gestalt was removed and a list of four words was presented. One of the words on the list was the correct solution to the gestalt. When asked to select the word that named the object in the gestalt they had just seen, participants were able to choose the correct word at a rate of 69% on trials preceded by coherent gestalts. The corresponding rate for trials preceded by incoherent gestalts was 52%. In both cases participants were able to choose the correct word well above the 25% rate expected by chance. As noted by Bowers *et al*, it was highly unlikely that such a result could occur as a result of anything other than participants responding to the quality of coherence in the gestalts.

While participants in Bowers' study demonstrated sensitivity to the presence of coherence, it was striking that even incoherent gestalts could lead to enhanced performance on the word-choice task. This led to the hypothesis that participants were extracting "something" from both coherent and incoherent gestalts that led to states of partial, or incomplete knowledge existing somewhere outside of consciousness. In the attempt to solve a visual gestalt, a problem-solver gradually accumulates implicit partial knowledge about the object portrayed in the gestalt. Even when this accumulation of partial knowledge fails to reach the level of completeness required to enter consciousness, it may still, however, assist the problem-solver in a subsequent attempt to solve a related problem.

Bowers' findings and bi-directional activation

As noted above, in Bowers' 1995 study participants' word choice performance was facilitated to above-chance levels for both coherent and incoherent gestalt trials, but facilitation on trials with coherent gestalts was greater than facilitation following trials with incoherent gestalts. This result will be referred to in this thesis as the "Coherent Advantage" and Bowers understood it to occur because the coherent gestalt for each item was simply a better clue than its incoherent counterpart, allowing problem-solvers to accumulate a higher level of residual energy at the correct "hunch" node. From this perspective, despite the fact that the same elements are contained in coherent and incoherent versions of each gestalt, sites for primary activation events are simply more accessible in the coherent version.

On the other hand, it may be that a coherent gestalt offers problem-solvers more than just increased opportunities for primary activation events. It may be problem-solvers engage with coherent gestalts in a quite different way than is possible with their incoherent versions. Problem-solvers may be able to employ what has been described above as secondary inductive activation from a "hunch" node back to the data of the gestalt. It is, however, likely that the process of secondary activation will be different for the coherent version of a gestalt than for the incoherent version because spatial relationships are maintained amongst image features in the coherent versions of gestalts but not in incoherent versions.

Secondary activation of a correct hunch node will send a wave of activation energy to nodes for a set of characteristics and spatial relationships amongst those characteristics that should be present for the hunch to be the correct solution. If the hunch is correct and the gestalt is coherent, many of these features and spatial relationships will actually be present in the "data" of the gestalt. The high level of residual energy at "expected characteristic" nodes will lead to recognition of matching features within the gestalt, further increasing the level of residual energy at "match" nodes. These high residual energy match nodes may then become sites for new primary activation events, from which additional activation energy will spread inductively to the hunch node. The resulting increase in residual energy at the hunch node may prompt another secondary activation event at that node, and another spread of deductive activation that will deposit additional residual energy at "expected characteristic" nodes. In this round more of these "expected characteristic" nodes may reach a level of residual energy that would permit matches with gestalt features, marking them as sites for new primary activation events, from which new inductive spreads of activation will deposit more energy at the hunch node.

Thus, by starting from one aspect of the gestalt and establishing a testable hunch about the identity of the thing that could legitimately “own” that aspect, a problem-solver can engage in rounds of alternating “inductive” and “deductive” activation, with each round of inductive/deductive activation incorporating new “bits” of the data from the gestalt, and each newly incorporated “bit” providing additional support for the hunch. Each new successful match of expected characteristic and actual gestalt feature will increase the amount of energy recirculating amongst the set of nodes belonging to the hunch. Like a wave carrying a surfer to shore, residual energy at the hunch node rises pushing the hunch closer and closer to the threshold of consciousness. Finally, as the level of residual energy reaches the threshold the problem-solver will experience the "aha" of achieving the desired solution.

In a case where an incorrect hunch is chosen, secondary activation of that node will activate nodes for a set of expected characteristics and for spatial relationships amongst those characteristics that will *not* be present in the data of the gestalt. It is possible that there may be a few matches between expected characteristics and actual features, but these will likely be limited to the node(s) responsible for the initial primary spread of activation that prompted the choice of the incorrect hunch in the first place.

Without the discovery of expected/actual matches, there will be no new sites for primary activation events, and no further deposits of energy at the hunch node, so, after a few rounds of fruitless inductive/deductive activation with an incorrect hunch node, the process will likely dead-end, leaving relatively low levels of residual energy at a few feature/organization nodes and a relatively low level of residual energy at the incorrect hunch, or “owner” node. At this point, the problem-solver may experience a sense of being stuck, of re-treading the same paths several times with no further success and arriving at the same dissatisfying dead-end pattern of residual activation.

For problem-solvers working with incoherent gestalts, the disruption of spatial relationships amongst the features of the gestalt will impact on the process of alternating activation. If the problem-solver generates an incorrect hunch from the data of the gestalt, the process of alternating activation simply dead-ends as described above. If, on the other hand, the problem-solver generates a correct hunch, secondary activation of the correct hunch node will produce virtually the same pattern of residual activation amongst expected characteristic nodes and spatial/organization nodes that would occur had the problem-solver generated and activated the correct hunch node from the coherent version of the same gestalt. As in the coherent case, the increased residual energy at expected characteristic nodes may lead to recognition of previously unattended gestalt features. These match nodes may then become sites for new primary activation events, from which inductive spreads of activation deposit energy at the correct hunch node.

Nodes for spatial relationships amongst expected characteristics, likely in the form of stored images, however, will *not* map onto the actual spatial relationships amongst features in the incoherent gestalt. Even though the problem-solver has been sensitized to perceive a particular set of spatial relationships amongst features in the data, these will not be present in the gestalt, and no expected/actual matches will occur. Without expected/actual matches, spatial organizational nodes will not accumulate the level of residual energy required to become new sites for primary activation events, and so no further energy will be passed inductively from these nodes to the correct hunch node. The ongoing presence of a moderate level of residual energy at these nodes will be of no further help to, and may in fact hinder, the problem-solver's attempts to incorporate previously unrecognized information from the gestalt. The problem-solver will simply be wasting time and resources by continuing to attempt to match expected spatial relationships with the actual relationships amongst gestalt features.

For trials involving incoherent gestalts, secondary activations from a correct "hunch" node can lead to further primary activations at nodes for expected characteristics, but not at nodes for the spatial organization of those characteristics. Thus, the overall potential for accumulation of residual energy at a correct hunch node through the process of alternating activation would be greater for trials with unsolved coherent gestalts than following trials with unsolved incoherent gestalts.

Preamble to Studies I to III

In the studies included in this dissertation, the visual gestalt methodology developed in the Bowers et al studies described above (1990, 1995) has been adapted and extended to provide what Bowers described (1995) as "a more subtle test of …. the thesis that cognitive processes prior to solving a gestalt are in fact converging toward a solution." As noted above, in Bowers *et al* (1995) study participants were presented with coherent and incoherent gestalts individually for five seconds. After each gestalt was removed, participants were presented with a list of four words, one of which was the name of the object they had just seen. Participants were then asked to choose the word from the list that correctly named the object they had seen in the gestalt. If participants were responding randomly to the word-choice task, one would expect a 25% success rate in choosing the correct word. What Bowers et al found, however, was a 69% success rate for trials involving coherent gestalts and a 52% success rate for trials involving incoherent gestalts. Bowers concluded that participants were gaining something from each gestalt presentation that informed their selection of the correct solution word for that trial, and that coherent gestalts provided participants with more to work with than did their incoherent counterparts.

Bowers' methodology required that participants simply choose the correct name of each visual gestalt object from a list containing four words. The current set of studies employs a much more difficult secondary task in which participants are asked to solve difficult partial-word puzzles, which, solved correctly, will reveal the name of the object portrayed in the gestalt for that item. Unlike participants in Bowers' study, participants in the current set of studies will not encounter the name of gestalt items at any point prior to achieving a successful solution to the secondary task. Participants are expected to use whatever implicit partial-knowledge they accumulate in their encounter with each visual gestalt as a "clue" to the solution of the corresponding partial-word puzzle. This more difficult secondary task provides a stricter test of the idea that participants can generate useful partial knowledge about a solution outside of conscious awareness through encounters with visual gestalts, and that the amount of partial knowledge accumulated will vary depending on the "quality" of the gestalt.

The studies that follow will demonstrate that intuition, which feels like an "all-or-nothing" phenomenon, is in fact an incremental, accumulative process in which a problem-solver will move gradually from a state of puzzlement through increasingly complete states of implicit partial knowledge before arriving at a solution. From the perspective of an all-or-nothing model, such as the qualitative change in state described by Gestalt theorists, failure to identify an object in a visual gestalt indicates that the problem-solver has not generated the necessary reorganization of the problem elements that must precede the achievement of a solution. Since the "all-or-nothing" explanation does not support states of partial, or intermediate knowledge between puzzlement and solution, the unsuccessful attempt to solve a visual gestalt should therefore provide the problem-solver with nothing whatsoever that might lead to facilitation of performance on a subsequent related problem. Overall, the "all-or-nothing" model predicts that following unsuccessful attempts to solve visual gestalts, participants' performance on related problems will not differ from the baseline level of performance, i.e., the level that would occur had they attempted the related problems without prior exposure to the visual gestalts.

If, on the other hand, intuition is an accumulative process, then the transit from puzzlement to conscious awareness of a solution should involve a gradual increase in implicit knowledge about the object portrayed in a visual gestalt. From this perspective, attempting but failing to identify a visual gestalt permits participants to generate useful partial knowledge about the object portrayed in a gestalt that can facilitate their subsequent performance on the related problem. The accumulative model predicts that following unsuccessful attempts to solve visual gestalts, participants' performance on related problems will be significantly greater than the baseline level of performance.

A second idea that will be examined is that, as an accumulative process, intuition will be very sensitive to the "quality" of the available data. From the "all-or-nothing" perspective it should not matter whether an unidentified visual gestalt is a "good" one or a “poor” one, because, in the absence of the qualitative change in state necessary for achievement of a solution, neither would provide the participant with anything that could be used to facilitate solution of the related problem. So long as a visual gestalt remains unrecognized, the “all-or-nothing” model predicts that the quality or coherence of that gestalt should have absolutely no impact on participants’ performance on the related problem.

From the accumulative perspective, on the other hand, it should matter whether an unidentified visual gestalt was a “good” one or a “poor” one. A problem-solver will accumulate more partial knowledge from an unsuccessful attempt to solve a “better” coherent gestalt than from an unsuccessful attempt to solve a “poorer” incoherent gestalt, which will be reflected in increased facilitation of performance on the related problem. Therefore, the accumulative model predicts that participants’ performance on related problems will be significantly greater on trials involving unsolved coherent gestalts than on trials involving unsolved incoherent gestalts.

Chapter 2 - Part A: Establishing the partial-word facilitation effect

Preliminary Study A1

Participants' attempts to solve visual gestalts prior to attempting to solve a corresponding partial-word puzzle are expected to lead to three distinct levels of partial-word facilitation. The greatest amount of partial-word facilitation is expected on trials in which participants achieve a successful solution to the visual gestalt and the name of the object portrayed in the gestalt reaches conscious awareness prior to the attempt to solve the partial-word puzzle. The next greatest amount of partial-word facilitation is expected on trials in which coherent visual gestalts are employed, but participants do not achieve a successful solution, i.e., the gestalt is unrecognized. The least amount of partial-word facilitation is expected on trials in which incoherent visual gestalts are employed, but participants do not achieve a successful solution. Preliminary Study A1, was designed to test these predictions.

Method

Participants

Participants (n = 32) were recruited from the University of Waterloo undergraduate pool. In the initial telephone contact, potential participants were asked if their vision was adequate for normal reading and if they had average English language proficiency. Participants were told that the purpose of the experiment was to study problem-solving skills and that if they agreed to participate they would be asked to try to solve puzzles, some of which would involve identifying objects in drawings and some of which would involve solving word puzzles related to the objects in the drawings. Participants were told that some of the problems were very difficult and that one's ability to solve them had no bearing on one's intelligence; rather, some people just have a "knack" with this sort of thing much like the way that some people seem to have a talent for music or drawing.

Materials

Visual gestalt items were chosen from a larger set of incomplete black and white drawings of humanly made objects, such as machines, tools, and buildings, and naturally occurring objects, such as animals and plants, developed for earlier studies by Bowers (1990). Each visual gestalt item was available in two forms: a coherent variant and an incoherent variant. In the coherent variant parts of the drawing had been omitted, forcing the viewer to mentally "fill in the blanks" in order to recognize the object. In the incoherent variant the same parts of the drawing had been omitted and in addition the remaining component parts of the drawing had been displaced and rotated relative to each other so that spatial relationships amongst component parts were disrupted. Solution rates for each of the visual gestalt items used in Bowers' previous studies were available in the form of item means, averaged across trials with coherent and incoherent variants. It was decided a priori to choose only the most difficult visual gestalts in order to maximize the number of trials in which visual gestalts are not recognized, since only these trials would be included in the analysis, and so 20 of the most difficult visual gestalt items were chosen. The resulting set of visual gestalts had an average visual gestalt solution rate of .12 (SD = .09). For each visual gestalt item, a partial-word puzzle was constructed by replacing several letters in the common name of the object portrayed in the gestalt with blanks. Unfortunately, no partial-word solution rates were available for the set of partial-word puzzles.

Procedure

Participants were tested individually. Participants entering the lab were informed that they would be participating in a study of visual perception and would be asked to look at some drawings of objects, which could be humanly made things such as buildings, tools, or machines, or naturally occurring things, such as people, animals, or plants, and then to try to identify them. It was explained that some of the items portrayed in the drawings were not easy to recognize and that everyone had difficulty with some of them. They were informed that after trying to identify the object in each drawing they would also be asked to try to solve a missing-letter word puzzle whose correct solution was the name of the object in the drawing. Participants were then asked to sign the participation consent form if they wished to participate in the study.

Participants were then informed that they would have 30 seconds to look at each drawing, write down the name of the object in the space provided, and rate how confident they were that their response was correct by writing in a number between 0 (indicating "no confidence – just a wild guess") and 100% (indicating "absolutely sure"). It was emphasized that it was important that they respond to each item and if stumped to take a wild guess and to rate their confidence for that item at a very low level to indicate that it was a guess.

Participants were then told that after writing down a response and a confidence rating they would get another chance to see the drawing, this time together with a word puzzle. The word in the word puzzle would be the name of the object in the drawing, but it would have blanks in the place of some of the letters. Participants were told that they would have 30 seconds to write down the word that correctly solved the word puzzle and revealed the identity of the object portrayed in the drawing.

Participants were timed as they completed each visual gestalt identification form. At the 25-second mark, if a participant appeared unable to identify the object, s/he was instructed to simply write down "whatever came to mind, even if it seems unlikely" while looking at the picture and to complete the confidence rating scale. After the participant supplied a confidence rating, the form containing the visual gestalt and the confidence rating scale was removed.

Immediately following removal of the visual gestalt identification form, the partial-word solution form was presented, which contained the same version of the visual gestalt item seen on the previous form along with its related partial-word puzzle. On the first few items participants were reminded that they would have 30 seconds and that the correct solution to the partial-word puzzle was the name of the object portrayed in the visual gestalt. At the end of the 30 second interval, the partial-word form was taken away, whether completed or not, and the visual gestalt identification form for the next item was presented. Each participant attempted all twenty stimulus items, ten presented in the coherent version and ten presented in the incoherent version. Stimulus items were randomized for each participant with respect to item order and item coherence.

It was predicted that the partial-word solution rate following successful attempts to identify visual gestalts would be significantly greater than the rate following unsuccessful attempts to identify visual gestalts. Second, it was predicted that the partial-word solution rate following unsuccessful attempts to identify coherent visual gestalts would be significantly greater than the partial-word solution rate following unsuccessful attempts to identify incoherent visual gestalts.

Results and Discussion

Preliminary Study A1 failed to reveal expected differences between coherent and incoherent facilitation of partial-word performance. A paired-samples t-test revealed that participants' partial-word performance following unsuccessful attempts to solve coherent gestalts ($\underline{M}$ = 0.36, $\underline{SD}$ = 0.04) was not significantly different, $\underline{t}(31) = 0.13$, $\underline{p} = .45$ (one-tailed), than following unsuccessful attempts to solve incoherent gestalts ($\underline{M}$ = 0.35, $\underline{SD}$ = 0.03).

A separate samples t-test assuming equal variances revealed that the visual gestalt item solution rate ($\underline{M}$ = 0.11, $\underline{SD}$ = 0.12) was not significantly different, $\underline{t}(38) = .19$, $\underline{p}$ = .85 (two-tailed), from that reported in Bowers' previous studies ($\underline{M}$ = 0.12, $\underline{SD}$ = .09) for this set of gestalt items, which was expected. A paired-samples t-test revealed that the gestalt solution rate for coherent trials ($\underline{M}$ = 0.20, $\underline{SD}$ = 0.21) was significantly greater, $t(19) = 4.35$, $p < .001$ (one-tailed), than the gestalt solution rate for incoherent trials ($\underline{M}$ = 0.01 , $\underline{SD}$ = 0.02), which was also expected to be the case.

Analysis of item solution data for the set of partial-word stimuli, however, revealed serious floor/ceiling problems with several items in the set. Two items had partial-word solution rates above .80 for both coherent and incoherent trials. For these items the partial-word stimuli were simply too easy to solve, leading to high rates of partial-word solution regardless of the coherency of the visual gestalt. In brief, the solution rate for these partial-word puzzles was uniformly high with little variability in participants' responses, making it impossible to discern a partial-word facilitation effect.

On the other hand, four items had partial-word solution rates below .17 for both coherent and incoherent trials. For each of these items the partial-word puzzle was simply so difficult that participants were unable to make use of anything gained from the attempt to solve the gestalt to the corresponding partial-word puzzle. Thus, Preliminary Study A2 was proposed to establish a set of stimuli with known partial-word baseline solution rates for use in subsequent studies that was free from the floor/ceiling problems demonstrated in Preliminary Study A1.

Preliminary Study A2

The failure to obtain expected results in Preliminary Study A1 made it clear that it would not be possible to demonstrate differences in partial-word facilitation without a set of partial-word stimulus items free of floor and ceiling effects. As well, it was noted that while it was supposed on theoretical grounds that unsuccessful attempts to solve both coherent and incoherent visual gestalts would facilitate subsequent partial-word performance, it would not be possible to demonstrate incoherent facilitation without explicit performance baselines for the partial-word stimuli for comparison. Thus, Preliminary Study A2 was designed to establish a set of stimuli with known partial-word baseline solution rates for use in subsequent studies that was free from the floor/ceiling problems demonstrated in Preliminary Study A1.

Method

Participants

Participants (n = 65) were recruited from the University of Waterloo undergraduate pool. In the initial telephone contact, potential participants were asked if their vision was adequate for normal reading and if they had average English language proficiency, and the purpose of the experiment was explained exactly as in Preliminary Study A1.

Materials

Partial-word puzzle variants were generated by systematically replacing letters in the common names of 58 gestalt items with blanks, with the restrictions that:

a) no more than 50% of the letters in any word should be replaced, and

b) no more than two blanks could appear consecutively.

For example, for the gestalt item camel, replacing every combination of two letters in the word “camel" with blanks would generate the following variants: *_ _mel, _a_el, _am_l, _ame_, c_ _el, c_m_l, c_me_, ca_ _l, ca_e_*, and *cam_ _*.

Of the possible partial-word puzzle variants generated for each visual gestalt item, each was compared to a 40,000 word dictionary (thought to represent an average vocabulary) in order to determine possible matches to words other than the gestalt object name. If a variant did match a word other than the desired object name, it was removed from further testing. From the remaining variants, two were selected for each item for testing on the basis of the most apparent difficulty.

Each of the selected partial-word puzzle variants was then randomly assigned to ten 58-item word lists so that only one variant of each item appeared on each list, i.e., five of the lists contained variant A of item 1 and five contained variant B of item 1. Order of appearance of each item on each list was also randomized. The word lists were laser-printed on 8.5 x 11 inch transparent overhead sheets using 24-point Times font. A cardboard mask was constructed so that each item on a word list could be presented individually.

<u>Procedure</u>

Participants were tested in groups of 3-5. Participants entering the lab were told that they would be participating in a study of problem-solving in which an overhead projector would be used to project word puzzles on a screen one at a time. Participants were informed that the solution to each puzzle was a real English word, but in each case some of the letters in the word had been replaced with blanks (underscore marks). They were told that their task was to solve each puzzle by discovering the correct letters to fill in the blanks and writing down the correct solution word on the response sheet. Participants were asked to read and sign the participation consent form if they wished to participate in the study.

Participants were seated in groups of 2 or 3 at two tables facing a standard overhead screen which was 6-7 feet away. The experimenter was seated between and slightly behind the two tables at the overhead projector, which was used to project each partial-word puzzle on a screen. Participants were told that each word puzzle would appear on the screen for 30 seconds, and their task was to write down the correct solution word on a provided response sheet. In order to discourage over-cautious response styles, participants were asked to write down a response for every item, even if they if they were sure it was not the correct answer. It was explained that writing something down for every item, rather than leaving blanks, often led to higher overall success rates.

At the 20-second mark for each item, participants were asked to write down an answer if they had not already done so, or to write down whatever came to mind if they could not correctly solve the puzzle. Participants responded to four practice items and fifty-eight stimulus items.

Results and Discussion

It was decided *a priori* to choose items whose solution rates fell between .20 and .40 for both the visual gestalt task and the partial-word task. Preliminary Study A1 had included only the most difficult visual gestalts in order to maximize the number of potential unsuccessful visual gestalt trials for analysis; however, it was noted that Preliminary Study A1 participants had frequently expressed discouragement about their ability to solve the visual gestalts. In order to minimize this sense of discouragement, the decision was made to select items whose visual gestalt solution rates fell between .20 and .40 in order to provide participants in future studies with some evidence of success in solving visual gestalts, while still permitting the use of .60 to .80 of the trials for analysis. The same .20 to .40 solution rate was proposed for selecting partial-word stimuli, for the same reason.

In fact, only 12 stimulus items were identified from the results of Preliminary Study A2 whose visual gestalt identification rates and partial-word solution rates both fell within the preferred .20 to .40 range. As a result, it was decided to include an additional 20 items whose visual gestalt and/or partial-word solution rates fell outside the preferred .20 to .40 rate. The resulting set of 32 items was deemed to have an acceptable partial-word solution rate (M = .27, SD = .10). See Table 1.   The 32-item set was also deemed to have an acceptable visual gestalt solution rate (M = .30, SD = .20) (from Bowers' previous studies - averaged across coherent and incoherent trials), although subsequent testing revealed a mean visual gestalt solution rate for the set of 32 items of .24 (SD = .14) (averaged across coherent and incoherent trials). See Table 2.

Table 1
Partial-word Stimulus Items

ITEM	NAME	PW Stimulus	Letters in Stimulus Item	Letters Replaced	Percent Replacement	PW Solution Rate
1	briefcase	__i_f_as_	9	5	0.56	0.14
2	camera	_am_r_	6	3	0.50	0.36
3	coffee..percolator	_of__e..p_r_o_at__	16	8	0.50	0.32
4	desklamp	d__k_a_p	8	4	0.50	0.17
5	diamond..ring	_i_m__d..r__g	11	6	0.55	0.19
6	doorknob	__o_k__b	8	5	0.63	0.19
7	elephant	__ep_a_t	8	4	0.50	0.21
8	fire..hydrant	f_re..__dr_n_	11	5	0.45	0.33
9	garbage..can	_a_ba__..c_n	10	5	0.50	0.38
10	giraffe	_i_af__	7	4	0.57	0.42
11	guitar	_ui_a_	6	3	0.50	0.14
12	helicopter	_el__op_e_	10	5	0.50	0.14
13	microscope	_i_r_s__pe	10	5	0.50	0.30
14	mitten	mi__en	6	2	0.33	0.37
15	moose	m_o_e	5	2	0.40	0.41
16	oil..lamp	_il..la_p	7	2	0.29	0.15
17	padlock	pa_l__k	7	3	0.43	0.26
18	pineapple	_i_ea_p__	9	5	0.56	0.22
19	pliers	p_ie_s	6	2	0.33	0.38
20	sailboat	_ai_bo__	8	4	0.50	0.40
21	scissors	s_i__or_	8	4	0.50	0.45
22	shovel	s_o_el	6	2	0.33	0.37
23	squirrel	s__ir__l	8	4	0.50	0.25
24	telephone	_e_e_h__e	9	5	0.56	0.21
25	tennis..racquet	_e_n_s..__c_ue_	13	7	0.54	0.15
26	toothbrush	t__t__r_sh	10	5	0.50	0.16
27	train..engine	t__in.._n_ine	11	4	0.36	0.27
28	turntable	__rn_ab__	9	5	0.56	0.32
29	turtle	tu_t__	6	3	0.50	0.31
30	umbrella	_m__el_a	8	4	0.50	0.20
31	violin	_io_i_	6	3	0.50	0.17
32	wedding..cake	_ed__n_..c_k_	11	6	0.55	0.27
Average			8.53	4.19	0.48	0.27

Individual visual gestalt item solution rates for each of the 32 items ranged from 0 to .79 (averaged across coherent and incoherent trials in Bowers' previous studies), with 9 items (28%) falling in the 0 to .19 range, 12 items (38%) falling in the desired .20 to .40 range, and 11 items (34%) falling in the .41 to .79 range. Subsequent testing revealed a mean visual gestalt solution rate for the coherent versions of the 32 items of .45 (SD = .26), with individual visual gestalt item solution rates ranging from 0 to .93, and a mean visual gestalt solution rate for incoherent versions of .04 (SD = .05), with individual visual gestalt item solution rates for each ranging from 0 to .20. See Table 2. Individual partial-word item solution rates for each of the 32 items ranged from .14 to .45, with 10 items (31%) falling in the .14 to .19 range, 19 items (59%) falling within the desired .20 to .40 range, and 3 items (9%) falling within the .41 to .45 range.

With the development of a set of 32 items with floor and ceiling free partial-word solution rates, Study I was proposed, in which participants would attempt to solve each visual gestalt and subsequently attempt to solve the related partial-word puzzle. It was predicted that in Study I the partial-word solution rate would be significantly greater than the baseline .27 partial-word solution rate established in Preliminary Study A2 for trials in which participants are unsuccessful in their attempts to solve visual gestalts, for both incoherent and coherent gestalts. It was also predicted that the partial-word solution rate following unsuccessful attempts to solve coherent visual gestalts would be significantly greater than the partial-word solution rate following unsuccessful attempts to solve incoherent visual gestalts.

Table 2
Item Visual Gestalt Solution Rates by Study

ITEM	NAME	Study I ITEM INC VGpc	Study I ITEM COH VGpc	Study II ITEM INC VGpc	Study II ITEM COH VGpc	Study III ITEM INC VGpc	Study III ITEM COH VGpc	Average ITEM INC VGpc	Average ITEM COH VGpc	Average ITEM INC + COH VGpc
1	briefcase	0.09	0.09	0.09	0.18	0.13	0.59	0.10	0.29	0.20
2	camera	0.00	0.27	0.00	0.18	0.00	0.11	0.00	0.19	0.09
3	coffee percolator	0.00	0.00	0.00	0.55	0.00	0.29	0.00	0.28	0.14
4	desklamp	0.00	0.55	0.18	0.91	0.08	0.62	0.09	0.69	0.39
5	diamond ring	0.00	0.45	0.00	0.60	0.00	0.35	0.00	0.47	0.23
6	doorknob	0.18	0.91	0.00	0.82	0.17	1.00	0.12	0.91	0.51
7	elephant	0.00	0.91	0.00	0.73	0.00	0.72	0.00	0.79	0.39
8	fire hydrant	0.00	0.36	0.00	0.18	0.00	0.21	0.00	0.25	0.13
9	garbage can	0.00	0.82	0.09	0.64	0.00	0.48	0.03	0.65	0.34
10	giraffe	0.18	0.91	0.18	0.91	0.22	0.97	0.20	0.93	0.56
11	guitar	0.00	0.27	0.18	0.27	0.21	0.10	0.13	0.21	0.17
12	helicopter	0.00	0.36	0.00	0.18	0.00	0.31	0.00	0.28	0.14
13	microscope	0.00	0.55	0.09	0.55	0.00	0.47	0.03	0.52	0.28
14	mitten	0.00	0.09	0.00	0.00	0.00	0.03	0.00	0.04	0.02
15	moose	0.00	0.73	0.00	0.64	0.00	0.65	0.00	0.67	0.33
16	oil lamp	0.00	0.09	0.00	0.09	0.10	0.24	0.03	0.14	0.09
17	padlock	0.00	0.27	0.00	0.18	0.00	0.08	0.00	0.18	0.09
18	pineapple	0.09	0.64	0.09	0.55	0.07	0.69	0.08	0.63	0.35
19	pliers	0.00	0.27	0.27	0.45	0.03	0.18	0.10	0.30	0.20
20	sailboat	0.00	0.64	0.09	0.64	0.00	0.65	0.03	0.64	0.34
21	scissors	0.00	0.64	0.00	0.82	0.00	0.81	0.00	0.75	0.38
22	shovel	0.00	0.91	0.00	0.73	0.00	0.62	0.00	0.75	0.38
23	squirrel	0.00	0.82	0.00	0.73	0.00	0.59	0.00	0.71	0.36
24	telephone	0.00	0.00	0.09	0.00	0.03	0.00	0.04	0.00	0.02
25	tennis racquet	0.00	0.45	0.09	0.45	0.00	0.45	0.03	0.45	0.24
26	train engine	0.00	1.00	0.36	0.82	0.00	0.03	0.12	0.62	0.37
27	toothbrush	0.00	0.00	0.00	0.00	0.18	0.87	0.06	0.29	0.17
28	turntable	0.18	0.82	0.00	0.36	0.00	0.72	0.06	0.63	0.35
29	turtle	0.00	0.18	0.00	0.27	0.00	0.24	0.00	0.23	0.11
30	umbrella	0.00	0.00	0.00	0.09	0.00	0.06	0.00	0.05	0.02
31	violin	0.00	0.55	0.00	0.55	0.00	0.48	0.00	0.52	0.26
32	wedding cake	0.00	0.09	0.00	0.36	0.00	0.38	0.00	0.28	0.14
Average		0.02	0.46	0.06	0.45	0.04	0.44	0.04	0.45	0.24

Study I

Study I was designed to determine whether intuition operates in an "all-or-nothing" fashion, providing either full knowledge of a solution to a puzzling problem or nothing at all, or in a graded, accumulative fashion, providing increasingly complete intermediate, or partial knowledge of a solution. If the former "all-or-nothing" model is correct, an unsuccessful attempt to solve a visual gestalt should provide the problem-solver with nothing that could facilitate solution of a subsequent, related partial-word puzzle. If, on the other hand, the partial knowledge model is correct, an unsuccessful attempt to solve a visual gestalt may provide the problem-solver with some accumulation of partial-knowledge that will facilitate solution of a subsequent, related partial-word puzzle. Further, while both unsolved coherent and unsolved incoherent visual gestalts could lead to partial-word facilitation, an unsolved coherent visual gestalt should provide a problem-solver with more partial-knowledge than an unsolved incoherent visual gestalt, and coherent partial-word facilitation should be greater than incoherent partial-word facilitation.

The set of 32 stimulus items developed in Preliminary Study A2 was employed in Study I. Each item in the set was represented by a visual gestalt and a partial-word puzzle, for which the correct solution was the name of the object represented in the visual gestalt for that item. The presentation of each item could take one of two forms: a coherent visual gestalt version and an incoherent visual gestalt version. The same partial-word puzzle was used for coherent and incoherent versions of each item.

It is predicted that participants' attempts to solve visual gestalts prior to attempting to solve the corresponding partial-word puzzle in Study I will lead to three distinct levels of partial-word facilitation. The greatest amount of partial-word facilitation is expected to occur on trials in which participants achieve a successful solution to the visual gestalt and the name of the object portrayed in the gestalt reaches conscious awareness prior to the attempt to solve the partial-word puzzle. The next greatest amount of partial-word facilitation is expected to occur on trials in which coherent visual gestalts are attempted, but not solved. The least amount of partial-word facilitation was expected to occur on trials in which incoherent visual gestalts are attempted, but not solved. It is predicted that in Study I, following unsuccessful attempts to solve visual gestalts:

a) participants' partial-word solution rate will be significantly greater than the .27 baseline rate for both coherent and incoherent trials, and
b) participants' coherent partial-word solution rate will be significantly greater than their incoherent partial-word solution rate.

Method

Participants

Participants (n = 22) were recruited from the University of Waterloo undergraduate pool on the basis of self-report of vision adequate for normal reading and average English language proficiency. In the initial telephone contact, participants were told that the purpose of the experiment was to study perceptual problem-solving skills and that they would be asked to try to solve puzzles, some of which would involve identifying objects in drawings and some of which would involve solving word puzzles related to the objects in the drawings. Participants were told that some of the problems were very difficult and that one's ability to solve them had no bearing on one's intelligence.

Materials

Materials for the visual gestalt identification phase consisted of coherent and incoherent versions of each of the 32 black and white visual gestalt items selected in Preliminary Study A2. From Bowers' previous studies, the mean visual gestalt solution rate (averaged across coherent and incoherent) for this set of 32 items was known to be .30 (SD = .20), and individual item gestalt solution rates (averaged across coherent and incoherent) ranged from 0 to .79. Each visual gestalt item was printed individually on the upper half of an 8.5 x 11 sheet of white paper. Below each visual gestalt on the page was the question, "What is this object?" with an underlined space to write in an answer, and a confidence rating scale, which consisted of the question, "How sure are you?" and a scale from 0 to 100%.

Materials for the partial-word solution phase consisted of the same set of coherent and incoherent visual gestalt items printed individually on the upper half of an 8.5 x 11 sheet of white paper. The partial-word solution task was placed on the lower half of each page. Below each visual gestalt was the instruction to "Fill in the missing letters" and a partial-word puzzle whose correct solution was the name of the object portrayed in the visual gestalt. It was found in the Preliminary Study A2 that the mean item partial-word solution rate for this set of items was .27 (SD = .10), and item partial-word solution rates ranged from .14 to .45.

Procedure

Participants in Study I were tested individually. Participants entering the lab were informed that they would be participating in a study of visual perception in which they would be asked to look at some drawings of objects, which could be humanly made things such as buildings, tools, or machines, or naturally occurring things, such as people, animals, or plants, and try to identify them. It was explained that some of the items portrayed in the drawings were not easy to recognize and that everyone had difficulty with some of them. They were informed that after trying to identify the object in each drawing they would also be asked to try to solve a missing-letter word puzzle, for which the correct solution was the name of the object in the drawing. Participants were then asked to sign the participation consent form if they wished to participate in the study.

Participants were then informed that they would have 30 seconds to look at each drawing, write down the name of the object in the space provided, and rate how confident they were that their response was correct by writing in a number between 0, indicating "no confidence – a wild guess," and 100%, indicating "absolutely sure". It was emphasized that it was important that they respond to each item and if stumped to take a wild guess and to rate their confidence for that item at a very low level to indicate that it was just a guess.

Participants were then told that after writing down a response and a confidence rating they would have another chance to see the drawing, but this time it would appear together with a word puzzle. The word in the word puzzle would be the name of the object in the drawing, but it would have blanks in the place of some of the letters. Participants were told that they would have 30 seconds to write down the word that correctly solved the word puzzle and revealed the identity of the object portrayed in the drawing.

Participants were timed as they completed each visual gestalt identification form. At the 25-second mark, if a participant appeared unable to identify the object, s/he was instructed to simply write down "whatever came to mind, even if it seems unlikely" while looking at the picture and to complete the confidence rating scale. After the participant supplied a confidence rating the form containing the visual gestalt and the confidence rating scale was removed.

Immediately following removal of the visual gestalt identification form, the partial-word solution form was presented, which contained the same version of the visual gestalt item that had appeared on the previous form along with its related partial-word puzzle. On the first few items participants were reminded that they would have 30 seconds and that the correct solution to the partial-word puzzle was the name of the object portrayed in the visual gestalt. At the end of the 30 second interval, the partial-word form was taken away, whether completed or not, and the visual gestalt identification form for the next item was presented.

Each participant attempted all thirty-two stimulus items, sixteen presented in the coherent version and sixteen presented in the incoherent version. Stimulus items were randomized for each participant with respect to item order and item coherence.

It was predicted that the partial-word solution rate following unsuccessful attempts to identify visual gestalts would be significantly greater than the baseline partial-word solution rate of .27 established in Preliminary Study A for both coherent and incoherent trials. As well, it was predicted that the partial-word solution rate following unsuccessful attempts to identify coherent visual gestalts would be significantly greater than the partial-word solution rate following unsuccessful attempts to identify incoherent visual gestalts.

Results and Discussion

With the use of dependent measures free of floor and ceiling effects, Study I clearly demonstrated that both successful and unsuccessful attempts to solve visual gestalts lead to significant facilitation of performance on the related partial-word task, as illustrated in Figure 13.

Analysis of item partial-word solution rates revealed that, for Study I trials in which visual gestalts were solved, the mean item partial-word solution rate was 1.0. An independent samples t-test comparison of item partial-word solution rates established in Preliminary Study A2 (partial-word baseline) and item partial-word solution rates obtained in Study I for trials in which gestalts were unsolved (collapsed across coherent and incoherent trials) revealed that the Study I rate ($M = .49$, $SD = .21$) was significantly greater, $t\,(43) = 5.41$, $p < .001$, than the Preliminary Study A2 partial-word solution rate ($M = .27$, $SD = .10$).

For Study I trials in which gestalts were not solved, an independent samples t-test of item partial-word solution rates revealed that the rate for unsolved coherent trials ($M = .59$, $SD = .31$) was significantly greater, $t\,(62) = 5.56$, $p < .001$ (one-tailed), than the Preliminary Study A2 partial-word solution rate. The rate for unsolved incoherent trials ($M = .41$, $SD = .19$) was also significantly greater, $t\,(62) = 3.64$, $p < .001$ (one-tailed), than the Preliminary Study A2 partial-word solution rate.

Within Study I, a paired samples t-test revealed that the item partial-word solution rate for unsolved coherent trials (M = .59, SD = .31) was significantly greater, $t(30) = 3.36$, $p < .002$ (one-tailed), than the item partial-word solution rate for unsolved incoherent trials (M = .41, SD = .20) (one item-pair deleted due to missing data). These results are consistent with *a priori* prediction of three distinct levels of partial-word facilitation. As predicted, the greatest amount of partial-word facilitation occurred on trials in which participants solved visual gestalts prior to attempting partial-word puzzles. Also as predicted, on trials in which visual gestalts were attempted, but not solved:

a) the item partial-word solution rate was significantly greater than the .27 baseline rate for both coherent and incoherent trials, and

b) the item partial-word solution rate was significantly greater for trials with coherent gestalts than for trials with incoherent gestalts.

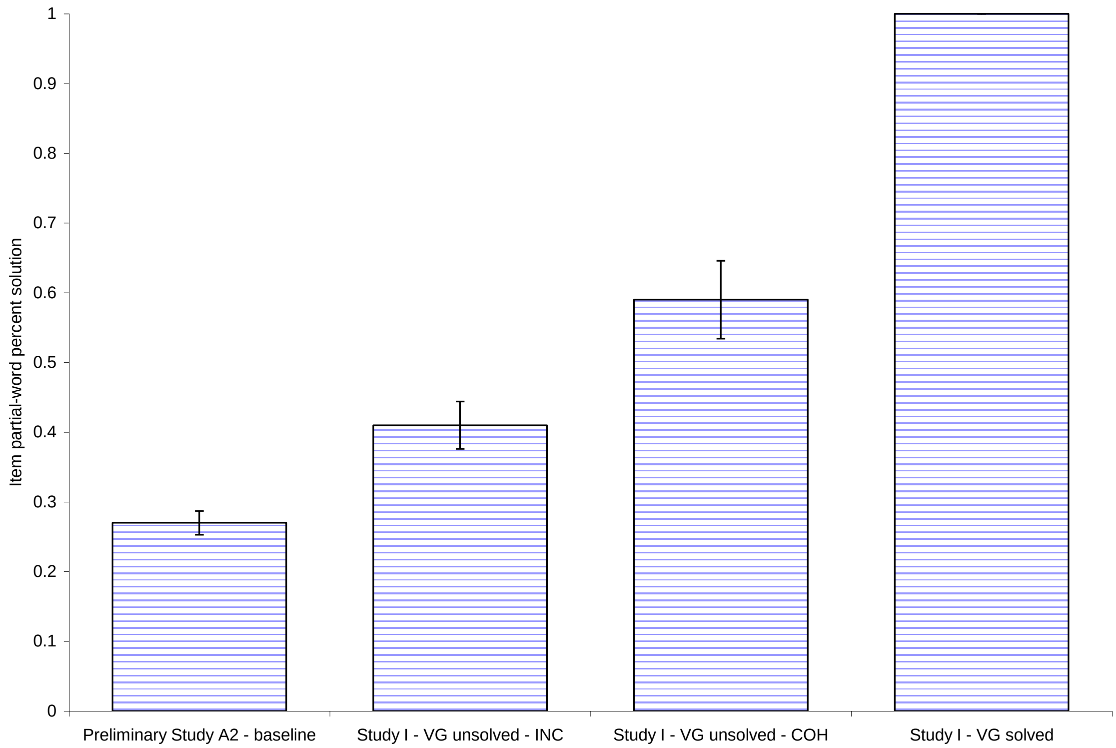

Figure 13. Item partial-word percent solution: Preliminary Study A2 vs. Study I

The latter finding, i.e., that in Study I the item partial-word solution rate was significantly greater for trials with coherent gestalts than for trials with incoherent gestalts, was echoed by the finding that amongst Study I trials in which gestalts were unsolved the participant partial-word solution rate was significantly greater for trials with coherent gestalts than for trials with incoherent gestalts. A paired-samples t-test revealed that the mean participant partial-word solution rate for trials involving coherent gestalts, $\underline{M} = .55$, $\underline{SD} = .17$, was significantly higher, $\underline{t}\ (21) = 3.60$, $\underline{p} < 0.001$ (one-tailed), than for trials involving incoherent gestalt trials, $\underline{M} = .41$, $\underline{SD} = .16$, a finding that will be referred to as the "Coherent Advantage." This finding is consistent with *a priori* predictions, and is supportive of an accumulative model, but not an "all-or-nothing" model.

Overall, these findings support the idea that participants exposed to a puzzling problem will accumulate increments of useable knowledge about a potential solution to that problem through their attempts to solve the problem, even when unable to achieve conscious awareness of the solution or to experience a sense of having any information about the solution. Further, the results of Study I demonstrate that the quality of the information available in the problem itself plays an important role in how much useable knowledge participants can accumulate in the absence of conscious recognition of stimuli. Participants in Study I were able to achieve a higher rate of partial-word solution following unsuccessful attempts to solve higher quality coherent stimuli than following unsuccessful attempts to solve the lesser quality incoherent stimuli, indicating that in their unsuccessful attempts to solve visual gestalts they were gaining more useful information from coherent gestalts than from incoherent gestalts. Thus, the findings of Study I are not seen to support an "all-or-nothing" model, but to support an accumulative model.

While collecting data from participants in Study I, experimenters noted two interesting phenomena. First, in the partial-word solution phase most participants appeared to be alternating their attention back-and-forth repeatedly between the visual gestalt and the partial-word puzzle. Second, several participants remarked that they found it disheartening that even when they believed that they had solved the partial-word puzzle they were still unable to identify the named item within the visual gestalt. Some participants even suggested that they might have performed better with the partial-word puzzles had the visual gestalts not been presented a second time. This raised questions about what it was that participants were actually doing in the partial-word solution phase, and for what reason. While the shifting of attention back and forth between the partial-word puzzle and the visual gestalt during the partial-word solution phase was almost ubiquitous amongst participants, it was not clear whether this behaviour was helping or hindering participants' attempts to solve the partial-word puzzles.

It was reasoned that if participants could achieve the same pattern of partial-word facilitation demonstrated in Study I while focusing solely on the partial-word puzzle during the partial-word solution phase, then the mechanism producing facilitation could be a straightforward example of what Yaniv and Meyer referred to as "memory sensitization" through the process of spreading activation. This explanation has frequently been proposed to explain facilitation in studies of verbal priming, i.e., the prime generates an accumulation of residual activation at solution-relevant nodes which facilitates subsequent performance on an implicit knowledge task. Thus, it may be that the spread of activation energy generated by participants' unsuccessful attempts to identify a visual gestalt deposits sufficient residual energy at a correct semantic/verbal label node to facilitate performance on the partial-word task. From this perspective the back and forth alternation of attention observed in Study I adds nothing to, and may in fact impair, partial-word facilitation by wasting attentional resources.

On the other hand, since most participants were observed to be alternating their attention back and forth between the partial-word puzzle and the visual gestalt during the partial-word solution phase, it may be that a simple spreading activation explanation is not sufficient to explain the pattern of partial-word facilitation demonstrated in Study I. It may be that back-and-forth alternation of attention is an important factor in partial-word facilitation, one that provides participants with additional increments in partial-knowledge by engaging in a different type of activation event, with a second type of activation event that takes place at a “hunch” node that is in some way relevant to both the visual gestalt and the partial-word puzzle.

Potential sites for this new, secondary type of activation event would be word nodes that have accumulated the most residual energy through participants’ activation of elements within the gestalt and initial attempts to solve the partial-word puzzle. As with the simple activation model, a participant’s unsuccessful attempts to solve a visual gestalt will generate a pattern of residual energy in the participant’s associative network. One of the nodes likely to have a relatively high accumulation of residual energy will be the node for the word that solves both the visual gestalt and the partial-word puzzle, but the accumulation may not yet be enough to facilitate solution of the partial-word puzzle.

While the accumulation of residual energy may not be sufficient to facilitate solution of the partial-word puzzle, it may be enough to set it apart from other activated word nodes, which would allow this word node to serve as the site for a secondary activation event. Energy from the secondary activation event then spreads from the activated node to nodes for concepts that are associatively and logically related to the activated node, creating a new, secondary pattern of residual energy in the participants’ associative network. At this point, there may be intersections with the existing pattern of residual activation generated by the primary activation event(s) at nodes for characteristics experienced as somehow relevant to the visual gestalt. These intersections will occur at nodes that are in some way meaningful to both information sources, likely at semantic nodes that connect images with their labels. Thus, it may be that an unsuccessful attempt to identify a visual gestalt does result in an accumulation of residual energy at a correct word node, but the accumulation is not sufficient to facilitate performance on the subsequent partial-word task. It may be that partial-word facilitation is dependent on the addition of activation energy from the intersection(s) of primary and secondary spreads of activation. From this perspective the back and forth alternation of attention observed in Study I would be an important contributor to partial-word facilitation.

Returning to the eagle example discussed earlier, in the attempt to identify a visual gestalt of an eagle, activation events at nodes corresponding to features perceived to be present in the gestalt will deposit a high level of residual energy at the “eagle” word node, relative to other word nodes. If, however, the participant is unable to solve the gestalt and then attempts to solve the corresponding partial-word puzzle, the accumulation of residual energy at the “eagle” word node may be insufficient to facilitate solution of the “eagle” partial-word puzzle. At this point, if the gestalt is still present the participant has the option to activate “backwards” from a “hunch,” i.e., a high residual energy word node, to the data of the visual gestalt. A trial activation of the word node retaining the highest accumulation of residual energy will send a spread of activation energy outward into the associative network to nodes for things that are associatively linked with that word, which logically would be nodes for semantic and imagistic information that is highly associated with the activated word node. If the node activated is for the word “eagle,” and the object portrayed in the visual gestalt is, in fact, an eagle then very many of the nodes receiving activation energy in the spread from the “eagle” word node will represent “eagle characteristics,” and these are likely to map onto features present in the gestalt, e.g., “beak,” “wing,” “talon,” “feather,” etc.

Nodes that are in some way meaningful to, and highly associated with both the "eagle" visual gestalt and the "eagle" partial-word puzzle may receive activation energy from both the initial, or primary spread of activation and the subsequent "backward," or secondary spread of activation. Some of this energy will be retained at these intersection nodes in the form of residual energy, and some will be passed on to other associated nodes, with the result being an increased localization of residual energy in the associative network at nodes within the "eagle pattern." These nodes will accumulate residual activation at a rapid rate compared with other possible patterns. Amongst nodes in the "eagle pattern" those at high levels of abstraction will accumulate residual energy at a particularly rapid rate due to their being tightly interconnected with each of the nodes in the "eagle pattern."

Thus, the activation of nodes associated with both the "eagle" visual gestalt and the "eagle" partial-word puzzle, will cause a rapid accumulation of residual energy at high-level nodes such as the word node for "eagle." It may be necessary for the problem-solver to engage in several rounds of alternating primary and secondary activation, activating different combinations of gestalt and partial-word puzzle nodes, before enough residual energy has accumulated at the "eagle" word node to allow the word eagle to breach consciousness as the desired solution. Given that repeated alternation of attention between gestalt and partial-word puzzle was the actual behaviour demonstrated by participants in the partial-word solution phase of Study I, this model, referred to in following sections as the alternating activation model, appears to hold promise as an explanation of the facilitation effect demonstrated in Study I.

Study II

Since it was unclear whether partial-word facilitation demonstrated in Study I could be best explained by a simple activation model or by an alternating activation model, Study II was designed to examine the significance of participants' behaviour in the partial-word solution phase in Study I. Study II followed the procedure of Study I, with one exception: the partial-word solution phase presentation of the visual gestalt was eliminated. With this alteration in procedure, activation from gestalt nodes to partial-word puzzle would remain a potential route to partial-word facilitation, but activation from a "hunch" word node back to expected gestalt characteristics would be completely dependent on participants' memory for previously unrecognized gestalt features, and therefore unlikely as a route to partial-word facilitation.

If the simple activation model is correct, eliminating the gestalt presentation in the partial-word solution phase should not decrease partial-word facilitation, and may, in fact, lead to an increase in partial-word facilitation since participants will be concentrating all of their attentional resources on the partial-word puzzle during the partial-word solution phase. From the simple activation perspective, the overall pattern of partial-word facilitation in Study II should closely resemble that seen in Study I, i.e., facilitation will be greatest on trials in which visual gestalts are solved, less on trials in which coherent visual gestalts are unsolved and least on trials in which incoherent visual gestalts are unsolved. In the latter two conditions, item partial-word performance will continue to be significantly greater than the partial-word solution baseline of .27 established in Preliminary Study A2.

The alternating activation model, on the other hand, predicts that eliminating the partial-word solution phase presentation of the gestalt will significantly disrupt partial-word facilitation. From this perspective, without the opportunity to alternate between primary and secondary activations participants will accumulate lesser amounts of residual energy at the correct word node. What is not clear, however, is whether eliminating the gestalt presentation in the partial-word solution phase will simply reduce partial-word facilitation, or eliminate it altogether. If the accumulation of residual energy at solution-relevant nodes is reduced somewhat, this may be reflected in reduced item partial-word facilitation, falling at some intermediate between the .27 (SD = .10) baseline established in Preliminary Study A2 and the .49 (SD = .21) level observed in Study I. Facilitation will likely continue to be affected by the coherence of unrecognized visual gestalts, and the partial-word solution rate following unrecognized coherent gestalts will likely continue to be greater than following unrecognized incoherent gestalts.

With the loss of the opportunity to alternate between primary and secondary activations, however, it may be that the accumulation of residual energy at solution-relevant nodes is no longer sufficient to facilitate solution of the partial-word puzzle, in which case item partial-word performance will not differ from the .27 baseline, and the coherence of unrecognized visual gestalts will have no effect on partial-word performance. In brief, the alternating activation model predicts that elimination of the partial-word solution phase presentation of the visual gestalt will reduce, but not eliminate, the overall level of partial-word facilitation and the coherent advantage will be maintained, or, alternatively, it will eliminate both partial-word facilitation and the coherent advantage.

Method

Participants

Participants (n = 22) were recruited from the University of Waterloo undergraduate pool on the basis of self-report of vision adequate for normal reading and average English language proficiency. In the initial telephone contact, participants were told that the purpose of the experiment was to study perceptual problem-solving skills and that if they agreed to participate they would be asked to try to solve puzzles, some of which would involve identifying objects in drawings and some of which would involve solving word puzzles related to the objects in the drawings.

Materials

Materials for the visual gestalt identification phase consisted of coherent and incoherent versions of each of the 32 black and white visual gestalt items selected in Preliminary Study A2. The mean item identification rate (pooled coherent and incoherent) for this set of stimulus items fell at .30 (SD = .20), and individual item identification rates (coherent and incoherent collapsed) ranged from 0 to .79. As in Study I, each stimulus item for the visual gestalt identification phase was printed on the upper half of an 8.5 x 11 inch sheet of white paper. Below each visual gestalt on the page was the question, “What is this object?” with an underlined space to write in an answer, and a confidence rating scale, which consisted of the question, “How sure are you?” and a scale from 0 to 100%.

Materials for the partial-word solution phase were similar to those used in Study I, with the important difference that the upper half of each 8.5 x 11 sheet was left blank in the space where the visual gestalt had appeared in the partial-solution phase of Study I.

As in Study I, the lower half of each sheet contained the partial-word solution task, which consisted of the instruction to "Fill in the missing letters" and a partial-word puzzle whose correct solution was the name of the object portrayed in the visual gestalt identification phase for that trial. The mean item partial-word solution rate for this set of items fell at .27 (SD = .10), and individual Item partial-word solution rates ranged from .14 to .45.

Procedure

Participants in Study II were tested individually. Participants entering the lab were informed that they would be participating in a study of visual perception in which they would be asked to look at some drawings and to try to identify the objects portrayed in each of the drawings. They were told that the objects in the drawings could be humanly made things such as buildings, tools, or machines, or naturally occurring things, such as people, animals, or plants. It was explained that some of the objects portrayed in the drawings were not easy to recognize and that everyone had difficulty with some of them. Participants were informed that after attempting to identify the object in a drawing, they would then be asked to try to solve a missing letter word puzzle, which, if solved correctly, would be the name of the object in the drawing they had just seen.

Participants were then informed that they would have 30 seconds to look at each drawing, write down the name of the object in the space provided, and rate how confident they were that their response was correct by circling a number on the rating scale or writing down a number between 0 (indicating "no confidence – a wild guess") and 100% (indicating "absolutely sure"). It was emphasized that it was important for the purpose of the study that they write down something for each item, even if it meant taking a wild guess. They were told that they should rate their confidence for that item at a very low level to indicate that it was just a guess.

Participants were told that after writing down a response and a confidence rating for a drawing, the drawing would be taken away and they would then be asked to try to solve the missing-letters word puzzle. Participants were informed that the solution to the word puzzle would be the name of the object in the drawing they had just seen. In order to reveal the solution they would have to fill in the blanks in the word puzzle with the correct letters. Participants were told that they would have 30 seconds to fill in the blanks to solve the word puzzle.

Participants were timed as they completed each visual gestalt identification form. If a participant appeared unable to identify the object at the 25-second mark, s/he was instructed to simply write down "whatever came to mind, even if it seems unlikely" while looking at the picture and to complete the confidence rating scale. After the participant supplied a response and a confidence rating the visual gestalt identification form was removed.

Immediately following removal of the visual gestalt identification form, participants were given the partial-word solution form, which contained the partial-word puzzle for the visual gestalt they had just seen. On the first few items participants were reminded that they would have 30 seconds to solve the word puzzle and that the correct solution was the name of the object portrayed in the visual gestalt they had just seen. At the end of the 30 second interval the partial-word form was taken away, whether completed or not, and the visual gestalt identification form for the next item was presented. Each participant attempted all 32 stimulus items, half in the coherent version and half in the incoherent version. Stimulus items were randomized for each participant with respect to item order and coherence of each item.

Results

The pattern of results for Study II was complex. As in Study I, Study II trials in which visual gestalts were solved resulted a near perfect item partial-word solution rate, $M = .96$, $SD = .15$. Also as was the case in Study I, on Study II trials in which visual gestalts were unsolved an independent samples t-test revealed that the mean (coherent and incoherent collapsed) item partial-word solution rate ($M = .39$, $SD = .20$), was significantly greater, $t(45) = 3.06$, $p < .002$ (one-tailed), than the baseline item partial-word solution rate ($M = .27$, $SD = .10$) obtained in Preliminary Study A2. The Study II mean item partial-word solution rate was, however, significantly lower, $t(62) = 2.90$, $p < .04$, two-tailed) than the mean item partial-word solution rate obtained in Study I ($M = .49$, $SD = .21$).

On Study II trials in which gestalts were not solved, an independent samples t-test revealed that the incoherent item partial-word solution rate ($M = .38$, $SD = .21$) was significantly greater, $t(62) = 2.77$, $p < .004$ (one-tailed), than the Preliminary Study A2 baseline partial-word solution rate ($M = .27$, $SD = .10$), as was the coherent item partial-word solution rate ($M = .39$, $SD = .23$), $t(59) = 2.54$, $p < .007$ (one-tailed). Unlike in Study I, however, in which the item partial-word solution rate for unsolved gestalts had been significantly greater on coherent trials than on incoherent trials, in Study II there was no such difference. A paired-samples t-test revealed that the Study II item partial-word solution rate for unsolved gestalts on coherent trials ($M = .39$, $SD = .23$) was not significantly different, t(29) = 0.32, p = .37 (one-tailed), than the rate for incoherent trials (M = .38, SD = .21) (two item-pairs deleted due to missing data).

Thus, as illustrated in Figure 14, while both successful and unsuccessful attempts to identify visual gestalts in Study II did lead to significant facilitation of partial-word performance, facilitation following trials with unsolved coherent gestalts was less than that observed in Study I and was not significantly different than facilitation following trials with unsolved incoherent gestalts in Study II.

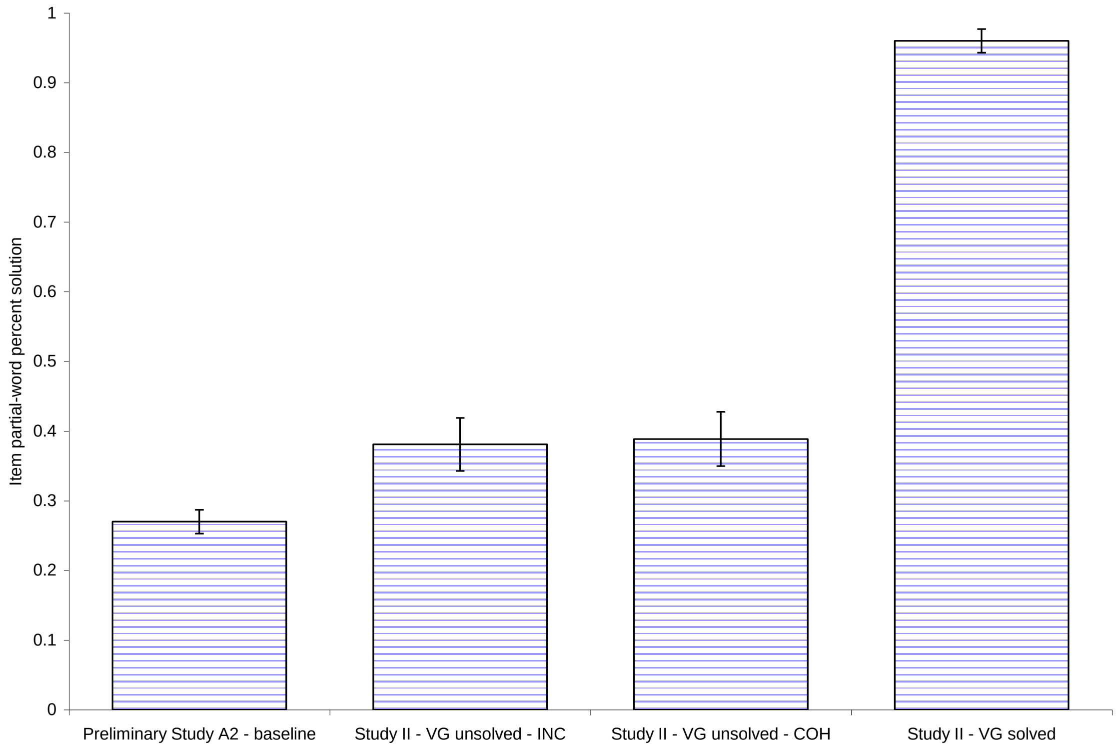

Figure 14. Item partial-word percent solution: Preliminary Study A2 vs. Study II

Echoing the finding of equivalence of item partial-word facilitation following unsolved coherent and incoherent gestalts in Study II, a paired-sample t-test revealed that for unsolved gestalts there was no significant difference, t(21) = 0.41, p < .34 (one-tailed), between the participant partial-word solution rate for coherent trials (M = .40, SD = .18) and incoherent trials (M = .39, SD = .18).

Comparing the Study I participant partial-word solution rate for trials with unsolved incoherent trials, M = .41, SD = .16, with the rate for Study II, M = .39, SD = .18, an independent samples t-test using separate variances revealed no significant difference, $t(42) = 0.46$, $p = .65$ (two-tailed). On the other hand, comparing Study I participant partial-word solution rates for trials with unsolved coherent trials, M = .55, SD = .17, with the rate for Study II, M = .40, SD = .18, an independent samples t-tests using separate variances revealed that the Study I rate was significantly greater, $t(42) = 2.81$, $p < .008$ (two-tailed), than the rate obtained in Study II.

To summarize, in Study II the elimination of the partial-word solution phase presentation of the visual gestalt had no effect on partial-word facilitation on trials in which participants attempted but failed to identify incoherent gestalts, a finding that is consistent with the simple activation model, but not the alternating activation model. On the other hand, for trials in which participants attempted but failed to identify coherent gestalts, the additional increment in partial-word facilitation observed in Study I was completely eliminated in Study II, a finding that is consistent with the alternating activation model, but inconsistent with the simple activation model. See Figure 15.

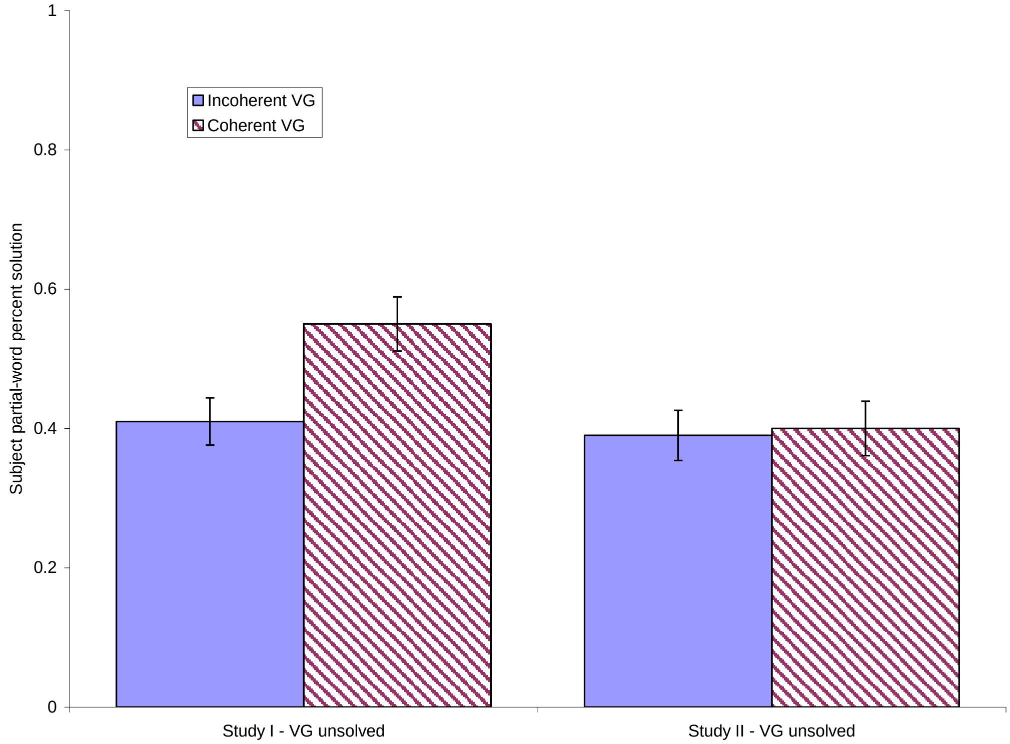

Figure 15 - Study I vs. Study II: The effect of eliminating the partial-word solution phase presentation of the visual gestalt on the coherent advantage

Discussion

The Study II partial-word solution rate for trials involving unsolved incoherent gestalts was unchanged from the rate observed in Study I, clearly demonstrating that the absence of the visual gestalt during the partial-word solution phase was irrelevant to incoherent partial-word facilitation. On the other hand, on trials involving unrecognized coherent gestalts, elimination of the visual gestalt during the partial-word solution phase had the effect of decreasing the coherent partial-word solution rate to a level that was not significantly different from the incoherent partial-word solution rate observed in Study I and Study II. In short, elimination of the partial-word solution phase visual gestalt presentation had the precise effect of eliminating the additional increment in partial-word facilitation demonstrated in Study I trials with unsolved coherent gestalts, i.e., the coherent advantage.

At first glance, the disappearance of the coherent advantage was puzzling: Why should eliminating opportunities for back-and-forth alternation between the partial-word puzzle and the visual gestalt result in a decrease in coherent facilitation, while leaving incoherent facilitation unchanged? The answer is likely to lie in a closer examination of the back-and-forth attention-shifting behaviour demonstrated by participants in Study I. As discussed in earlier sections, when a problem-solver first attempts to solve a visual gestalt, s/he may respond to some feature of the gestalt as a known characteristic, such as a "beak." With primary activation of a node corresponding to the concept "beak," a spread of activation energy is sent throughout the problem-solver's associative network. Some of the activation energy will spread along logical links to nodes for things at a higher level of abstraction that are capable of "owning" the activated characteristic. Among these nodes for higher-level things receiving activation energy will be the node for the name of a potential owner, which may serve as a "hunch" that can assist the problem-solver in his/her subsequent attempts to solve the word puzzle, whose solution will be the name of the potential owner of the noted gestalt feature.

When the problem-solver attempts but fails to solve the partial-word puzzle, a secondary, deductive activation at the "hunch" node may occur, sending a highly focused spread of activation to nodes for things within the "hunch system," i.e., nodes for things that are closely associated with that hunch. Included in the "hunch system" will be nodes for characteristics and organizational relationships amongst those characteristics that should be present in the visual gestalt and the partial-word puzzle for that hunch to be the correct solution. Thus, following a secondary activation event at a correct “hunch” node, a high level of residual energy will accumulate at nodes for a set of expected characteristics and organizational relationships amongst those characteristics.

When the problem-solver turns his/her attention back to the gestalt, the relatively high accumulation of residual energy at nodes for things within the “hunch” system will sensitize him/her to detect their presence within the data of the gestalt.   If the gestalt is coherent, there may be many matches between expected characteristics/organization and actual gestalt features, and whether consciously registered or not, each expected/actual match will result in an additional increment of residual energy at nodes where these matches occur. The relatively high residual energy held at these nodes then marks out each “match” node as a potential site for a new primary inductive activation event. When a primary activation event occurs at one of these “match” nodes, some of the activation energy will flow “upward” through logical links to nodes for things with the potential to “own” the matching gestalt feature. If the “hunch” node is the correct solution, each activated “match” node will send activation energy to the “hunch” node, so that the residual energy accumulates rapidly at the “hunch” node.

When the problem-solver shifts his/her attention back to the partial-word puzzle, the level of residual energy now held at the “hunch” node may be sufficient to allow the problem-solver to solve the partial-word puzzle. If not, the “hunch node” may serve as the site for another secondary activation, sending more activation energy through the “hunch system” and depositing more energy at nodes for characteristics/organizational relationships that should be present, thereby increasing the likelihood that the problem-solver will respond to the presence of previously ignored gestalt features, and, increasing the likelihood of new matches between expected characteristics/organization and gestalt features, adding new "match" sites for subsequent primary activation events which will send more activation energy to the "hunch" node.

So long as the problem remains unsolved, this pattern of alternating back-and-forth between primary and secondary activations can continue, with each secondary activation of the "hunch" node differentially depositing energy at nodes in the "hunch system" and every primary activation of a new "match" node differentially depositing energy at the "hunch" node. After several rounds of alternating activation, enough residual energy may accumulate at the correct "hunch" node to boost it above the threshold of consciousness, at which point the problem-solver will experience the "aha" of recognition as the concept corresponding to the "hunch" node enters consciousness.

Logically, however, elimination of the partial-word phase presentation of the visual gestalt would severely hamper the strategy of alternating attention back-and-forth between visual gestalt and partial-word stimuli. To engage in alternating activation under these circumstances, participants would be forced to attempt to recall features and/or organizational relationships from the visual gestalt without ever having consciously identified the object portrayed in that gestalt. Thus, the process of alternating activation would be entirely reliant on a participant's ability to carry forward something in memory from the unrecognized visual gestalt. The most likely candidate in this would be any aspect of the gestalt that participants can "tag" with a verbal label. For example, it would be fairly easy to retain a detail from the visual gestalt in memory if it could be tagged as a "beak." Supporting this idea is the observation that participants fairly frequently reported that when they could not identify the object in a gestalt, they would focus on any feature or features that they did feel they could recognize.

What this means for the alternating activation process is that as the problem-solver engages in secondary activation from a “hunch” node, the potential for matches between expected characteristics/organization and actual gestalt features will be limited to nodes for gestalt features that the problem-solver has been able to tag with a verbal label. This in turn limits the amount of activation energy that can be passed back to the “hunch” node in the subsequent spread of primary activation from “match” nodes, since there will be few or no matches between expected organizational relationships and gestalt features not tagged with verbal labels in the visual gestalt identification phase.

It should be pointed out here that for incoherent gestalts, even in Study I, in which the visual gestalt was available throughout the partial-word solution phase, the process of alternating activation would likely only involve nodes for characteristics and not nodes for organizational information. While secondary activation of a correct “hunch” node will result in the accumulation of residual energy at nodes for an expected set of characteristics and for the expected organization amongst those characteristics, this organization will not be present in the actual data of the incoherent gestalt. While subsequent attempts to match nodes for expected characteristics may result in matches with some of the actual gestalt features, the attempt to match nodes for expected organizational information with nodes for the actual organization of gestalt features will almost certainly result in mismatches. For incoherent gestalts, primary activation of nodes for correct organizational information will add little or nothing to the overall accumulation of energy at a correct “hunch” node. As a result, even when participants are given the opportunity to alternate attention between visual gestalt and partial-word, as was the case in Study I, the accumulation of residual energy at the “hunch” node through the process of alternating activation will only involve nodes for expected characteristics and not nodes for expected organizational information, and will necessarily be less than for its coherent counterpart. Thus, elimination of the partial-word solution phase presentation of the visual gestalt will have little impact on partial-word facilitation for trials involving unsolved incoherent gestalts, which was demonstrated by the results of Study II, in which the partial-word solution rate for incoherent trials was unchanged from that of Study I, despite the elimination of the partial-word solution phase presentation of the gestalt in Study II.

Without the additional accumulation of residual energy provided by matches between nodes for expected organization and actual gestalt features, the coherent and incoherent form of each visual gestalt should provide relatively equivalent expected characteristic/actual feature information to the alternating activation process, and as a result, one would expect equivalent participant partial-word performance on trials with unrecognized gestalts regardless of coherence, which was the result observed in Study II. As noted above, for trials involving unrecognized coherent gestalts this pattern of results strongly supports the alternating activation model, and not the simple activation model.

Since the coherent advantage was clearly present in Study I, in which the visual gestalt and partial-word were present together throughout the partial-word solution phase, and clearly absent in Study II, in which the visual gestalt was not present during the partial-word solution phase, the question arose: "Is the coherent advantage all-or-nothing?” or, to put it another way, “Will incrementally limiting exposure to the visual gestalt during the partial-word solution stage cause the coherent advantage to degrade in an incremental or abrupt manner?" In order to answer this question, Study III was undertaken, in which it was proposed that the visual gestalt be made available to participants for differing lengths of time during the partial-word solution phase. It was reasoned that by varying the availability of the visual gestalt during the partial-word solution phase, from full availability (gestalt present throughout the attempt to solve the partial-word), decreasing partial availability (gestalt present for some portion of the attempt to solve the partial-word) and zero availability (gestalt absent during the attempt to solve the partial-word), the coherent advantage could be made to degrade, and the coherent partial-word solution rate would drop to the incoherent partial-word solution rate, as it had in Study II. It was reasoned that the coherent advantage could drop abruptly, likely at zero gestalt availability, or it could degrade by increments with decreases in the availability of the gestalt.

Chapter 3 - Part B: Increasing interstimulus intervals and the facilitation effect

Preliminary Study B

Preliminary Study B was designed to more closely examine the question of whether elimination of the coherent advantage was necessarily all-or-nothing, as it had been in Study II of Part A, or whether it could be made to degrade in an incremental fashion by progressively limiting availability of the visual gestalt during the partial-word solution phase. What was not clear from the results of Study II was how the coherent advantage would be impacted if access to the visual gestalt during the partial-word solution phase was reduced by increments. On one hand, the coherent advantage could gradually degrade with decreasing availability of the visual gestalt. On the other hand, the coherent advantage could be maintained intact so long as some availability to the gestalt is provided, and then degrade suddenly in an "all-or-nothing" fashion at the point where the visual gestalt is totally absent from the partial-word solution phase, as was the case in Study II.

In the Preliminary Study B participants were exposed to four delay conditions in which the amount of time that the visual gestalt was available during the partial-word solution phase was incrementally reduced. In Study II of Part A, incoherent partial-word facilitation did not degrade with elimination of the partial-word solution phase gestalt presentation, and it was reasoned that since total absence of the gestalt during the partial-word solution phase in Study II had no effect on the incoherent partial-word solution rate, decreasing the amount of time that the visual gestalt was present during the partial-word solution phase should also have no effect on incoherent partial-word performance. Since it was the degradation pattern of the coherent advantage that was under investigation, and since each participant in this study would be exposed to all four delay conditions, the decision was made to use only coherent gestalts in order to conserve power.

Method

Participants

Participants (n = 16) were recruited from the University of Waterloo undergraduate pool on the basis of self-report of vision adequate for normal reading and average English language proficiency. In the initial telephone contact, participants were told that the purpose of the experiment was to study perceptual problem-solving skills and that if they agreed to participate they would be asked to try to solve puzzles, some of which would involve identifying objects in drawings and some of which would involve solving word puzzles related to the objects in the drawings.

Materials

Unlike Study I and II in Part A, in which stimulus items were presented on 8.5 x 11 sheets of paper, stimulus items in Preliminary Study B were presented on a computer screen to allow for very precise manipulation of the presentation of stimuli during the partial word solution phase. A presentation program was written specifically for this study so that materials could be consistently presented at the appropriate times. As well, the presentation program was designed to allow maximum flexibility in the order of stimulus presentation, onset of stimulus presentation, and duration of stimulus presentation through customized sets of individual command files.

Stimulus items consisted of the same set of visual gestalts (coherent versions only) and partial-word puzzles employed in Part A studies, which was scanned at high resolution and saved as a set of graphics files for presentation on an IBM-compatible computer with a 17-inch monitor. In the visual gestalt identification phase, each visual gestalt item was presented on the upper half of the screen, with the question, "What is this object?" appearing below the visual gestalt with an underlined space to type in an answer. Participants' responses to the request to identify the gestalt item appeared in the space as they typed them in. Below the space for the response was a confidence rating scale, which consisted of the question, "How sure are you?" and a scale from 0 to 100%. Below the confidence rating scale was a space to enter a number indicating confidence, which appeared as the participant typed it in. Once the participant entered a response and a confidence rating, the visual gestalt identification phase stimuli left the screen.

At this point the partial-word solution phase began with the reappearance of the visual gestalt in the same location onscreen as in the visual gestalt identification phase, but this time without the request to solve the puzzle and the confidence rating scale. At some point during the partial-word solution phase the partial-word task would appear on the lower half of the screen. As in previous studies, the partial-word task consisted of the instruction to "Type in the word that solves the word puzzle," below which was the partial-word puzzle for that item and a space to type in a response. Participants' responses appeared in the space as they typed them in.

In each trial the visual gestalt appears continuously for 30 seconds during the partial-word solution phase. The partial-word puzzle appears for 30 seconds in one of the following conditions:

a) <u>0 sec PW delay</u> - gestalt and partial-word puzzle appear simultaneously and are onscreen together for 30 seconds.

b) 15 sec PW delay - gestalt appears for 15 seconds; gestalt and partial-word puzzle appear for 15 seconds together; partial-word puzzle appears for 15 seconds.

c) 25 sec PW delay - gestalt appears for 25 seconds; gestalt and partial-word puzzle appear for 5 seconds together; partial-word puzzle appears for 25 seconds.

d) 30 sec PW delay - gestalt appears for 30 seconds; partial-word puzzle appears for 30 seconds.

As determined in the Preliminary Study A2, the mean solution rate for the set of 32 partial-word items was .27 (SD = .10), and individual item solution rates ranged from .14 to .45.

Procedure

Participants were tested individually. Participants entering the lab were informed that they would be participating in a study of visual perception in which they would be asked to look at some drawings of objects on a computer screen, which could be humanly made things such as buildings, tools, or machines, or naturally occurring things, such as people, animals, or plants, and to try to identify them. It was explained that some of the items portrayed in the drawings were not easy to recognize and that everyone had difficulty with some of them. They were informed that after trying to identify the object in each drawing they would get a second chance to see the drawing, and at some point a missing letter word puzzle would also come onto the screen. They would then be asked to try to solve the missing letter word puzzle, which if solved correctly, would be the name of the object in the drawing they had just seen.

Participants were then informed that they would have 30 seconds to look at each drawing, type in the name of the object in the space provided, and rate how confident they were that their response was correct by typing in a number into the space provided between 0 (indicating “no confidence – a wild guess”) and 100 (indicating “absolutely sure”). It was explained that the drawing would only remain onscreen for 30 seconds, but the program would not go on to the next part until a response and confidence rating were typed in. It was emphasized that for the purpose of the study it was important that they respond to each item and if stumped to take a wild guess and rate their confidence for that item at a very low level to indicate that it was just a guess.

Participants were then told that after typing in a response and a confidence rating they would get a second chance to see the drawing for another 30 seconds. At some point, either immediately or after some delay, the missing letter word puzzle for that drawing would come onto the screen. The word puzzle would be the name of the object in the drawing they had just seen, but it would have blanks in the place of some of the letters. Participants were told that they would have 30 seconds to type a word into the space provided that solved the word puzzle and revealed the identity of the object portrayed in the drawing, but after 30 seconds onscreen the word puzzle would disappear whether they had finished typing in a response or not, and the program would move on to the next drawing.

Participants were given four practice items, each using the coherent form of the gestalt for that item, whose gestalt solution base rate was .12 (SD = .12) and whose partial-word solution base rate was .71 (SD = .15). One item was presented in each of the four partial-word delay conditions. Participants were reminded on the trial items that the correct solution to the word-puzzle was the name of the object in the drawing. Each participant attempted all 32 items, with eight items in each of the four delay conditions. Items were randomized for order of presentation and delay condition.

In this study, it was expected that the partial-word solution rate would drop significantly in at least one of the delay conditions. What was not clear from the outset was whether the partial-word solution rate would decrease incrementally at each delay condition, or be maintained throughout and decrease abruptly in the 30 sec. partial-word delay condition, which is most similar to the conditions in Study II in which the coherent partial-word solution rate decreased to a rate not different than the incoherent partial-word solution rate.

Results and Discussion

In Preliminary Study B the mean item partial-word solution rate for trials in which gestalts were solved was .98 (SD = .14), while the mean item partial-word solution rate for trials in which gestalts were not solved was .52 (SD = .40), collapsed across delay conditions. Both of these are not dissimilar to Study I solution rates on trials with coherent gestalts.

As expected, for solved gestalts there was no significant difference amongst the item partial-word solution rates at the four partial-word presentation conditions, $F(3,104) = 0.90$, $p = .45$. Against prediction, however, on trials in which gestalts were not solved, analysis of variance with partial-word delay condition as a within-participants factor revealed that there was no significant difference in the item partial-word solution rate amongst the four partial-word presentation conditions, $F(3,96) = 0.11$, $p = .95$. See Figure 16. Thus, rather than either a gradual decrease or an “all-or-nothing” elimination of the coherent advantage, there was *no* significant decrease in item partial-word performance at any of the four delay conditions.

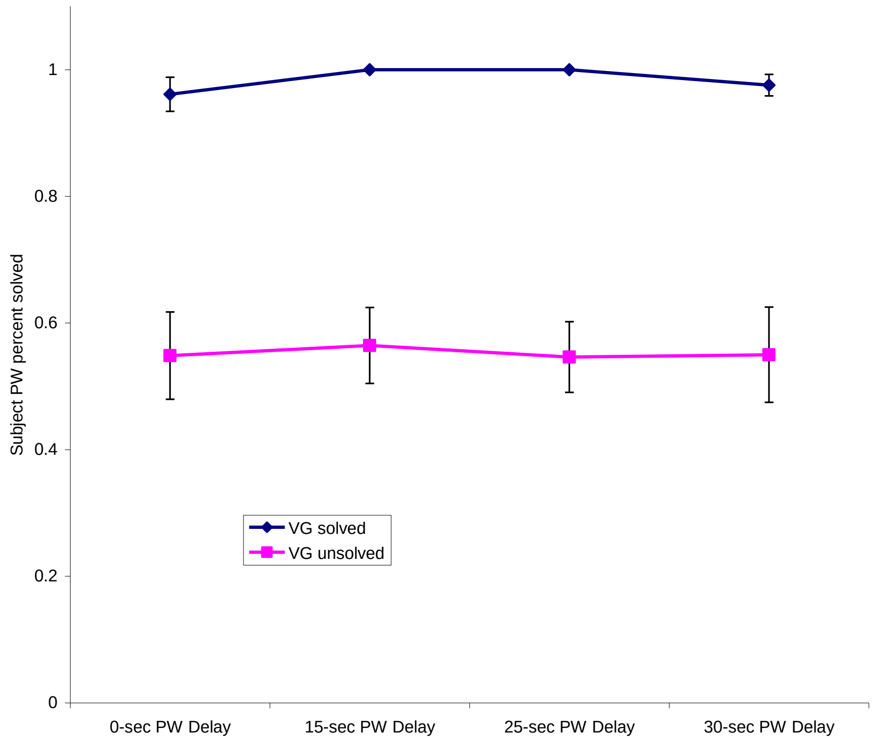

Figure 16. Preliminary Study B item partial-word solution rates at each delay condition – Coherent gestalt solved vs. unsolved

It should be noted that it had been expected that the level of partial-word facilitation would be similar to the partial-word item solution rate for unsolved coherent gestalts (.59) observed in Study I in at least the shortest delay condition in Preliminary Study B, in which the visual gestalt and partial-word puzzle were onscreen together for the full 30 seconds of the partial-word solution phase. Instead, the item partial-word solution rates following unsuccessful attempts to solve visual gestalts ranged from .50 to .56 in Preliminary Study B, with a mean of .52 (SD = .40). It is not clear why the level of partial-word facilitation was less than expected, although it may be related to the switch from pencil-and-paper to computerized presentation of materials.

The pattern of participant partial-word solution rates in Preliminary Study B mirrored findings with item rates. On trials in which gestalts were not solved analysis of variance with partial-word delay condition as a within-participants factor revealed that there was no significant difference in the participant partial-word solution rate amongst the four partial-word presentation conditions, $F(3,58) = 0.02$, $p = 1.0$. Participant partial-word solution rates following unsuccessful attempts to solve visual gestalts ranged from .55 to .56, with a mean of .55 ($SD = .25$).

It had been predicted beforehand that in one or more Preliminary Study B delay condition on trials with unrecognized coherent gestalts, the coherent partial-word solution rate would drop. It was predicted that the partial-word solution rate would drop to a rate similar to that observed in Study II in the longest delay condition, in which the visual gestalt and partial-word puzzle were not onscreen together during the partial-word solution phase, thereby eliminating the availability of the gestalt for alternating activation. It was unclear whether the expected decrease in partial-word facilitation would be sudden, occurring only in the longest delay condition, or if it would be gradual, corresponding to decreasing availability of the gestalt as partial-word delays increase. In Preliminary Study B the expected decrease in partial-word facilitation did not occur, and there was no significant difference in partial-word performance at any of the four delay conditions.

After further thought about this result, it became clear that none of the conditions in Preliminary Study B fully replicated the conditions present in Study II, in which the rate of partial-word solution following unrecognized coherent gestalts did decrease significantly compared to the corresponding rate in Study I. Study II, which was a pencil and paper study, contained an uncontrolled interval of time between the removal of the gestalt stimulus at the completion of the visual gestalt identification phase and the beginning of the partial-word solution phase, at which time the participant received the partial-word stimulus. After collection of the gestalt identification form, there was an interval of approximately 3-7 seconds during which participants had no stimulus material in front of them before receiving the partial-word solution form.

In the current study there is no condition that replicates this interval of "dead air" time between the two stages. This being the case, it is interesting to note that there was no degradation of the coherent solution rate, and by implication, the coherent advantage at any condition in Preliminary Study B, including the longest partial-word delay condition, which points to the robustness of the coherent advantage. It appears that in Preliminary Study B, the interval of dead air between the offset of the visual gestalt and the onset of the partial-word puzzle was not of sufficient length to allow degradation of the gestalt in short-term visual memory. Thus, participants in Preliminary Study B were able to maintain the visual gestalt in memory, mentally “carrying forward” the visual gestalt for use in alternating activation.

If it is the case that participants were able to “carry forward” gestalts in short-term visual memory, logically there should be some time limit on this ability, since an unrecognized gestalt would have few tags for retrieval. If participants were to experience an interval of dead air sufficient to allow the gestalt to degrade in visual memory prior to the appearance of the partial-word puzzle, an unrecognized, and therefore unlabelled gestalt should be unavailable to alternating activation, at which point the coherent advantage should be eliminated, as it was in Study II.

Study III was designed to examine the effect of longer dead air intervals between the offset of the visual gestalt and the onset of the partial word puzzle. It was reasoned that at some limiting interval of dead air the gestalt would become unavailable to alternating activation and the coherent advantage would disappear. A buffer limit of approximately 1 second has been reported consistently in prior studies of sensory memory (Sperling, 1960; Averbach & Coriell, 1961; Averbach & Sperling, 1961; Treisman, 1964; Bliss *et al*, 1966; Geyer, 1966; Norman, 1969; Posner, Boies, Eichelman, & Taylor, 1969; Darwin, Turvey, & Crowder, 1972). Blumenthal (1977) notes that on tasks such as the same-different letter discrimination procedure employed by Posner et al (1969), facilitation of discrimination disappears when delay intervals between stimulus letter and target letter are extended beyond 1.5 seconds, suggesting that the likely upper limit on memory for visual patterns should be approximately 1.5 seconds.

Study III

In Study III increasing intervals of dead air will be inserted between the offset of the partial-word solution phase presentation of the visual gestalt and the onset of the partial-word puzzle. In Study II the coherent advantage was completely eliminated with elimination of the partial-word solution phase presentation of the gestalt and the insertion of an uncontrolled dead air interval between the offset of the visual gestalt and the onset of the partial-word puzzle. On the other hand, in Preliminary Study B, which contained no such dead air interval in any condition, the coherent advantage was maintained at all delay conditions. This suggested that at longer intervals of dead air between offset of the gestalt and onset of the partial-word puzzle, exceeding the limit of visual memory, the gestalt would become unavailable to alternating activation and the coherent advantage would disappear, as it had in Study II. As in Preliminary Study B, it was unclear whether the degradation of the coherent advantage would occur in a sudden or an incremental fashion.

In this Study III, the decision was made to present half of the visual gestalts seen by each participant in the coherent form and half in the incoherent form. While it was not expected that the longer delay conditions employed in Study III would have a significant impact on incoherent partial-word performance, this had not been established empirically.

In order to test the hypothesis that the coherent advantage could be made to degrade at some longer interval of dead air between offset of the gestalt and the onset of the partial-word puzzle, Preliminary Study B procedures were modified to include longer intervals of dead air. As was noted earlier, a buffer limit of approximately 1 second has been reported in many studies of sensory memory and thus it was proposed that dead air intervals of 1.5 seconds and 3.0 seconds would exceed the limit of the sensory memory buffer, leading to decreased availability of memory for unsolved gestalts and consequent degradation of the coherent advantage.

Three delay conditions were created. The first included a 30-second delay in which the offset of the partial-word solution stage presentation of the visual gestalt offset was immediately followed by the onset of the partial-word puzzle for that item so that participants experienced no dead air interval. In Preliminary Study B, a similar condition yielded no degradation in coherent partial-word performance relative to other delay conditions. The second condition included a 31.5-second delay of which 1.5 seconds was a dead air interval, and the third condition included a 33-second delay of which 3 seconds was a dead air interval. In the latter two conditions, it was expected that the interval of dead air would exceed the 1 second sensory memory buffer by .5 seconds and 2.0 seconds respectively.

It was predicted that, compared to the results of Preliminary Study B, for Study III trials in which coherent gestalts are unsolved there should be no degradation in the partial-word solution rate in condition one (0 sec. dead air), since the limit of the sensory memory buffer would not be reached in this condition. On the other hand, the dead air intervals in conditions two (1.5 sec. dead air) and three (3 sec. dead air) should exceed the buffer limit, and therefore it was predicted that, compared to the results of Preliminary Study B, for Study III trials in which coherent gestalts are unsolved there should be degradation in the partial-word solution rate in conditions two and three. In the conditions two and three, it was expected that the coherent partial-word solution would fall to a level equivalent to the coherent partial-word solution rate observed in Study II.

Incoherent partial-word solution rates were not expected to vary at any partial-word delay condition, and it was predicted that for Study III trials in which incoherent gestalts are unsolved there would be no significant difference in the partial-word solution rate at any delay condition.

Method

Participants

Participants (n = 65) were recruited from the University of Waterloo undergraduate pool on the basis of self-report of vision adequate for normal reading and average English language proficiency. In the initial telephone contact, participants were told that the purpose of the experiment was to study perceptual problem-solving skills and that if they agreed to participate they would be asked to try to solve puzzles, some of which would involve identifying objects in drawings and some of which would involve solving word puzzles related to the objects in the drawings.

Materials

Stimulus items for Study III were presented on a computer screen to allow for very precise manipulation of dead air intervals in the partial-word solution phase between the offset of the visual gestalt and the onset of the partial-word puzzle. Three dead air conditions were created as a between-participants factor in order to reduce the possibility that individual participants were being "thrown off" by having to contend with differing delays from trial to trial. Since it had not been demonstrated whether dead air intervals would have any impact on incoherent gestalt trials, the incoherent versions of visual gestalts were included in Study III. Thus, each participant was exposed to only one of the three partial-word delay conditions and attempted all 32 items, half presented in the coherent form and half in the incoherent form. Participants were randomly assigned to delay condition and stimulus items were randomized for item order and item coherence.

The presentation program written for Preliminary Study B was employed to ensure that stimulus materials could be consistently presented at the appropriate times, and responses and response latencies saved for each participant. Each computer-presented visual gestalt identification form presents one visual gestalt item, either coherent or incoherent, on the upper half of the screen. Below the visual gestalt on the screen is the question, “What is this object?” with an underlined space to type in an answer. Participants’ responses to the request to identify the gestalt item appear in the space as they type them in. Below the space for the response to the request for the identity of the gestalt is a confidence rating scale, which consisted of the question, “How sure are you?” and a scale from 0 to 100% with a space to enter a response, which appears as it is typed in.

Following the visual gestalt identification stage, the visual gestalt is presented for 30 seconds on the upper half of the screen. After the visual gestalt disappears from the screen, the partial word task appears in one of three onset delay conditions. In condition one, the partial-word puzzle appears immediately at the offset of the visual gestalt. In condition two, the partial-word puzzle appears 1.5 seconds after the offset of the visual gestalt. In condition three, the partial-word puzzle appears 3 seconds after the offset of the visual gestalt. In the latter two conditions, the screen remains blank in the interval between offset of the visual gestalt and onset of the partial-word task.

As in previous studies, the partial-word task remains onscreen for 30 seconds on the lower half of the screen. The partial-word task consists of the instruction to “Type in the word that solves the word puzzle" and a space to type in a response, which appears as it is typed in. As was determined in Preliminary Study A2, the mean partial-word solution for the set of thirty-two items was .27 (SD = .10), and individual partial-word solution rates ranged from .14 to .45.

Procedure

Participants in Study III were tested individually. Upon entering the lab, participants were provided with the same instructions as in Preliminary Study B and first completed the same four practice items. Participants were randomly assigned to delay condition and each participant attempted all 32 items. Stimulus items were randomized for order of presentation and coherence.

In Study III it is predicted that partial-word solution rates on trials involving incoherent visual gestalts will be similar to those observed in Study I and Study II, and will not vary at any partial-word delay condition. It is also predicted that in condition one there will be no degradation of the coherent partial-word solution rate, relative to that observed in Preliminary Study B, i.e., approximately .52, because the 0 sec. interstimulus dead air interval does not exceed the expected limit of the visual memory buffer. In condition one, therefore, the coherent advantage should be maintained. On the other hand, it is predicted that in conditions two and three, coherent partial-word performance should decrease to approximately .40, the partial-word solution rate observed for unsolved coherent gestalts in Study II, because the 1.5 sec. interstimulus dead air interval in condition two and the 3.0 sec. interstimulus dead air interval in condition three should exceed the buffer limit. In conditions two and three, therefore, the coherent advantage should disappear.

Results and Discussion

For Study III trials in which gestalts were solved, an ANOVA with coherence as a within-participants factor and partial-word delay condition as a between-participants factor revealed no significant interaction between coherence and partial-word delay, F(2,33) = 0.05, p = .95, and no significant main effect for coherence, F(1,33) = 1.64, p < .21, with the coherent partial-word solution rate (M = .98, SD = .09) not significantly different than the incoherent partial-word solution rate (M = .91, SD = .28). There was no significant main effect for partial-word delay, F(2,33) = 0.23, p = .80.

For Study III trials in which gestalts were not solved, an ANOVA with coherence as a within-participants factor and partial-word delay condition as a between-participants factor revealed a significant interaction between coherence and partial-word delay, F(2,62) = 6.77, p = .002, and a significant main effect for coherence, F(1,62) = 25.31, p < .001, with the coherent partial-word solution rate (M = .46, SD = .23) significantly greater than the incoherent partial-word solution rate (M = .40, SD = .15). There was no significant main effect for partial-word delay, F(2,62) = 0.61, p = .55.

It had been predicted that the coherent advantage would be maintained in condition one, but would disappear in condition two and condition three. Instead, in Study III planned comparisons revealed that the coherent advantage was maintained in conditions one and two and disappeared in condition three. In condition one, as predicted, there was a significant difference, t(20) = 3.99, p < .001 (one-tailed), between partial-word performance for coherent trials (M = .45, SD = .24) and incoherent trials (M = .36, SD = .14). In condition two, against prediction, there was also a significant difference, t(23) = 4.6, p < .001 (two-tailed), between partial-word performance for coherent trials (M = .47, SD = .25) and incoherent trials (M = .37, SD = .14). In condition three, as predicted, there was no significant difference, $t(19) = .11$, $p = .91$ (two-tailed), between partial-word performance for coherent trials (M = .47, SD = .23) and incoherent trials (M = .47, SD = .15). While the finding of equivalence between coherent and incoherent partial-word performance in condition three was predicted, it did not occur in the manner expected. It was expected that the disappearance of the coherent advantage would occur due to a decrease in the coherent partial-word solution rate to a level equivalent to that of the incoherent partial-word solution rate. Instead, the disappearance of the coherent advantage in condition three came about due to an unexpected increase in the incoherent partial-word solution rate, rather than the expected decrease in the coherent partial-word solution rate. See Figure 17.

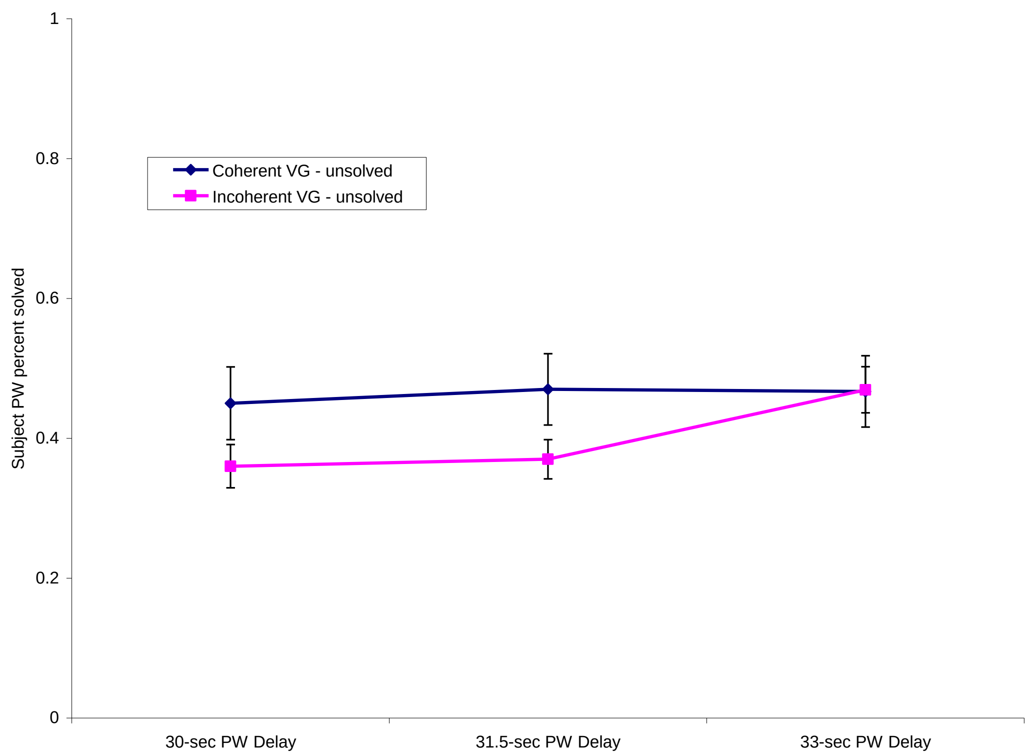

Figure 17. Study III - Coherence x partial-word delay

Looking only at incoherent trials, an ANOVA using partial-word delay as a between-participants factor revealed a significant difference in partial-word performance amongst the delay conditions, $F(2,62) = 3.69$, $p < .03$. Pairwise Tukey comparisons revealed no significant difference in partial-word performance ($p = .997$) between condition one ($M = .36$, $SD = .14$) and condition two ($M = .37$, $SD = .14$), but the condition three incoherent partial-word solution rate ($M = .47$, $SD = .15$) was significantly greater ($p = .054$) than that of condition one and significantly greater ($p = .053$) than that of condition two. In fact, as noted above, incoherent partial-word performance in condition three increased to such an extent that it was not significantly different from the coherent rate for that condition, which was not significantly different from the coherent rate in the other two conditions, $F(2,62) = 0.04$, $p = .96$. Overall, in Study III the predicted decrease in coherent partial-word facilitation did not occur, and coherent partial-word facilitation was equivalent in all delay conditions. Equally unexpected was the finding that incoherent partial-word facilitation did not remain stable as predicted; instead, in condition three it increased to a level that was not significantly different from coherent partial-word facilitation.

With regard to the failure to demonstrate the expected decrease in coherent partial-word facilitation at some interval of dead air in Study III, it may be that the changes in methodology worked against obtaining the expected decrease. First, it is notable that for coherent gestalts participant partial-word performance in Study III ($M = .46$, $SD = .23$) fell at a level midway between those observed in Study I ($M = .55$, $SD = .17$) and Study II ($M = .40$, $SD = .18$). Thus, coherent facilitation was decreased in Study III compared to Study I, but it was consistently less, even in condition 1 in which facilitation was not expected to decrease. For incoherent gestalts, despite significantly increased facilitation in condition three, participant incoherent partial-word performance in Study III (M = .40, SD = .15), was similar to those observed in Study I (M = .41, SD = .17) and Study II (M = .39, SD = .19). While this overall decrease in coherent facilitation is interesting and unexpected, it does not shed light on the failure to demonstrate decreased coherent facilitation in one or both of the dead air conditions in Study III. In retrospect, prior to beginning Study III it would have been prudent to replicate Studies I and II using the computer-presentation methodology employed in Study III in order to establish new benchmarks for partial-word performance.

A more likely explanation for the unexpected pattern of results observed in Study III may be found in other methodological differences from earlier studies. First, compared to Study II, in which the coherent advantage disappeared, Study III provided participants with an additional opportunity to view each visual gestalt. Whereas participants in Study II saw each visual gestalt one time for a total of 30 seconds, participants in Study III saw each visual gestalt two times for a total of 60 seconds. The additional opportunity to view each gestalt and longer total exposure to each gestalt in Study III may have provided participants with opportunities to rehearse each gestalt, thereby making memory for unsolved gestalts more resistant to degradation.

A second important difference between Study II and Study III is that the dead air interval occurring in Study II was estimated to be 3-7 seconds, while the longest dead air interval in Study III was 3 seconds. Thus, it may be that visual memory for unrecognized visual gestalts is longer than anticipated, and the dead air intervals employed in Study III were simply not long enough to allow memory for unsolved gestalts to degrade. Yaniv and Meyer (1987) found that memory sensitization by prompts with rare-word definitions could lead to facilitation effects for as long as a half-hour. Facilitation effects with unrecognized, unlabelled visual stimuli would not be expected to last this long; however, they may last longer than expected, particularly given the additional opportunities to view gestalts and the relatively long duration of gestalt exposures discussed above. Thus it may be that the failure to show decreased coherent facilitation in one or both of the dead air conditions in Study III was due to the combined impact of providing participants with conditions that made memory for unsolved gestalts more resistant to degradation and of using too-brief intervals of dead air between gestalt and partial-word stimuli.

The methodological differences noted above could also potentially account for the unexpected increase in incoherent partial-word facilitation observed in condition three of Study III. In particular, opportunities for rehearsal of unrecognized gestalts may have played a large role in the observed increase in incoherent partial-word facilitation. As noted by Tyler et al. (1979), participants who attempted to solve anagrams and missing-word sentences were able to recall the words from trials with more difficult anagrams and sentences (high effort condition) than easier ones (low effort condition). From this perspective, participants were putting in more effort with incoherent gestalts than with coherent gestalts in Study III, which led to increased recall for incoherent gestalts and subsequently increased incoherent partial-word performance. This alone does not, however, explain why incoherent partial-word facilitation would increase in condition three but not in condition two. It may be that the effort effect may become more pronounced at longer dead air intervals, but it may also be that longer intervals also provide conditions for “forgetting” fixation on misleading incoherent information.

Against prediction, in the longest delay condition in Study III, unsuccessful attempts to solve incoherent gestalts led to significantly increased partial-word facilitation. This brings to mind the debate about possible mechanisms of the incubation effect in problem-solving, in which, after unsuccessful conscious attempts to solve a problem, participants given a period of time off-task prior to returning to the problem often demonstrate an increased rate of solution. This result is usually explained through either a spreading activation account or a forgetting account. In brief, according to the spreading activation account, time off-task allows for encounters with new solution-relevant information, with the result that residual activation energy accumulates to the threshold of consciousness at the solution node in the problem-solver's associative network. From the forgetting perspective, however, the time spent off-task allows problem-solvers to "forget" fixations on information that are irrelevant to a solution and to make a "fresh start" using only solution-relevant information.

Given the events occurring in dead air intervals were the same in both dead air conditions, it seems very unlikely that encounters with new information would occur only in trials with incoherent visual gestalts in the longest delay condition. On the other hand, given that the overall "whole" portrayed in an incoherent visual gestalt is inconsistent with images of the "whole" expected on the basis of activating a correct solution node, it may be that the continuing presence of the incoherent "whole" in consciousness interferes with problem-solvers' attempts to solve partial-word puzzles, setting up a competition between correct and incorrect "wholes." Thus, it may be that when faced with incoherent visual gestalts, problem-solvers may be using time off-task to allow solution-irrelevant incoherent "wholes" to decay from the visual memory buffer, and with longer periods of time off-task the decay is more complete, with the result that interference is decreased, leading to increased partial-word facilitation.

Chapter 4 - General discussion

Summary of findings

In Study I participants' unsuccessful attempts to recognize objects portrayed in visual gestalts facilitated their performance on a subsequent partial-word task. Facilitation of partial-word performance occurred whether the unrecognized gestalt was coherent or incoherent, but significantly more facilitation occurred on trials with coherent gestalts than on trials with incoherent gestalts, a finding which was referred to as the "coherent advantage." Thus, through their unsuccessful efforts to solve gestalts, participants acquired useful knowledge in the form of an incomplete or partial implicit knowledge about the objects portrayed. As well, unsuccessful attempts to solve "better" coherent visual gestalts provided participants with a greater amount of partial knowledge than unsuccessful attempts to solve "poorer" incoherent visual gestalts.

Before proceeding, it should be noted that a second explanation of the coherent advantage observed in Study I cannot be ruled out at this time. It is possible that the increase in coherent partial-word facilitation was the result of partial-word solution phase solutions of previously unsolved coherent gestalts. Since participants in Study I were not tested for visual gestalt solution during the partial-word solution phase it is not known whether the opportunity to view gestalts a second time, with the corresponding partial-word puzzles, did in fact lead to additional gestalt solutions favoring coherent gestalts. Thus, the coherent advantage demonstrated in Study I could be explained by participants solving additional coherent gestalts during the partial-word phase, rather than by incremental increases in implicit knowledge without gestalt solutions. Alternating activation could potentially serve as the generative mechanism for either of these;

however, should it turn out to be the case that participants are solving previously-unsolved coherent gestalts during the partial-word phase, then the mechanism underlying the coherent advantage should be understood as "all-or-nothing" rather than accumulative. Once solved, the gestalt cannot be "unsolved." On trials in which participants solve the gestalt in the partial-word phase, one would expect the corresponding partial-word solution rate to be similar to the observed rate on trials in which the gestalt was solved in the visual gestalt solution phase, i.e., near 100%. Under these conditions, one would expect the partial-word solution rate to be stable and resilient to degradation, which was the case in Study III.

Additional studies would be required to determine how frequently "second-presentation" gestalt solutions do occur. A finding that participants are able to achieve a substantial rate of second-presentation coherent gestalt solution would support the position that additional coherent gestalt solutions were occurring in the partial-word solution phase in Study I, and that these late solutions are the source of the coherent advantage. On the other hand, a low second-presentation gestalt solution rate would be supportive of an accumulative model in which gestalts remain unrecognized.

Despite the uncertainty about whether the coherent advantage demonstrated in Study I takes place through an accumulative or an all-or-nothing process, in the case of unsolved incoherent gestalts partial-word facilitation was clearly not reliant on unrecognized gestalt solutions. There was significant partial-word facilitation following trials with unsolved incoherent gestalts in Study I, and the rate of incoherent partial-word facilitation did not differ in Study II, in which there was no partial-word solution phase presentation of the gestalts. Thus, it appears fairly certain that incoherent partial-word facilitation was not caused by unrecognized gestalt solutions. Overall, the findings with incoherent gestalts support the notion that problem-solvers are acquiring and accumulating partial knowledge about solutions without having achieved awareness of those solutions, a finding consistent with an incremental model of intuition, but not with an "all-or-nothing" model.

Spreading activation was discussed as a likely explanation of how an unsuccessful attempt to solve a visual gestalt could facilitate subsequent performance on a related partial-word problem. According to the spreading activation model, any feature within the gestalt that seems in some way relevant to the problem-solver can serve as a starting point in the search for a solution to the gestalt. If a known characteristic is experienced as somehow similar to the relevant gestalt feature, an activation event may occur at the node for that characteristic, sending a spread of activation to associatively-linked nodes in the problem-solver's associative network. If the chosen characteristic is, in fact, correct for the object portrayed in the gestalt the pattern of residual energy generated amongst nodes in the problem-solvers' associative network will resemble a weaker version of the solution pattern, i.e., the pattern that would exist had the problem-solver actually recognized the object. This weaker pattern may then be refined and "sculpted" by additional activation events at nodes for other characteristics experienced as relevant to other gestalt features. Of particular importance in the "sculpting" of the pattern of residual energy are the points of intersection in spreads of activation from relevant characteristic nodes. These intersections will occur at nodes representing things that are associated with each of the activated characteristics, one of which is likely to be the name of the object portrayed. Because of the high degree of association between each activated correct characteristic and the correct name of the object, each new activation of a correct characteristic node will deposit energy at the correct name node, so that the level of residual energy held at the name node increases rapidly toward the threshold at which the problem-solver will become conscious of the name as the correct solution to the gestalt.

Even when the problem-solver is unable to accumulate sufficient residual energy at the name node to permit conscious awareness of the correct solution, the relatively high level of residual energy at the name node may still serve: a) as a useful implicit clue that the thing represented by this name node has potential as a solution, and b) as a means through which new solution relevant information can be quickly recognized and assimilated. When the problem solver shifts his/her attention from the unsolved gestalt to the partial-word puzzle the encounter with the solution word in the form of the partial-word puzzle may then provide sufficient additional energy to push the level of residual energy at the name node above the threshold, resulting in a sudden recognition of the name as the solution to the partial-word puzzle.

It was noted that most participants in the partial-word solution phase of Study I appeared to be alternating their attention back and forth between the visual gestalt and the partial-word puzzle in their attempts to solve each partial-word puzzle. It was not clear what purpose this alternation served, but alternation of attention was observed with nearly all participants tested. Some participants stated that they found the presence of the visual gestalt during the partial-word solution phase distracting, and speculated that they might have been more successful with partial-word puzzles had each been presented without its corresponding visual gestalt. Two possibilities were posed: a) alternation of attention was non-essential to the partial-word facilitation effect and simply a distraction that wasted resources, or b) alternation of attention was an essential component in the facilitation effect.

If alternation of attention is not important in the partial-word facilitation effect, then it is likely that the spreading activation procedure underlying partial-word facilitation occurs as described above, i.e., through simple "one-way" inductive spreads of activation from "parts" (nodes for characteristics experienced as in some way relevant to features of the gestalt) to a "whole" (a node corresponding to something at a higher level of abstraction capable of "owning" the activated characteristics, in particular the node for the name of the object portrayed). With each new activation of a correct characteristic node the pattern of residual activation will be "sculpted" to more closely resemble the correct solution pattern with a relatively large accumulation of residual energy at the correct name node.

A problem-solver using this sort of "one-way" model, here labeled simple activation, would not benefit from this alternation of attention in his/her attempts to solve partial-word puzzles, and so it would only be a waste of resources. Thus, if the simple activation model is correct, eliminating the opportunity to alternate attention between the visual gestalt and the partial-word puzzle during the partial-word solution phase should not decrease, and may increase partial-word facilitation by freeing up attentional resources.

On the other hand, since alternation of attention was so frequently observed in the partial-word solution phase of Study I, it may be important to the facilitation effect and may mirror an important facet of the spreading activation procedure. It may be that spreading activation takes place through an alternation between inductive activation of nodes for characteristics experienced as relevant to gestalt features and deductive activation of a high residual energy “potential owner” word node.

From the alternating activation perspective, the pattern of residual energy established through inductive activation of a node for a characteristic deemed relevant to a gestalt feature may be most efficiently refined, or “sculpted” by deductive activation of a high residual energy “potential owner” node. Deductive activation of the “potential owner” node will send a spread of activation outward to nodes for the “expected characteristics” of that “potential owner.” If the activated “potential owner” is the correct solution, resulting high levels of residual energy at each of these “expected characteristic” nodes increases the likelihood that the problem-solver will respond to corresponding features in the visual gestalt. When matches occur between expected characteristics and actual features, the level of residual energy at each matching “expected characteristic” node increases again, marking these nodes as potential sites for new inductive activations. With the inductive activation of each matching “expected characteristic” node, additional energy will be deposited at the correct “potential owner” node, which may then serve as the site for another deductive activation event, and so on, and so on. With each round of alternating activation, the pattern of residual energy in the problem-solver’s associative network comes to more closely resemble the correct solution pattern, in which the node for the name of the object will be amongst the nodes holding the highest levels of residual energy.

In this way, the process of alternating activation provides problem-solvers with a way to rapidly: a) discover a hunch about a solution by generating a pattern of residual energy in which a “potential owner” may be found amongst the nodes holding the highest level of residual energy, and b) “refine” the residual energy pattern to verify that the identified “potential owner” is the correct solution by preferentially increasing the residual energy held at the set of “expected characteristic” nodes for that “potential owner” and comparing these expected characteristics with actual gestalt features. Unlike the simple activation model, the alternating activation model requires that participants alternate their attention between gestalt and partial-word puzzle in order to “sculpt” the residual energy pattern by selectively raising residual energy at correct “potential owner” and “expected characteristic” nodes. If the alternating activation model is correct, eliminating the opportunity to alternate attention between the gestalt and the partial-word puzzle during the partial-word solution phase should decrease and could eliminate partial-word facilitation.

Study II was designed to determine the importance of alternating activation to the partial-word facilitation effect observed in Study I. With the elimination of opportunities for alternating activation in the partial-word solution phase, participants in Study II were forced to rely on simple activation alone. Results demonstrated that the elimination of opportunities to engage in alternating activation had no affect on partial-word facilitation on trials with unsolved incoherent gestalts, but had the effect of eliminating the coherent advantage so that coherent partial-word facilitation decreased to a level not significantly different from that of incoherent partial-word facilitation in Studies I and II.

Since incoherent partial-word facilitation in Study II was not different from that observed in Study I, it can be assumed that when faced with an incoherent gestalt participants rely exclusively on simple activation, even when they have the option to engage in alternating activation. In retrospect this makes sense because deductive activation of a correct solution word node will sensitize a problem-solver to recognize a particular set of characteristics and spatial relationships amongst those characteristics. While some or all of these characteristics may match features present in the incoherent gestalt, the expected spatial relationships amongst characteristics will be so discrepant with the actual spatial relationships amongst incoherent gestalt features that the problem-solver will likely give up attempts at deductive activation.

On the other hand, when given the opportunity to alternate attention back and forth between a coherent gestalt and its partial-word puzzle, as was the case in Study I, participants may successfully employ alternating activation to gain additional increments of partial knowledge, or, alternatively, additional gestalt solutions, that lead to increased partial-word facilitation, i.e., the coherent advantage. When denied the opportunity to alternate attention back and forth between a coherent gestalt and its partial-word puzzle, as was the case in Study II, participants could not employ alternating activation to gain these additional increments of partial knowledge/additional gestalt solutions, and, as a consequence the coherent advantage disappeared.

Given that intuition, whose products appear in consciousness in an “all-or-nothing” fashion, appeared to occur through an incremental, accumulative process involving states of implicit partial knowledge in Study I trials, the question arose, “Is it the case that the coherent advantage, which was ‘all’ in Study I, and ‘nothing’ in Study II, is generated by an incremental accumulative process?” In other words, is it necessarily the case that the coherent advantage degrades suddenly and completely as it had in Study II, or is it possible to demonstrate intermediate levels of the coherent advantage?

Studies in Part B were designed to examine this question by incrementally reducing opportunities for alternating activation to determine, first, whether there is a point at which the coherent advantage is disrupted, and, second, whether the coherent advantage degrades in an abrupt or gradual manner. Part B studies reintroduced the partial-word solution phase gestalt presentation, but unlike in Study I, in which the visual gestalt and the partial-word puzzle were presented together throughout the entire partial-word solution phase, in Part B studies the onset of each partial-word puzzle was delayed by some amount relative to that of its visual gestalt. In another change from Part A studies, in Part B stimulus items were presented on a computer monitor rather than printed on sheets of paper.

Preliminary Study B was completed using coherent gestalts only and four within-participants partial-word delay conditions. Preliminary Study B failed to demonstrate the expected degradation of coherent facilitation in any partial-word delay condition, but it was reasoned that this may have been because each of the delay conditions allowed for some alternating activation, either through some simultaneous presence of gestalt and partial-word puzzle onscreen or through representations of gestalts in memory. It was noted that the observed partial-word facilitation in Preliminary Study B was somewhat less than would be expected on the basis of the results of Study I, but it was not clear why partial-word performance would decrease as a result of the changes in methodology.

Study III was completed using coherent and incoherent gestalts and three between-participants partial-word delay conditions. Delay condition one was equivalent to the longest delay condition in Preliminary Study B, in which the visual gestalt appeared onscreen for 30 sec. during the partial-word solution phase and then was immediately replaced by the partial-word puzzle. In the other two partial-word delay conditions intervals of “dead air” were inserted between the offset of the visual gestalt from the screen and the onset of the partial-word puzzle. It was reasoned that in both conditions two and three the length of the dead air intervals exceeded the theoretical limit of the visual memory buffer, and so participants’ mental representations of unrecognized gestalts were expected to degrade prior to the appearance of the partial-word puzzle, thereby decreasing or eliminating opportunities for alternating activation.

It was predicted that in delay condition one the level of coherent partial-word facilitation would be similar to that observed in Preliminary Study B, but in conditions two and three the level of coherent partial-word facilitation would decrease. It was unclear whether the decrease in coherent partial-word facilitation would occur in an abrupt and complete manner as it had been in Study II, or whether it would be gradual and stepwise, with some decrease occurring in condition two and a further decrease occurring in condition three. It was also predicted that incoherent partial-word facilitation would be unaffected by dead air intervals and would not differ in any partial-word delay condition. Results of Study III failed to support either prediction. There was no significant decrease in coherent partial-word facilitation in any delay condition, and also against prediction, incoherent partial-word facilitation increased significantly in delay condition three.

<u>What has been shown</u>

First, participants who attempt but fail to recognize ambiguous visual stimuli show facilitated performance on related problems. The pattern of results on trials with unsolved incoherent gestalts in Studies I and II and with unsolved coherent gestalts in

Study II supports the idea that participants were accumulating implicit partial knowledge about solutions to gestalts in the absence of achieving solutions. This result strongly supports the idea that, through their unsuccessful attempts to solve a visual gestalt, participants are generating and accumulating implicit partial-knowledge about the solution in the form of a pattern of residual energy amongst nodes in the associative network that resembles the pattern that would exist had the participant achieved conscious recognition of the object represented in the gestalt, i.e., the solution pattern.

Since consciousness is, however, a serial process that cannot accept a complex pattern of residual energy as meaningful information, in order to be useful to consciousness there must be a "distillation" of the pattern into a representative that can be passed into consciousness as an information-dense "bite-size" chunk. The most likely candidate to represent a pattern of residual energy will be something at a fairly high level of abstraction that can integrate all of the activated elements in a meaningful way. One such something will be the name of the object, whose node will be closely associated with all of the nodes within the pattern of activation. Fortunately for the "distillation" process, because of its close association with other nodes in the pattern, the name node will be amongst the nodes that have accumulated the highest levels of residual energy in the pattern, bringing it closer to the threshold of consciousness.

Second, the "quality" of the unrecognized visual stimuli appears to impact on the amount of partial-knowledge that can be accumulated from it, which will be directly reflected in the amount of partial-word facilitation that occurs. For both coherent and incoherent unsolved gestalts the node for the correct solution word should be amongst the nodes at the highest level within the pattern of residual energy, but the problem-solver working with an unsolved coherent gestalt should be able to generate a pattern of residual energy that more closely approximates the correct solution pattern, and to accumulate more energy at the correct solution node than a problem-solver working with an unsolved incoherent gestalt. In fact, in the context of the partial-word solution phase in Study I, juxtaposition of the partial-word puzzle with the previously unsolved coherent gestalt may result in such a rapid accumulation of residual energy that some previously unsolved gestalts become solved. As has been noted, it is not clear at this point whether the additional increment of partial-word facilitation provided by unsolved coherent gestalts in Study I was due to increases in implicit partial knowledge without gestalt solution, or to additional late solutions of the previously unsolved gestalts. Further research will be required to determine whether the mechanism underlying the coherent advantage is incremental or abrupt.

Third, the differences in the pattern of partial-word facilitation for coherent and incoherent gestalts observed in Study I suggest that when the problem-situation permits, participants are able to engage in a bi-directional search for a solution through a process of alternating activation, initiated from the "parts" of the problem situation and moving toward a "whole" at a higher level of abstraction capable of "owning" those parts, and then reversing direction to move from that "whole" back to the "parts" of the problem that should be present in the problem-situation for that "whole" to be the correct solution.

Separate but interconnected processing of imagistic and verbal/semantic elements of the problem situation would be predicted by Paivio (1991), who described the functional independence of verbal and non-verbal systems. From this perspective, the independent operations of verbal and non-verbal systems can result in an additive effect that can facilitate recall. Paivio noted that despite their functional independence, the two systems are interconnected so that processing can occur: a) “representatively” from one unit to another within its system (word-to-word, image-to-image), b) “referentially” from a unit within one system to a unit within another (word-to-image, image-to-word), or c) “associatively” to units in both systems simultaneously. In this thesis, Paivio’s referential processing has been described as inductive activation (image-to-word) and as deductive activation (word-to-image). As well, under specific conditions, for example, when the gestalt is coherent and the gestalt and partial-word puzzle are both accessible, these processes may be combined in what has been described as alternating activation. As noted above, while alternating activation with coherent gestalts leads to increased partial-word facilitation, at this time it is not clear whether this takes place through increases in implicit partial knowledge, or through additional late gestalt solutions. Thus, while it is unclear whether alternating activation is exactly the simultaneous processing of verbal and non-verbal information described by Paivio, the additional increment of partial-word facilitation on Study I trials with coherent gestalts is suggestive of a qualitatively different process than that which takes place on trials with incoherent gestalts.

Fourth, “part-to-whole” processing appears to be conserved when conditions prevent participants from fully engaging in the “whole-to-part” processing. When the problem situation was changed to prevent participants from engaging in “whole-to-part” deductive activation, problem-solvers were still able to accumulate partial-knowledge through “part-to-whole” inductive activation. It is possible that some alternating activation may occur even under these conditions, since some high residual energy “part” nodes may still be available to participants for use in the deductive activation matching procedure, but this is purely speculative. In any case, it appears that "part-to-whole" processing is a fallback strategy that is employed when the necessary conditions for "whole-to-part" processing are not met by the problem situation.

In this vein, an important theme in recent research is that problem-solvers have a range of problem-solving strategies available to them in any given problem situation, and will choose a strategy on the basis of which is most likely to be effective given the characteristics of the problem environment. Gigerenzer and Selten (2001) have proposed a model of the mind as an "adaptive toolbox" containing many simple heuristic "tools" designed for specific problem-solving situations. Gigerenzer and Goldstein (1996) point to Simon's (1956) observation that the human mind is adapted to real-world environments, and that problem-solving algorithms have evolved to cope with situations in which the problem-solver has limited time to make a decision, has limited information available, and has limited computational capacity. Simon described the operation of the mind in the environment as "bounded rationality," and noted that most real-world problems rarely require an optimal solution, merely a solution that meets the needs of the current situation, i.e., a "satisficing" solution that can successfully exploit the structure of the environment without extensive data collection, summation, and integration procedures.

Gigerenzer and Goldstein (1996) have described a set of "fast and frugal" cognitive heuristics that can operate on a simple recognition principle, rather than on the summation and integrative processing of data. Using population data for German cities, Gigerenzer and Goldstein found that three such heuristics performed extremely well in simulation trials against classical inferential models in decision tasks such as, deciding which of two cities, e.g., Heidelberg or Bonn, has more inhabitants. Unlike classical inferential models, these fast and frugal heuristics do not assume “unlimited time, knowledge and computational might” (p. 650), but, nonetheless, can be used to successfully perform inference tasks using limited knowledge as an input, and users can actually “profit from lack of knowledge” (p. 652).

Perhaps the best known of these fast and frugal heuristics, the “Take the Best” (TTB) heuristic employs a limited search procedure without summation or integration of data. According to the TTB, if one alternative of a pair is recognized and the other is not, the recognized alternative is chosen. If neither is recognized, the choice is random. If both are recognized, a search process begins through cues, or facts about the alternatives that have been rank ordered in terms of their cue validity (a subjective ranking of the likelihood that a cue will discriminate which of the alternatives has the highest criterion value). When a cue is discovered that does discriminate in favor of one of the alternatives, the search process is halted and that alternative is chosen. Gigerenzer and Goldstein (1996) note that in the task of choosing between two recognized cities, a possible cue with high cue validity might be whether either of the pair has a professional major league soccer team. If one city is recognized to have a professional major league soccer team and the other is not, the city with the team would be the alternative chosen.

Gigerenzer and Goldstein (1996) tested two other heuristics that can operate on even less information than the TTB heuristic, the “Take the Last” (TTL) heuristic, and the Minimalist heuristic. In the TTL heuristic, there is no ranking of subjective cues on the basis of likelihood of discriminating between alternatives. In this model, when two alternatives are both recognized, the cue or fact that discriminated on the previous trial is simply tried first, and if that cue fails to discriminate the cue that discriminated on the trial before last is tried, and so on. Thus, the TTL heuristic requires less information to operate than the TTB heuristic, since nothing needs to be known about cue validity. All that needs to be known to use the TTL heuristic is when a cue was last used successfully. In the Minimalist heuristic, cues are simply tried randomly and there is no need to know anything about cue validity or about when a cue was last used successfully.

Richter and Späth (2006) state that problem-solvers can use these sorts of recognition-based heuristics effectively if two conditions are met in the problem situation: first, some, but not all of the alternatives must be recognized, i.e., there must be recognition variance; and second, there must be a correlation between recognition and the criterion that is to be inferred, which they refer to as recognition validity. Further, Richter and Späth state that if the recognition validity correlation is larger than the correlations that exist between cues and the criterion, which they refer to as knowledge validity, a “less-is-more” effect can occur, so that a problem-solver with less knowledge can actually perform better on criterion judgment tasks than a problem-solver with more knowledge.

There has been empirical support for the less-is-more effect: Gigerenzer and Hoffrage (1995) have shown that Germans made more successful decisions about which city in pairs of US cities had the larger population than did Americans; Borges, Goldstein, Ortmann, and Gigerenzer (1999) have shown that amateur investors basing their investment decisions on the recognition principle made better choices than experts; and Gigerenzer and Goldstein (2002) have shown that over the course of repetitive testing, Germans’ recognition of US city names increased, but their accuracy in predicting which city in pairs of US cities had the highest population decreased. The latter finding is particularly illustrative of the less-is-more effect, in that problem-solvers with quite minimal knowledge about a problem situation can employ these sorts of fast-and-frugal heuristics to perform prediction tasks very successfully, but as their recognition knowledge of previously unrecognized alternatives increased, prediction performance decreased. Logically, a problem-solver with complete knowledge of the problem situation would have zero recognition variance for either alternatives or cues, and would be unable to use the recognition heuristic at all.

Since recognition-based heuristics can be used effectively only when boundary conditions are met in the problem situation, it is likely that problem-solvers will have other procedures for use when these conditions are not met. It may be that some problems lend themselves to a variety of different types of problem-solving procedures, and for these types of problems, the choice of procedure is likely to hinge on characteristics of the problem situation and personal preference.

Bröder and Schiffrin (2003) note that, from the "adaptive toolbox" perspective, people appear quite competent in the choices they make about which heuristic is most likely to be effective in a given situation. One factor that has been shown to be important in a problem-solver's choice of a heuristic is the relative cost of obtaining information from the environment versus retrieving information from memory. In studies in which participants "bought" information to help them predict which of pairs of stocks would be more profitable, Bröder (2000) found that 65% of participants employed a TTB heuristic when the cost of information was high, but this dropped to 15% when the cost was low or nothing. Newell and Shanks (2003) also found that participants were more likely to use a TTB heuristic as the cost of obtaining information from the environment increased.

Bröder and Schiffrin (2003) stated that representational format of the problem should also play a role in participants' choice of problem-solving procedure, and that sequential procedures, such as the TTB heuristic, should be better suited for problems in which information is verbally encoded and more likely to be retrieved from memory in a sequential manner, whereas simultaneous and compensatory processing is more likely to be engaged by problems presented in a pictorial format. In the above mentioned studies, Bröder (2000) found that participants used the TTB heuristic more frequently when information was verbally presented and used compensatory procedures more frequently when information was presented pictorially.

Bröder found, however, that even when the experimental conditions clearly favored the use of the TTB heuristic not all participants chose to use this approach, which led to the conclusion that there are distinct individual differences in the choice of problem-solving procedures. Newell and Shanks (2003) obtained similar results, finding that fully 25% of participants violated the TTB stopping rule, despite experimental conditions strongly manipulated to favor use of the TTB heuristic. Thus, it appears that when problem conditions permit a range of effective problem-solving procedures, the choice of procedure is partly down to the personal preference of users.

With respect to the "adaptive toolbox" model described above, the distinction between simple and alternating activation presented in this dissertation may reflect choices that problem-solvers are making about the most appropriate problem-solving procedures given the conditions present in the problem situation. When coherence is detected in a gestalt, problem-solvers choose alternating activation, a procedure that is particularly attuned to the overall wholeness, or spatial organization of gestalt features, and which can effectively exploit wholeness as useful information in problem-solving. On the other hand, when faced with an incoherent gestalt, or when conditions do not permit alternating activation, problem-solvers choose simple activation, a procedure that is less reliant on the overall *gestalt* and more reliant on recognizable individual features.

Fifth, the unexpected increase in incoherent partial-word performance observed in the longest partial-word delay condition in Study III resembles an incubation effect (Smith & Blankenship, 1989), in which a break in problem-solving leads to improved performance. This finding may offer some insight into a possible mechanism of incubation in which problem-solvers spontaneously switch from incremental, integrative problem-solving procedures to a simpler, faster non-compensatory heuristic procedure, triggering a "less-is-more" effect.

Knoblich, Ohlsson and Raney (2001) note that attempts at problem-solving often reach an impasse, at which point the problem-solver feels "stuck" despite the fact that achieving solution does not require skill or information beyond that possessed by the problem-solver. After some period of time off-task, i.e., an incubation period, the impasse can resolve allowing the problem-solver to rapidly solve the problem. Silveira (1971) has noted that incubation effects tend to be greater when the incubation period occurs at a later stage in problem-solving, which was the case in Study III in which the facilitation effect occurred only in the longest delay condition. The increase in incoherent partial-word facilitation observed in the longest delay condition in Study III suggests that an incubation effect did take place. It should be noted that incoherent partial-word facilitation not only increased in the longest delay condition, but actually increased to the point that it was not different from coherent partial-word facilitation, thus eliminating the coherent advantage although not in the expected way.

As noted by Kohn (2005), the mechanism underlying the incubation effect has been explained through relief from mental fatigue (Woodworth & Schlosberg, 1954; Posner, 1973); through continuing incremental work on the problem during the incubation period, either consciously (Browne & Cruse, 1988; Weisberg & Alba, 1981) or unconsciously (Yaniv and Meyer, 1987; Bowers et al., 1990); and through forgetting incorrect fixation (Smith & Blankenship, 1991; Smith & Vela, 1991). As Kohn (2005) states, the mental fatigue hypothesis has largely been discounted as an explanation for incubation effects, since incubation can occur even when problem-solvers engage in difficult tasks during the incubation period (Smith & Blankenship, 1991). Likewise, the conscious incremental hypothesis has difficulty explaining studies that show incubation effects when incubation intervals are filled with tasks that would interfere with conscious problem-solving efforts (Smith & Blankenship, 1991; Smith & Vela, 1991). However, there is substantial evidence for both the unconscious incremental hypothesis and the forgetting fixation hypothesis.

The unconscious incremental account of incubation employs a spreading activation model similar to that discussed in this thesis. According to Yaniv and Meyer (1987), initial problem-solving attempts activate memory traces critical to the problem's solution to sub-threshold levels. The relatively high residual energy at these traces facilitates recognition of the target word in a subsequent encounter in the environment. As Yaniv and Meyer note, activation of the semantic network by a failure to reach solution to a problem prompts more efficient assimilation of new solution-related stimuli from the environment. Unfortunately, such an explanation cannot adequately explain why facilitation should suddenly increase in the longest delay condition in Study III on incoherent trials, but not on coherent trials. If the explanation for increased incoherent facilitation in condition three is that problem-solvers simply have more time to employ unconscious incremental procedures, one would expect both coherent and incoherent facilitation to increase in condition three, which was not the case.

With regard to the forgetting fixation hypothesis, as Knoblich, Ohlsson and Raney (2001) note, insight-type problems are particularly likely to trigger an initial direction that is unhelpful in solving the problem. Activation of an incorrect mental representation at the start of problem-solving may lead to the activation of related concepts, ideas, analogies, etc. that are not useful to the goal of solving the problem at hand, while simultaneously blocking activation of more useful knowledge elements. According to the forgetting fixation hypothesis (Smith, 1995), once fixation on an incorrect association has occurred continued problem-solving attempts may simply lock the incorrectly fixated association into an ongoing competition with the correct solution. An incubation period can facilitate achievement of a correct solution by allowing the incorrect fixation to dissipate and become less accessible than the correct solution. Knoblich *et al* (2001) suggest that this may occur through deactivation of the incorrect knowledge element that has constrained consideration of other options (Ohlsson, 1992), or by the process of chunk decomposition, in which components of a perceptual chunk are separated, allowing them to be recombined in new ways (Knoblich, Ohlsson, Haider, & Rhenius, 1999).

For participants in Study III working with an incoherent gestalt, the organization of features within the gestalt will, at best, be discrepant with the expected organization activated by the deductive activation of a correct hunch node. The resulting mismatch between the expected organization of characteristics and the actual organization of gestalt features will likely seriously limit the amount of energy that can passed to the correct hunch node through inductive activations of matching organization nodes. At worst, the organization of incoherent gestalt features may actually resemble something other than the correct solution, leading to the activation of competing hunch nodes and the above-mentioned interference/blocking effect. As discussed above, this competition could be resolved in favor of the correct solution by the insertion of an incubation period, i.e., a dead air interval of long enough duration to allow for selective degradation of the incorrect fixation. With increasing durations of dead air interval, memory for an un-named organization of gestalt features would likely become increasingly difficult to maintain. On the other hand, relatively large accumulations of residual energy at nodes for gestalt features may be less difficult to maintain. Thus, memory for the incoherent spatial organization may fade rapidly compared to memory for gestalt features, allowing participants to focus their efforts on gestalt features that support the correct solution pattern.

It is possible, however, that the process of forgetting is non-specific, rather than a selective forgetting of an incorrect fixation. It may be that that both incorrect and correct patterns of activation begin to degrade during the longer period of dead-air in condition three. With residual energy patterns fading, problem-solvers may make the implicit decision to switch procedures in order to cope with changes occurring in the problem situation. Problem-solvers may abandon further attempts to use integrative spreading activation procedures and switch to a fast-and-frugal recognition-based heuristic procedure, and in so doing trigger a "less-is-more" effect. The dramatic increase in incoherent partial-word facilitation observed in condition three of Study III may be understood as a "less-is-more" effect.

For participants faced with the dilemma of resolving the competition between two "potential owners" as patterns of residual activation fade may very well prompt a decision to switch strategies from an integrative attempt to refine weights within the residual energy pattern to a simpler, faster procedure geared to operate with limited information; a procedure similar to the TTB heuristic described above in which the problem-solver invokes a limited search procedure with a full-stop rule whenever a discriminating fact is discovered that favors one alternative over another. If the problem-solver chooses to approach the problem in this way competition between false and correct "potential owners" may be decided successfully through a single recognition-based decision. Thus, counter-intuitively, as information in the problem situation decreases, switching to a simpler heuristic procedure can lead to increased incoherent partial-word facilitation, which was what was observed in condition three of Study III.

Thus, problem-solvers appear to be acutely attuned to changes taking place in the problem situation and competent in their implicit decisions about appropriate problem solving strategies. In Study II, in response to changes in the problem situation that prevented use of the strategy of alternating activation with coherent gestalts, participants chose to "fall back" on a simpler strategy, i.e., simple activation. In a similar way, when the problem situation in the longest delay condition in Study III no longer supported a strategy of accumulation and integration of partial-knowledge through spreading activation participants chose to “fall back” on a simpler, recognition-based heuristic procedure with a limited search and a stopping rule that specifies a halt to the search at the discovery of the first piece of evidence that favors one alternative over the other, similar to the TTB/TTL/Minimalist approaches.

In summary, problem-solvers appear highly sensitive to changes in the problem conditions, and cope with these changes by making intelligent, implicit decisions about the most appropriate problem solving strategy to meet the new problem situation. In the tasks encountered by participants in the current set of studies, when conditions were optimal, e.g., opportunity to alternate attention between a coherent gestalt and its partial-word puzzle, participants chose alternating activation as the appropriate procedure. When conditions changed, e.g., incoherent gestalts or no opportunity to alternate attention, participants chose simple activation as the appropriate procedure. When conditions changed further, e.g., incoherent gestalts/unresolved competition between “potential owners”/patterns of residual activation fading rapidly, participants chose to use a “fast-and-frugal” heuristic to quickly resolve the competition between alternatives.

What has not been shown

As noted above, while it has been proposed that the coherent advantage demonstrated in Study I takes place through incremental increases in implicit knowledge generated by alternating activation, the possibility that the observed increase in coherent partial-word facilitation is due to additional solutions of previously unrecognized coherent gestalts taking place during the partial-word solution phase cannot be ruled out. It may be that, under optimal conditions, the process of alternating activation moves from partial knowledge to successful solution so rapidly that it resembles the sort of "simultaneous processing" described by Paivio (1969). The frequency of occurrence of solution of previously unsolved coherent gestalts in the partial-word solution phase requires further investigation.

In Part B the primary objective was to determine whether the disappearance of the coherent advantage was necessarily abrupt, as it had been in Study II. It was predicted that with the insertion of a sufficient length of dead air interval between the offset of the partial-word solution phase gestalt and the onset of the partial-word puzzle, participants' memory for unrecognized gestalts would degrade, thereby preventing them from using alternating activation procedures and decreasing coherent partial-word facilitation. In Study III, however, the predicted decrease in coherent partial-word facilitation did not occur at any interval length employed.

It is possible that Study III failed to demonstrate the expected degradation of coherent facilitation due to methodological differences between Study III and Study II, in which degradation of the coherent advantage had occurred. It was noted that overall coherent partial-word facilitation was somewhat less in Study III than was observed in Study I, suggesting that something had impacted globally on participants' coherent partial-word performance. In retrospect, prior to beginning Study III, it would have been prudent to replicate Studies I and II using the computer presentation methodology employed in Study III to establish new benchmarks for partial-word performance.

Likely of more importance with respect to failure to show decreased coherent partial-word facilitation in Study III is that Study II participants saw the visual gestalt for each item only once for a total of 30 seconds, while Study III participants saw each visual gestalt twice, for a total of 60 seconds. The additional exposure and longer duration of exposure to each gestalt in Study III may have served as a sort of rehearsal that permitted participants to extend the length of time that gestalts could be maintained in memory. It may be that by shortening gestalt exposures degradation of coherent facilitation will occur at the durations of dead air employed in Study III, however it may be necessary to employ both shorter exposure to gestalts and longer dead air intervals to overcome the effect of repeated exposure to each gestalt. Also, having participants engage in some sort of unrelated activity during dead air intervals, rather than simply waiting for the onset of the partial-word puzzle, may be effective in disrupting rehearsal effects, allowing memory for gestalts to degrade as expected in Study III.

As well, as discussed above, it may be that the coherent advantage was the result of additional, unrecognized solutions of previously unrecognized coherent gestalts during their presentation in the partial-word solution phase, rather than by increases in partial, implicit knowledge. If upon further study this turns out to be the case, then one would not expect the coherent advantage to degrade with increasing intervals of dead air, since conscious recognition of a gestalt at its second presentation should produce a result similar to that which occurred on trials in which gestalts were solved during the visual gestalt solution phase presentation, i.e., near-perfect partial-word performance.

In any case, while the predicted degradation of the coherent advantage did not occur in Study III, this result neither supports or condemns the alternating activation model proposed in this thesis. If further studies demonstrate that the second-presentation coherent gestalt solution rate is substantial, then increased implicit partial knowledge is unlikely as the source of the coherent advantage, and since such a finding would support an “all-or-nothing” model it would not make sense to pursue the idea of demonstrating gradual degradation of the coherent advantage. If, on the other hand, it can be shown that the second-presentation coherent gestalt solution rate is minimal, modifications to Study III procedures to more effectively isolate and incrementally decrease access to memory for gestalts may yet show that coherent facilitation degrades with decreasing opportunities to engage in alternating activation. This still leaves an as open question whether such a degradation would be abrupt, which would be the case if problem-solvers respond to the changes in the problem situation by abruptly switching from alternating to simple activation, or gradual, which would be the case if problem-solvers choose to employ alternating activation for as long as it provides some benefit over simple activation.

Conclusions and recommendations

So, you are faced with a difficult and puzzling problem. What should you do? Anecdotal reports and empirical evidence presented in this thesis and elsewhere indicate that problem-solvers are often successful in their attempts to solve puzzling problems using intuitive procedures. It is even likely that problem-solvers will have a wide range of potentially useful intuitive procedures available to them in most problem situations, and, from the perspective of the “adaptive toolbox” model described by Gigerenzer and Selten (2001), human beings appear to be very sensitive to changes in the problem situation and competent at choosing the most appropriate procedure for a given problem situation. While personal preference appears to play some role in the choice of problem-solving procedures, the results of the studies included in this thesis demonstrate that, in general, problem-solvers respond to changes in conditions within the problem situation by making implicit, intelligent choices about the most appropriate procedure to employ in the changed problem situation.

When a problem-solver is faced with a difficult, puzzling problem and the elements of the problem situation seem very familiar and the available information appears rich, the problem-solver should probably stay focused on active problem-solving, since these are conditions that favor a problem-solving procedure that involves alternation between inductive activation from “parts” of the problem situation to a “whole” potentially capable of owning those parts, and deductive activation from a high residual energy “potential owner” to “parts” that should be present in the problem situation for that “potential owner” to be the correct solution. As has been noted in this thesis, when the information present in the problem situation is coherent and conditions permit, problem-solvers can employ this sort of alternating activation procedure to achieve greater facilitation of performance on a related task that is greater than can be gained through a simple inductive activation procedure.

On the other hand, when the elements of the problem situation seem unfamiliar and the available information in the problem situation appears sparse, confusing, and contradictory, perhaps the best problem-solving strategy would be to allow the mind to simply “wander” amongst the elements in the problem situation, activating nodes for characteristics that are in some way relevant to “parts” of the problem. If no solution seems immediately apparent and you have the experience of feeling “stuck,” it may be beneficial to take a break from active problem-solving. The feeling of being stuck may indicate that interference, in the form of a competition between correct and incorrect patterns of association, is occurring, and a break from active problem-solving may allow for one or both of two things to occur that may lead to a resolution of the competition in favor of the correct solution.

First, the incorrect pattern may simply degrade at a more rapid rate than the correct pattern. Termination of input activation supporting the node for the incorrect pattern may cause it to degrade from memory particularly rapidly, since it is likely to be based on fewer pieces of information than its correct competitor. Any subsequent encounter with new solution-relevant information in the environment may then benefit the correct residual energy pattern but not the incorrect pattern, thereby resolving the competition in favor of the correct solution.

Second, it may be that both correct and incorrect patterns of residual energy degrade at a fairly similar rate. For the problem-solver this represents a dilemma, since both patterns are now degrading and becoming less accessible. Under these conditions, it would make sense for the problem-solver to abandon further attempts to accumulate and integrate partial-knowledge through spreading activation, and instead switch to a rapid, non-compensatory heuristic strategy to increase the likelihood of making a correct decision between the competing "potential owners."

Future studies

As noted earlier, it is not clear whether the coherent advantage results from increases in implicit knowledge without additional gestalt solutions or from unrecognized second-presentation gestalt solutions. In either case, the process of alternating activation may play a role; however, before speculating further additional research is required to clarify the frequency of second-presentation solutions of previously unsolved coherent gestalts. This could be accomplished by altering the procedures of Study I so that participants are asked to attempt to provide a solution to the visual gestalt in the partial-word solution phase instead of the partial-word puzzle. A resulting second-presentation coherent gestalt solution rate similar to the Study I first-presentation coherent gestalt solution rate of 46% would lend support to the incremental increasing partial knowledge explanation of the coherent advantage, while a rate similar to the Study I partial-word solution rate of 55% would lend support to the “all-or-nothing” late solution model.

It would also be prudent to replicate Part A studies using the computerized presentation of stimuli employed in Part B in order to establish that the effects demonstrated in Study I and II are maintained with the new methodology.

With respect to the failure to demonstrate degradation of the coherent advantage in Part B, as noted earlier, it may be that solutions of previously unrecognized coherent gestalts occurred in the partial-word solution phase, and under these conditions increasing the duration of dead-air intervals would have little effect on the coherent partial-word solution rate. Whether a gestalt is solved in the visual gestalt solution phase or the partial-word solution phase, one would expect that the partial-word solution rate for that item to be close to 100% regardless of the delay condition. On the other hand, from the perspective of the increased implicit partial knowledge explanation, the failure to demonstrate degradation of the coherent advantage in Part B could indicate that participants’ ability to maintain the “whole” of an unsolved coherent visual gestalt in memory is simply greater than the proposed theoretical limit, due to the repeated exposure to gestalts and longer durations of gestalt exposure employed in Study III. Thus, if it can be shown that the rate of additional solutions of previously unsolved coherent gestalts in the partial-word solution phase is fairly minimal, future attempts to demonstrate coherent advantage degradation should include shorter overall exposure to each gestalt, as was the case in Study II, dead-air intervals of longer duration, and the inclusion of a distractor task during dead-air intervals to interfere with conscious or unconscious rehearsal procedures.

With respect to the unexpected increase in incoherent partial-word performance in condition three of Study III, this is an effect that needs to be replicated. In a follow-up study not included in this thesis for methodological reasons, the increased incoherent partial-word facilitation observed in the longest dead air interval in Study III was observed again under similar conditions, but this needs to be formally replicated.

In future research the less-is-more effect observed on trials with unsolved incoherent gestalts in condition three of Study III should be the focus of closer examination. It may be that the less-is-more effect can be enhanced by arranging conditions to favor fast-and frugal procedures. Given that the less-is-more effect seems most likely to occur when problem-solvers have a fairly minimal amount of knowledge about elements of the problem situation and must obtain discriminating information from memory rather than from the environment, problem conditions should limit the potential for participants to accumulate partial knowledge through spreading activation and hinder any strategies that might extend memory for unsolved gestalts. Thus, a procedure employing a single gestalt presentation, very short durations of gestalt exposure, dead air intervals of varying lengths, and a distractor task between the gestalt identification phase and the partial-word solution phase would increase the likelihood that participants will choose fast-and-frugal heuristics and consequently maximize the less-is-more effect.

In Study II, elimination of the partial-word solution phase gestalt presentation led to dissipation of the coherent advantage. Since it appears that participants are employing a simple activation strategy for both coherent and incoherent gestalts under these conditions, it would be interesting to observe whether manipulating problem conditions to favor fast-and-frugal heuristics as described above would have any impact on coherent facilitation. It seems unlikely that a less-is-more effect could be triggered with coherent gestalts, since: a) problem-solvers likely obtain too much good information from a coherent gestalt to permit successful use of a recognition based fast-and-frugal heuristic procedure, and b) it seems unlikely that there will be the necessary competition between correct and incorrect "potential owners" to engage a fast-and-frugal decision heuristic. It is not clear what an increase in coherent facilitation under these conditions would represent, since, as noted above, fast-and-frugal heuristics are unlikely to be engaged by coherent gestalts, and since "forgetting" would involve the loss of useful, rather than misleading information. It seems much more likely that coherent gestalts will prove resistant to fast-and-frugal processing, and arranging conditions to favor use of fast-and-frugal heuristic procedures will likely result in a decrease in coherent facilitation due to reduced exposure to sources of useful information and reduced time on task.

It would also be informative to reverse the direction of stimuli, i.e., using partial-word puzzles as clues to the solution of visual gestalts. It is likely that facilitation of gestalt solution will occur for both coherent and incoherent gestalts, but it is unclear whether facilitation will differ for coherent and incoherent gestalts. It seems logical that the clue value of the unsolved partial-word puzzle will be the same in either case, and so the amount of facilitation of gestalt solution is likely to be similar for coherent and incoherent gestalts. It would also be possible to employ a graduated partial-word clue approach by manipulating the completeness of each partial-word puzzle. This could provide another demonstration of the relationship between the quality of clues and the amount of partial knowledge that can be obtained, as reflected in the amount of resulting gestalt facilitation. It may also be that reversing the direction of the stimuli will favor the use of fast-and-frugal heuristics. As noted by Bröder (2003), while presentation of stimuli in an imagistic format favors simultaneous processing through compensatory summing and integration procedures, such as spreading activation, presentation in a verbal format favors sequential processing through non-compensatory procedures, such as fast-and-frugal heuristics. In summary, the increase in incoherent facilitation demonstrated in the longest delay condition in Study III could be examined in more depth by varying experimental conditions to favor/disfavor fast-and-frugal heuristics.

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APPENDICES

Appendix A

Practice items – Visual gestalt identification phase and partial-word solution phase

Practice Item 1: Image 033 – CAMEL coherent version

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Practice Item 1: Image 033 – CAMEL coherent version

Fill in the missing letters:

_AM_L

Practice Item 2: Image 034 – CAN OPENER coherent version

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Practice Item 2: Image 034 – CAN OPENER coherent version

Fill in the missing letters:

C_N _PE_E_

Practice Item 3: Image 035 – LIGHTER coherent version

1. What is this object?

____

2. How sure are you? ________

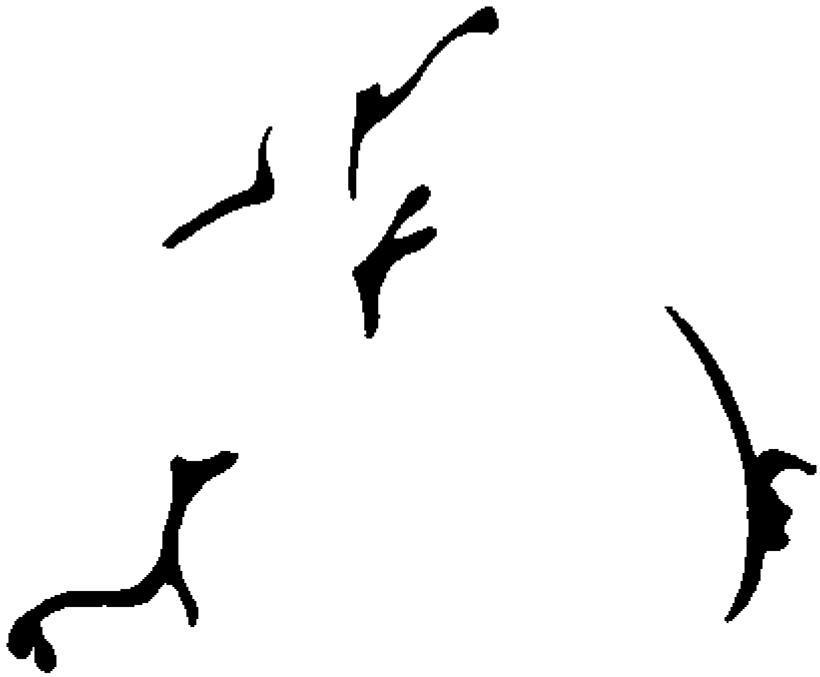
0% 50% 100%

Practice Item 3: Image 035 – LIGHTER coherent version

Fill in the missing letters:

L__HT_R

Practice Item 4: Image 036 – RABBIT coherent version



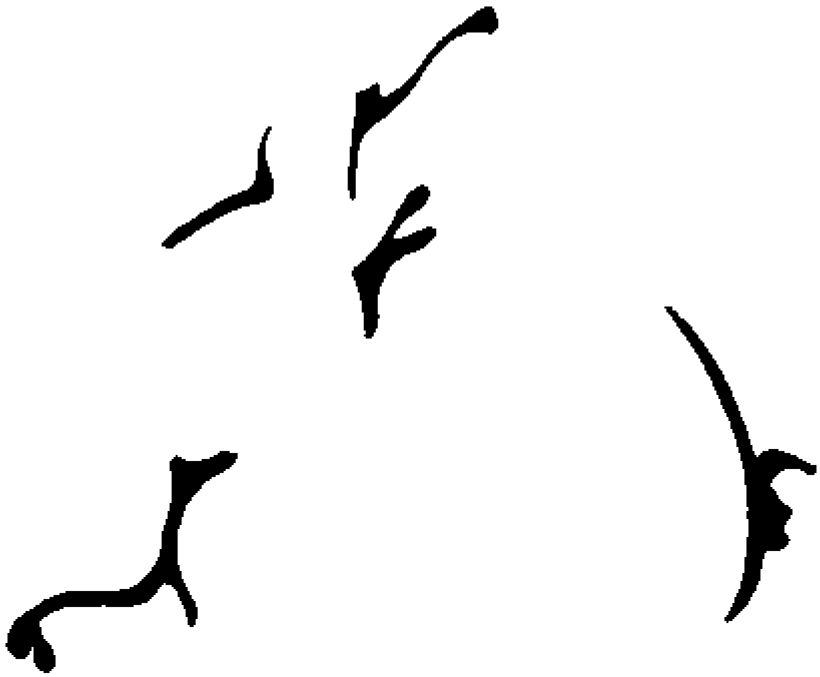
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Practice Item 4: Image 036 – RABBIT coherent version



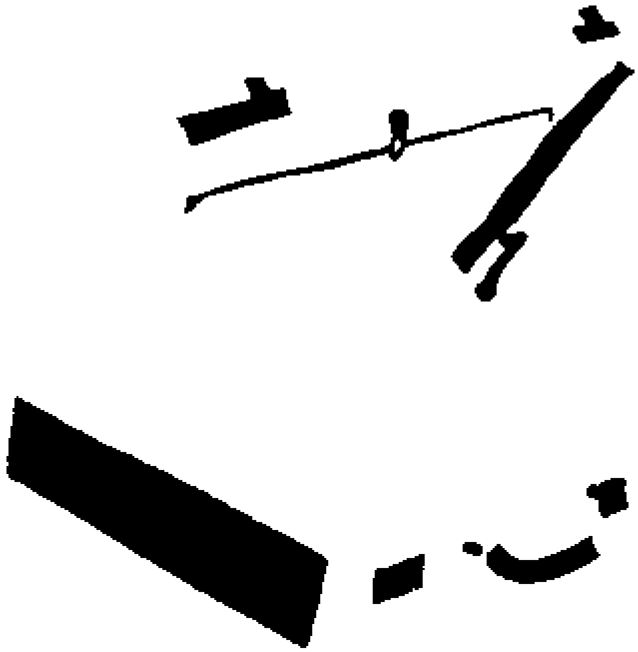
Fill in the missing letters:

R__BI_

Appendix B

Test items – Visual gestalt identification phase and partial-word solution phase

Test Item 1: Image 001 Coherent version – BRIEFCASE



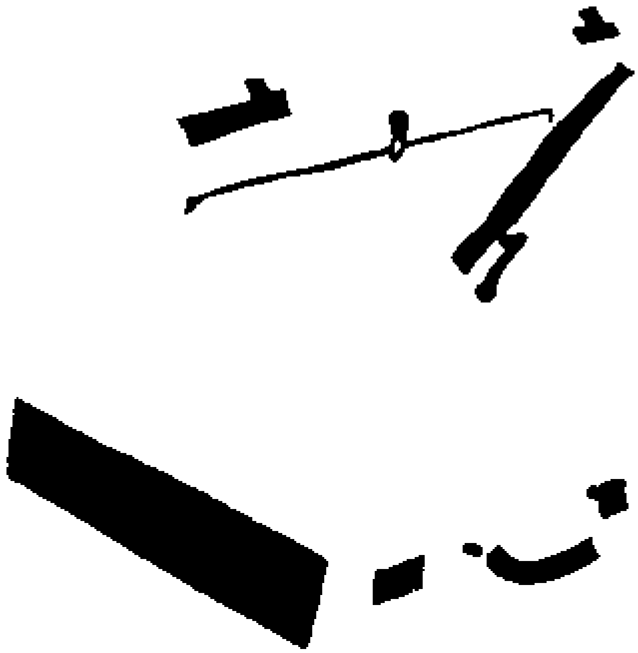
1. What is this object?

____

2. How sure are you? _________

0%   50%   100%

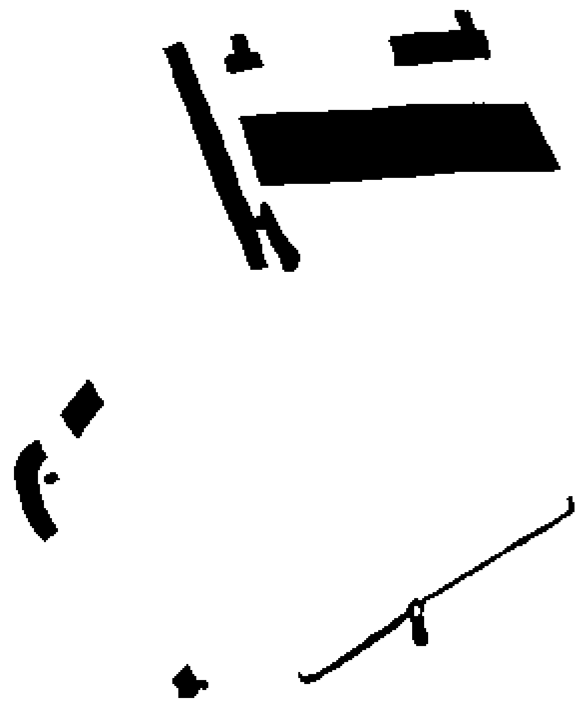
Test Item 1: Image 001 Coherent version – BRIEFCASE



Fill in the missing letters:

__i_f_as_

Test Item 1: Image 001 Incoherent version – BRIEFCASE



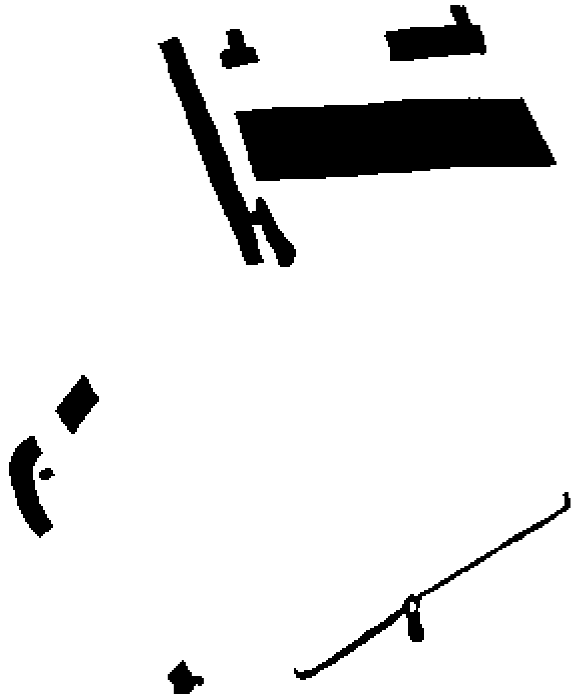
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Test Item 1: Image 001 Incoherent version – BRIEFCASE



Fill in the missing letters:

__i_f_as_

Test Item 2: Image 002 Coherent version – CAMERA

1. What is this object?

____

2. How sure are you? ________

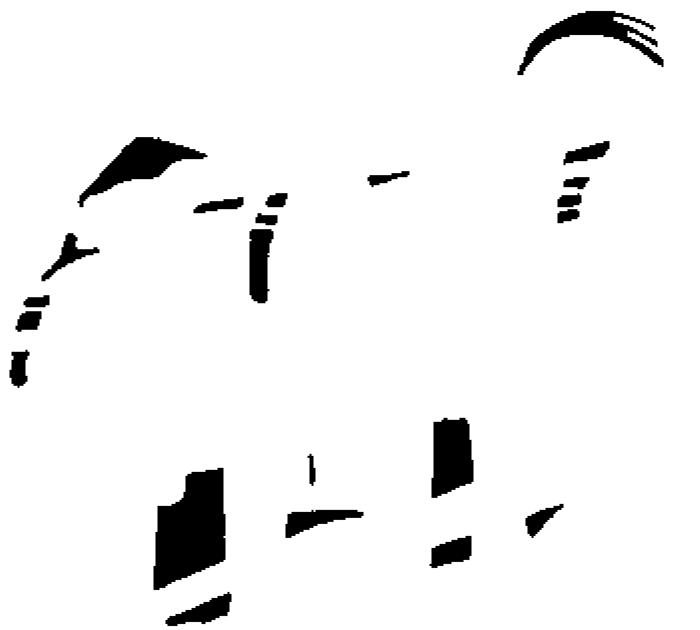
0% 50% 100%

Test Item 2: Image 002 Coherent version – CAMERA

Fill in the missing letters:

_am_r_

Test Item 2: Image 002 Incoherent version – CAMERA



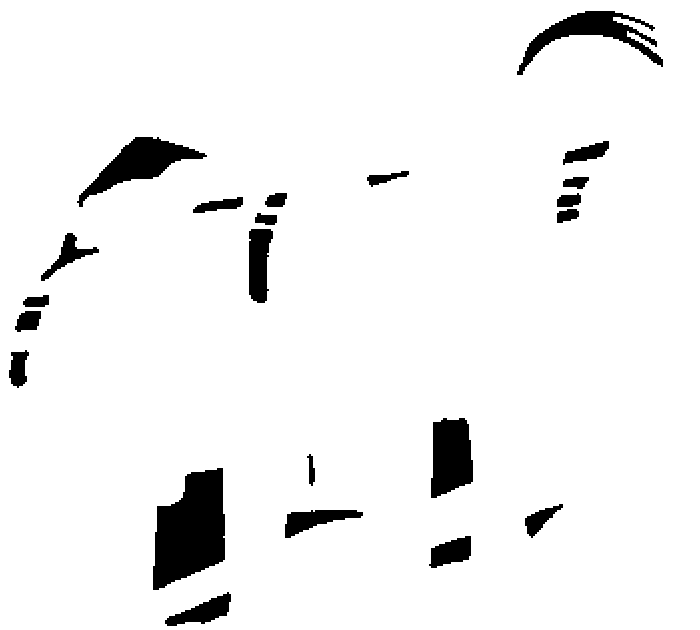
1. What is this object?

____

2. How sure are you? __________

0%   50%   100%

Test Item 2: Image 002 Incoherent version – CAMERA



Fill in the missing letters:

_am_r_

Item 3: Image 003 Coherent version – COFFEE PERCOLATOR

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 3: Image 003 Coherent version – COFFEE PERCOLATOR

Fill in the missing letters:

_of__e..p_r_o_at__

Item 3: Image 003 Incoherent version – COFFEE PERCOLATOR

1. What is this object?

____

2. How sure are you? _________

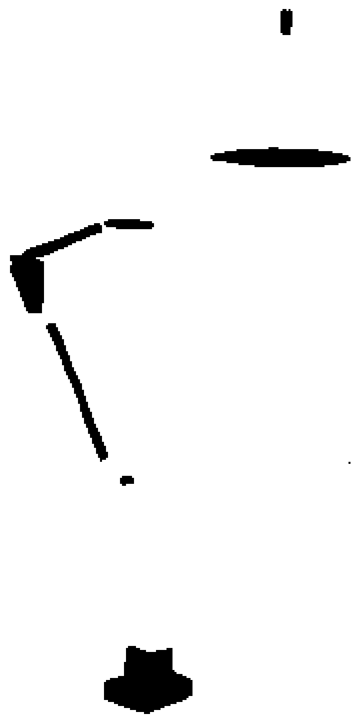
0% 50% 100%

Item 3: Image 003 Incoherent version – COFFEE PERCOLATOR

Fill in the missing letters:

_of__e..p_r_o_at__

Item 4: Image 004 Coherent version – DESKLAMP



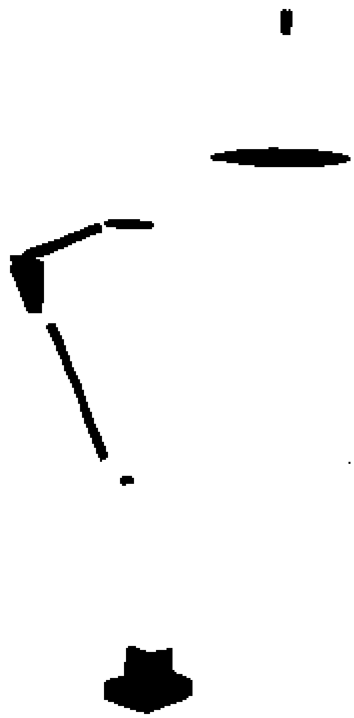
1. What is this object?

____

2. How sure are you? _________

0%   50%   100%

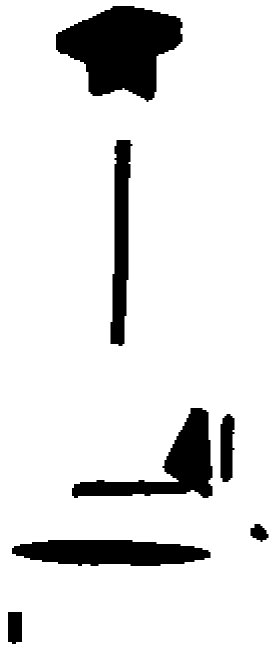
Item 4: Image 004 Coherent version – DESKLAMP



Fill in the missing letters:

d__k_a_p

Item 4: Image 004 Incoherent version – DESKLAMP



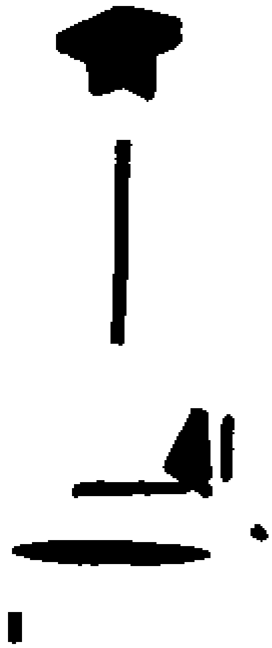
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

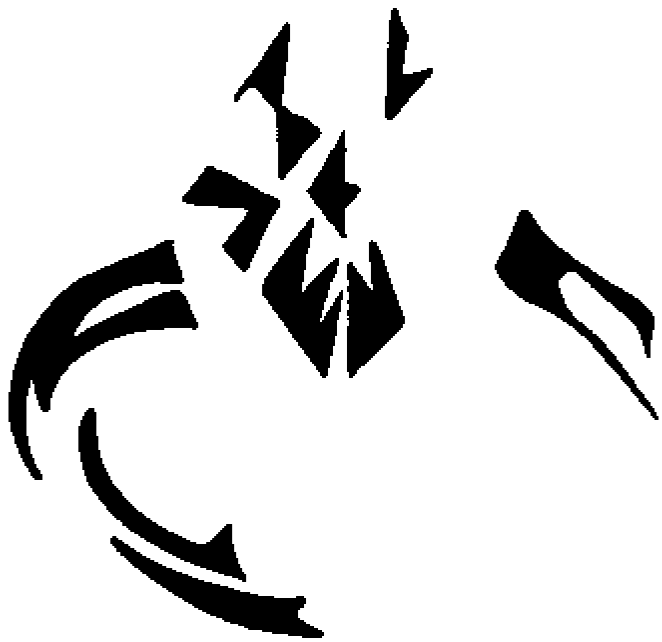
Item 4: Image 004 Incoherent version – DESKLAMP



Fill in the missing letters:

d__k_a_p

Item 5: Image 005 Coherent version – DIAMOND RING



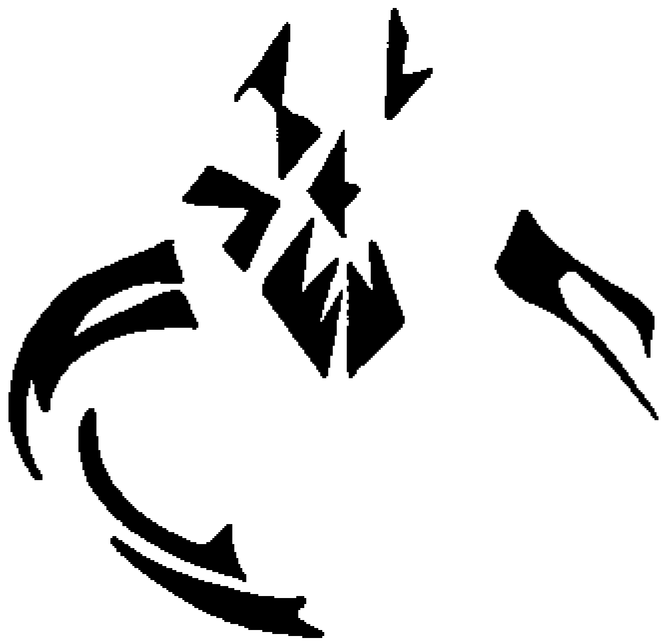
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 5: Image 005 Coherent version – DIAMOND RING



Fill in the missing letters:

_i_m__d..r__g

Item 5: Image 005 Incoherent version – DIAMOND RING

1. What is this object?

____

2. How sure are you? _________

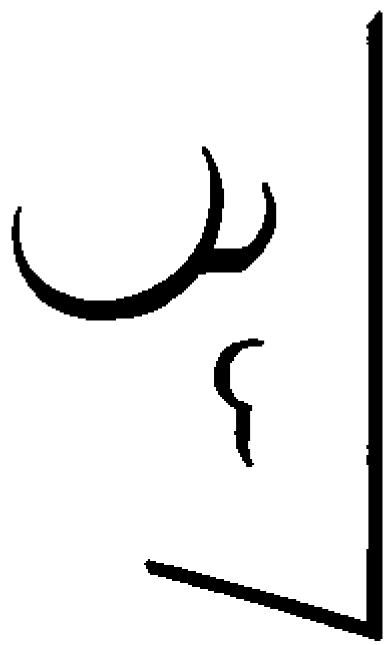
0% 50% 100%

Item 5: Image 005 Incoherent version – DIAMOND RING

Fill in the missing letters:

_i_m__d..r__g

Item 6: Image 006 Coherent version – DOORKNOB



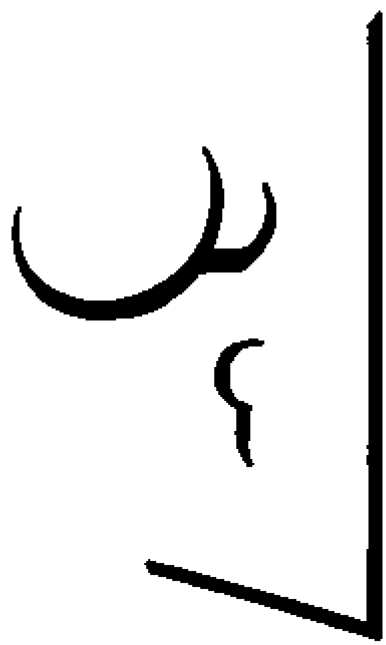
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

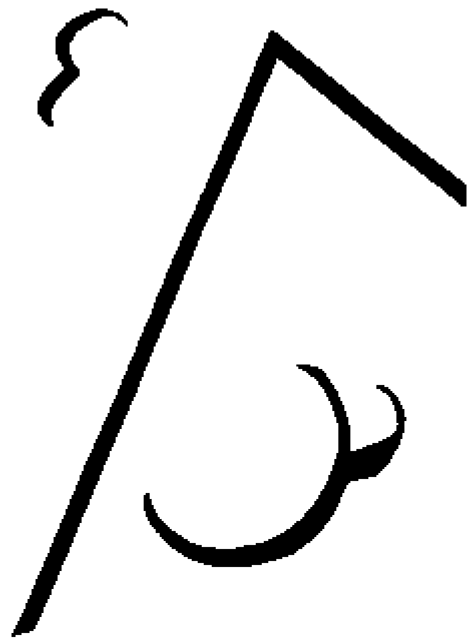
Item 6: Image 006 Coherent version – DOORKNOB



Fill in the missing letters:

__o_k__b

Item 6: Image 006 Incoherent version – DOORKNOB



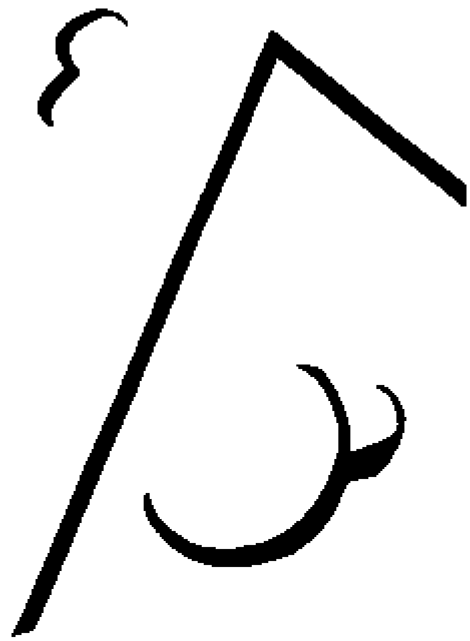
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 6: Image 006 Incoherent version – DOORKNOB



Fill in the missing letters:

__o_k__b

Item 7: Image 007 Coherent version – ELEPHANT

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 7: Image 007 Coherent version – ELEPHANT

Fill in the missing letters:

__ep_a_t

Item 7: Image 007 Incoherent version – ELEPHANT

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 7: Image 007 Incoherent version – ELEPHANT

Fill in the missing letters:

__ep_a_t

Item 8: Image 008 Coherent version – FIRE HYDRANT

1. What is this object?

____

2. How sure are you? _________

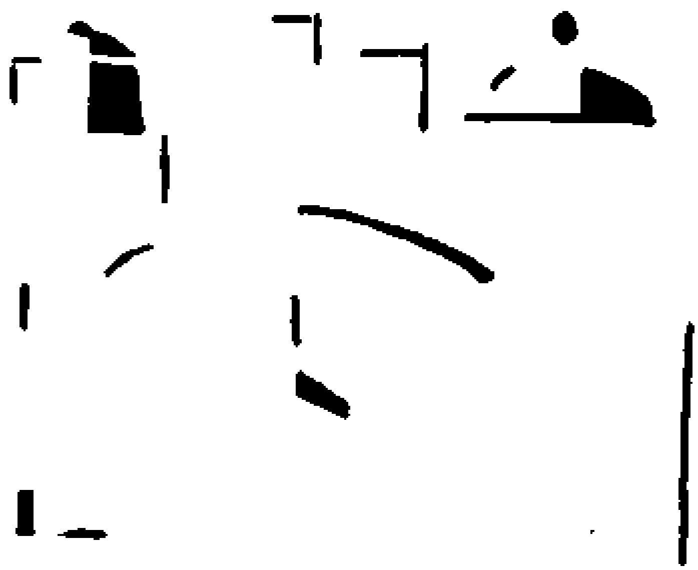
0% 50% 100%

Item 8: Image 008 Coherent version – FIRE HYDRANT

Fill in the missing letters:

f_re..__dr_n_

Item 8: Image 008 Incoherent version – FIRE HYDRANT



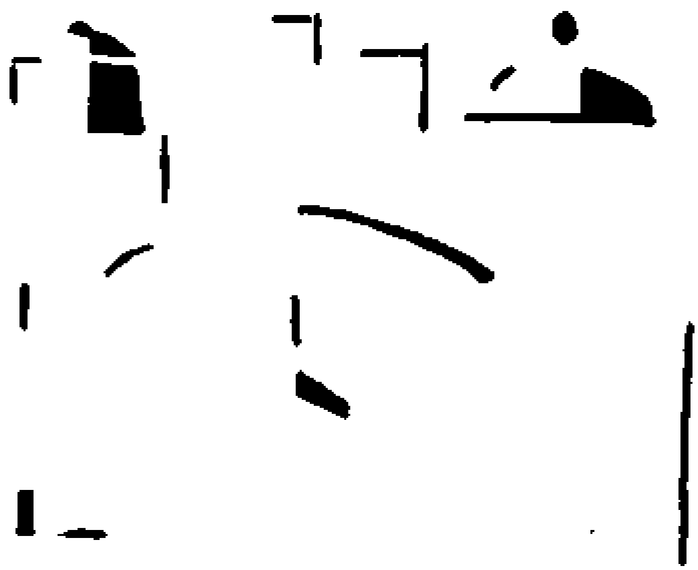
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 8: Image 008 Incoherent version – FIRE HYDRANT



Fill in the missing letters:

f_re..__dr_n_

Item 9: Image 009 Coherent version – GARBAGE CAN

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 9: Image 009 Coherent version – GARBAGE CAN

Fill in the missing letters:

_a_ba__..c_n

Item 9: Image 009 Incoherent version – GARBAGE CAN

1. What is this object?

____

2. How sure are you? ________

0%   50%   100%

Item 9: Image 009 Incoherent version – GARBAGE CAN

Fill in the missing letters:

_a_ba__..c_n

Item 10: Image 010 Coherent version – GIRAFFE

1. What is this object?

____

2. How sure are you? __________

0%   50%   100%

Item 10: Image 010 Coherent version – GIRAFFE

Fill in the missing letters:

_i_af__

Item 10: Image 010 Incoherent version – GIRAFFE

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 10: Image 010 Incoherent version – GIRAFFE

Fill in the missing letters:

_i_af__

Item 11: Image 011 Coherent version – GUITAR

1. What is this object?

____

2. How sure are you? ________

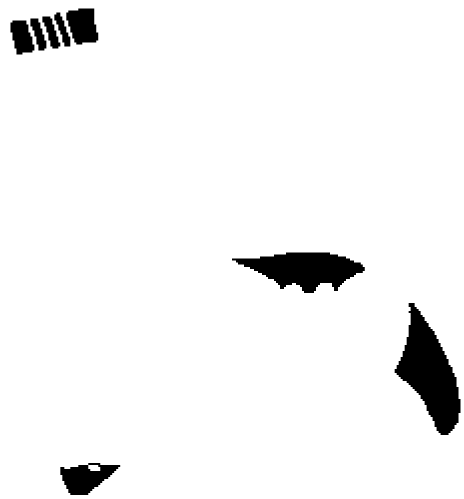
0% 50% 100%

Item 11: Image 011 Coherent version – GUITAR

Fill in the missing letters:

_ui_a_

Item 11: Image 011 Incoherent version – GUITAR



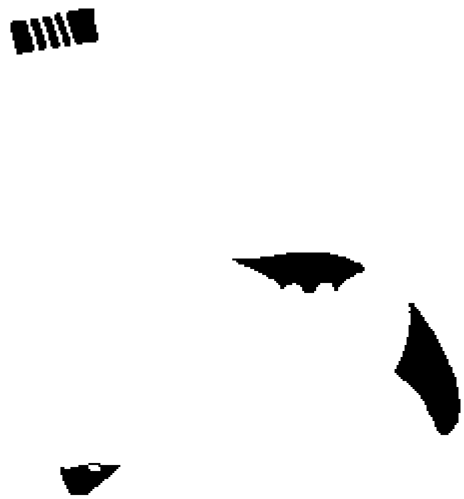
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 11: Image 011 Incoherent version – GUITAR



Fill in the missing letters:

_ui_a_

Item 12: Image 012 Coherent version – HELICOPTER

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 12: Image 012 Coherent version – HELICOPTER

Fill in the missing letters:

_el__op_e_

Item 12: Image 012 Incoherent version – HELICOPTER

1. What is this object?

____

2. How sure are you? ________

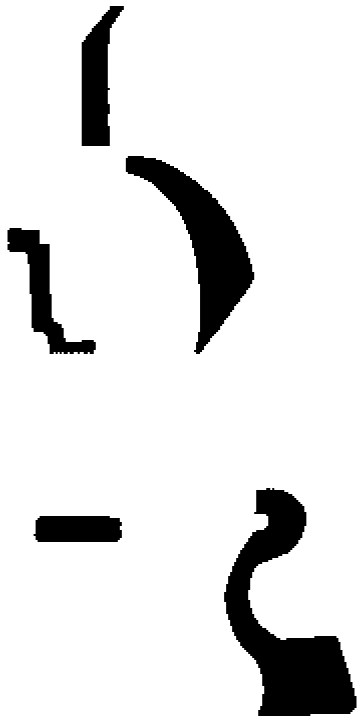
0% 50% 100%

Item 12: Image 012 Incoherent version – HELICOPTER

Fill in the missing letters:

_el__op_e_

Item 13: Image 013 Coherent version – MICROSCOPE



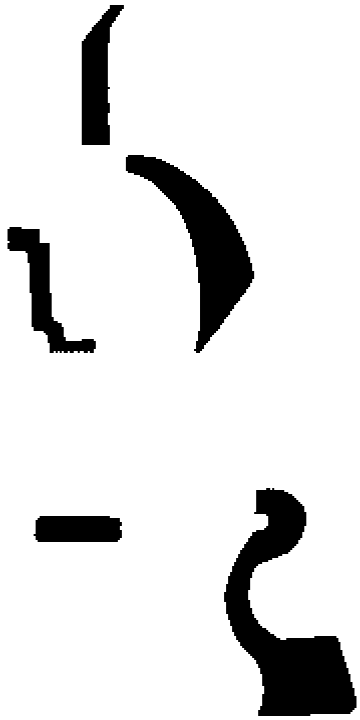
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 13: Image 013 Coherent version – MICROSCOPE



Fill in the missing letters:

_i_r_s__pe

Item 13: Image 013 Incoherent version – MICROSCOPE

1. What is this object?

____

2. How sure are you? ________

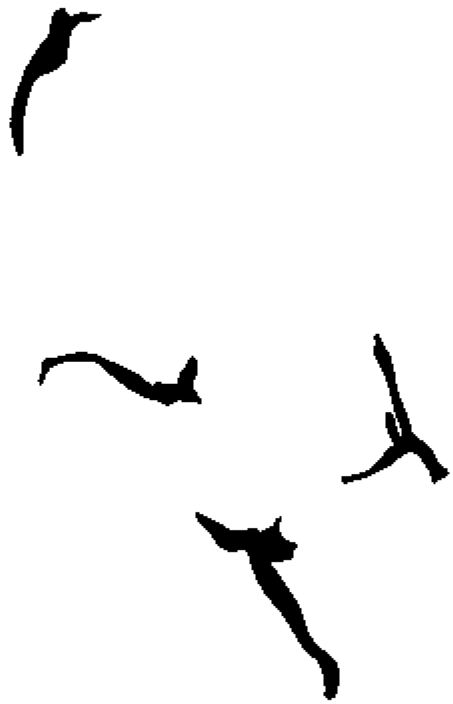
0% 50% 100%

Item 13: Image 013 Incoherent version – MICROSCOPE

Fill in the missing letters:

_i_r_s__pe

Item 14: Image 014 Coherent version – MITTEN



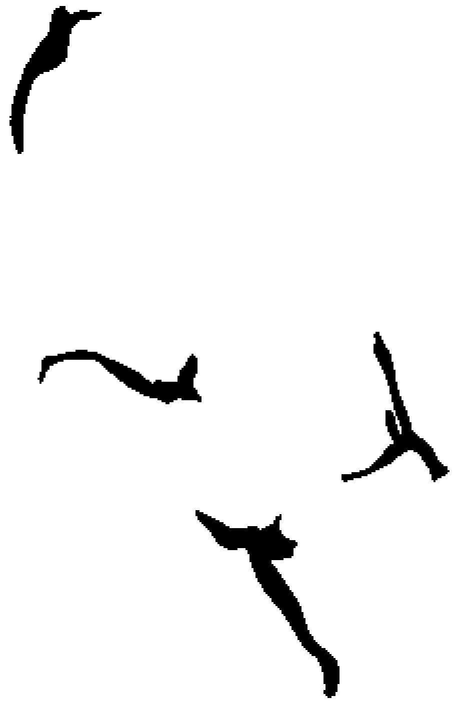
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 14: Image 014 Coherent version – MITTEN



Fill in the missing letters:

mi__en

Item 14: Image 014 Incoherent version – MITTEN

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 14: Image 014 Incoherent version – MITTEN

Fill in the missing letters:

mi__en

Item 15: Image 015 Coherent version – MOOSE

1. What is this object?

____

2. How sure are you? _________

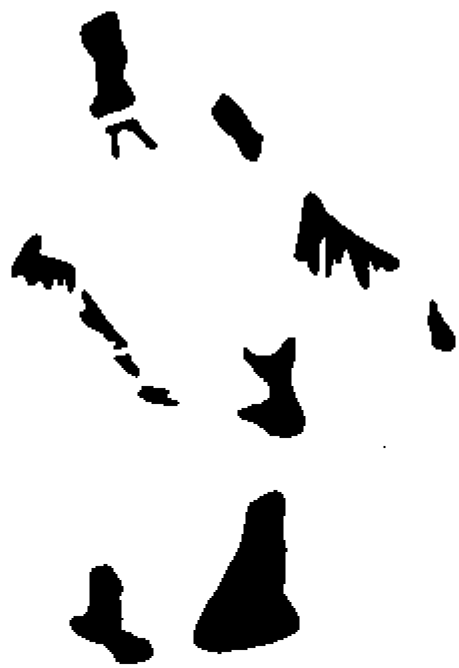
0% 50% 100%

Item 15: Image 015 Coherent version – MOOSE

Fill in the missing letters:

m_o_e

Item 15: Image 015 Incoherent version – MOOSE



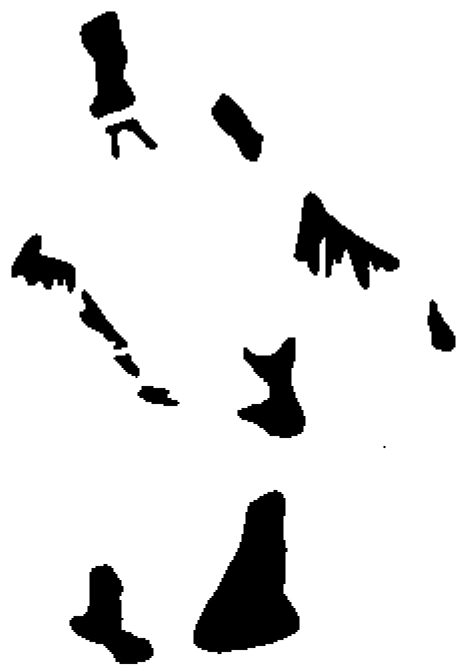
1. What is this object?

____

2. How sure are you? _________

0%   50%   100%

Item 15: Image 015 Incoherent version – MOOSE



Fill in the missing letters:

m_o_e

Item 16: Image 016 Coherent version – OIL LAMP

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 16: Image 016 Coherent version – OIL LAMP

Fill in the missing letters:

_il..la_p

Item 16: Image 016 Incoherent version – OIL LAMP

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 16: Image 016 Incoherent version – OIL LAMP

Fill in the missing letters:

_il..la_p

Item 17: Image 017 Coherent version – PADLOCK

1. What is this object?

____

2. How sure are you? ________

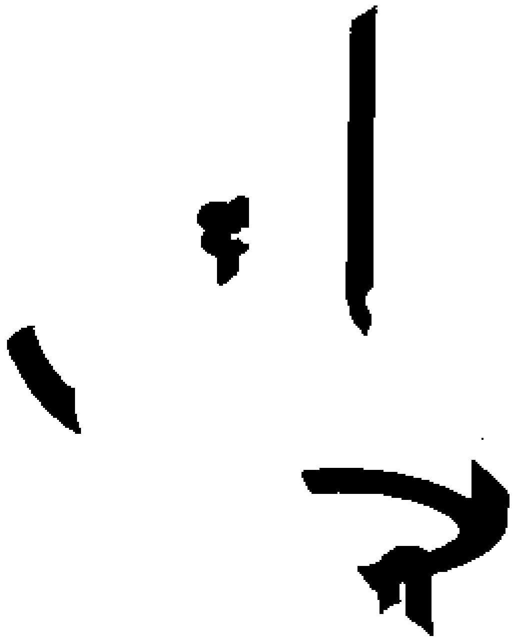
0% 50% 100%

Item 17: Image 017 Coherent version – PADLOCK

Fill in the missing letters:

pa_l__k

Item 17: Image 017 Incoherent version – PADLOCK



1. What is this object?

____

2. How sure are you? ________

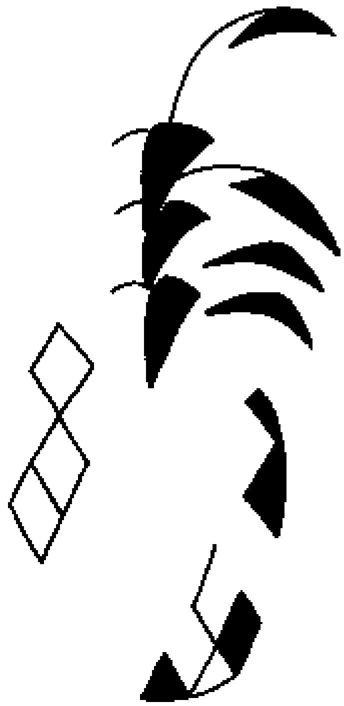
0%   50%   100%

Item 17: Image 017 Incoherent version – PADLOCK

Fill in the missing letters:

pa_l__k

Item 18: Image 018 Coherent version - PINEAPPLE



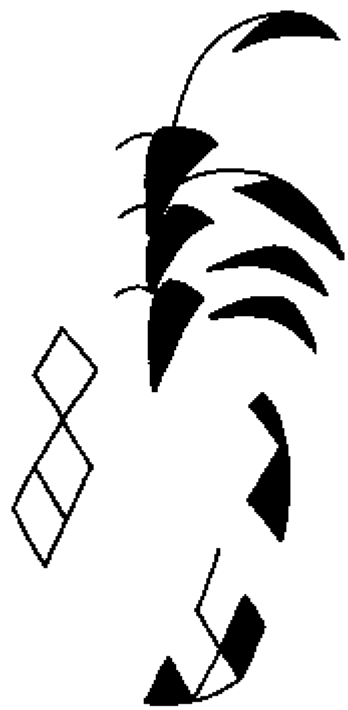
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 18: Image 018 Coherent version - PINEAPPLE



Fill in the missing letters:

_i_ea_p__

Item 18: Image 018 Incoherent version - PINEAPPLE

1. What is this object?

____

2. How sure are you? __________

0% 50% 100%

Item 18: Image 018 Incoherent version - PINEAPPLE

Fill in the missing letters:

_i_ea_p__

Item 19: Image 019 Coherent version - PLIERS

1. What is this object?

____

2. How sure are you? _________

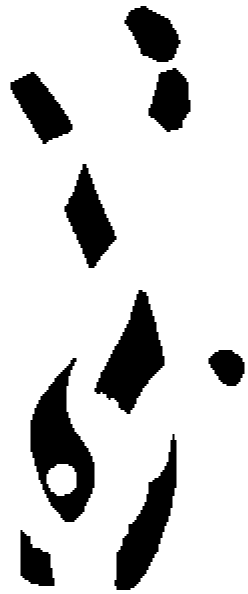
0% 50% 100%

Item 19: Image 019 Coherent version - PLIERS

Fill in the missing letters:

p_ie_s

Item 19: Image 019 Incoherent version - PLIERS



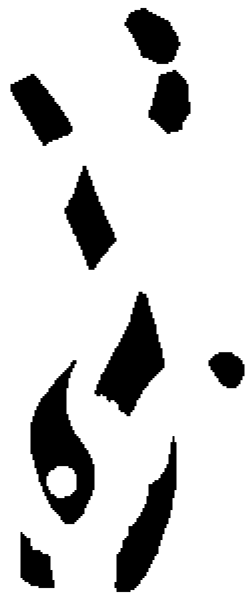
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

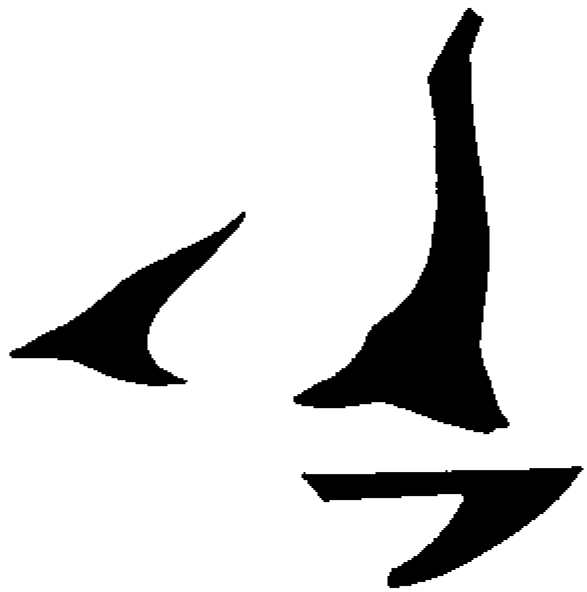
Item 19: Image 019 Incoherent version - PLIERS



Fill in the missing letters:

p_ie_s

Item 20: Image 020 Coherent version - SAILBOAT



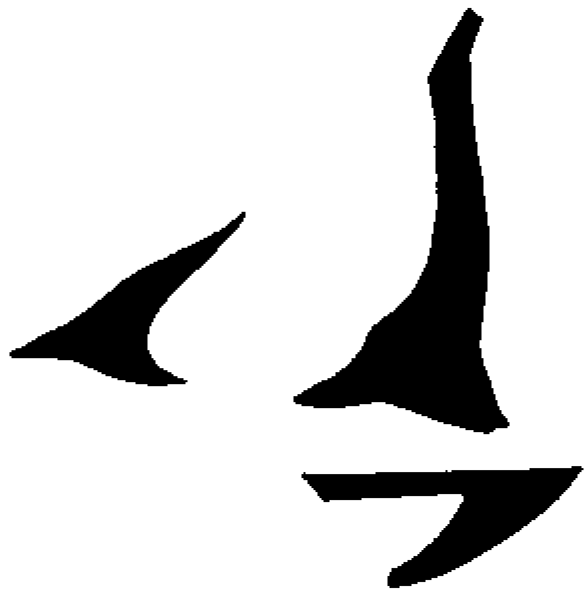
1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 20: Image 020 Coherent version - SAILBOAT



Fill in the missing letters:

_ai_bo__

Item 20: Image 020 Incoherent version - SAILBOAT

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 20: Image 020 Incoherent version - SAILBOAT

Fill in the missing letters:

_ai_bo__

Item 21: Image 021 Coherent version - SCISSORS

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 21: Image 021 Coherent version - SCISSORS

Fill in the missing letters:

s_i__or_

Item 21: Image 021 Incoherent version - SCISSORS

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 21: Image 021 Incoherent version - SCISSORS

Fill in the missing letters:

s_i__or_

Item 22: Image 022 Coherent version – SHOVEL

1. What is this object?

____

2. How sure are you? _________

0% 50% 100%

Item 22: Image 022 Coherent version – SHOVEL

Fill in the missing letters:

s_o_el

Item 22: Image 022 Incoherent version – SHOVEL

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 22: Image 022 Incoherent version – SHOVEL

Fill in the missing letters:

s_o_el

Item 23: Image 023 Coherent version – SQUIRREL

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 23: Image 023 Coherent version – SQUIRREL

Fill in the missing letters:

s__ir__l

Item 23: Image 023 Incoherent version – SQUIRREL

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 23: Image 023 Incoherent version – SQUIRREL

Fill in the missing letters:

s__ir__l

Item 24: Image 024 Coherent version – TELEPHONE

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 24: Image 024 Coherent version – TELEPHONE

Fill in the missing letters:

_e_e_h__e

Item 24: Image 024 Incoherent version – TELEPHONE

1. What is this object?

____

2. How sure are you? _________

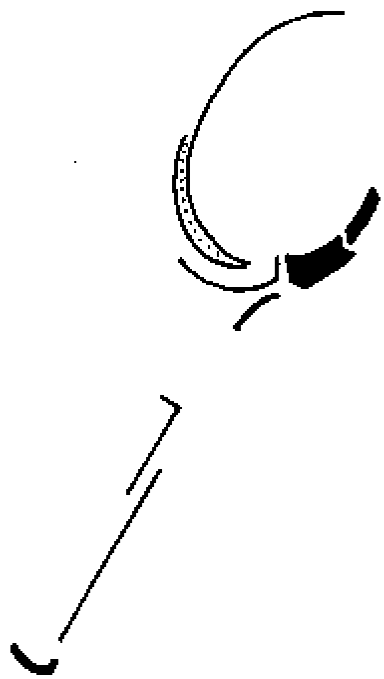
0% 50% 100%

Item 24: Image 024 Incoherent version – TELEPHONE

Fill in the missing letters:

_e_e_h__e

Item 25: Image 025 Coherent version – TENNIS RACQUET



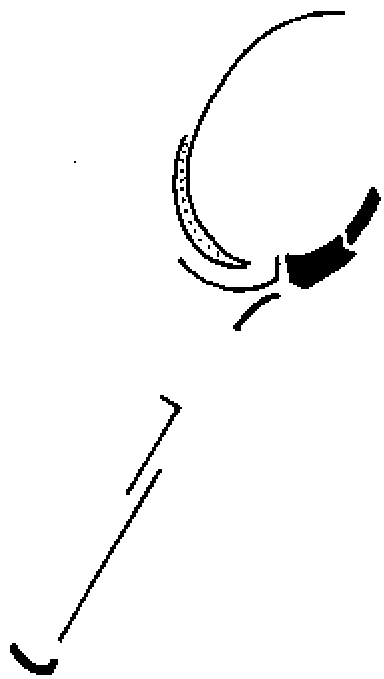
1. What is this object?

____

2. How sure are you? ________

0%   50%   100%

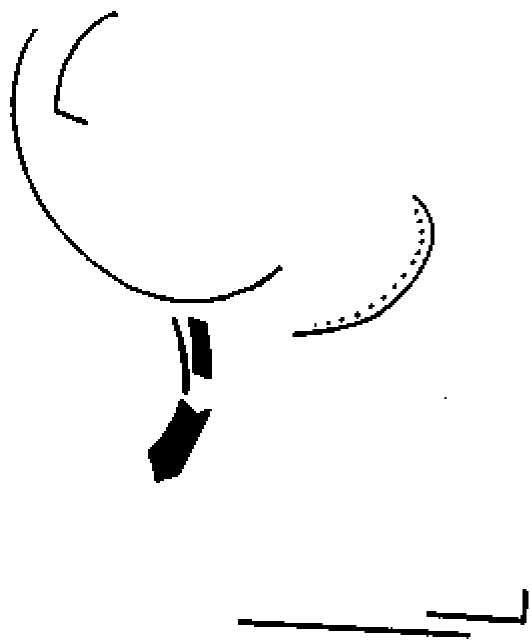
Item 25: Image 025 Coherent version – TENNIS RACQUET



Fill in the missing letters:

_e_n_s..__c_ue_

Item 25: Image 025 Incoherent version – TENNIS RACQUET



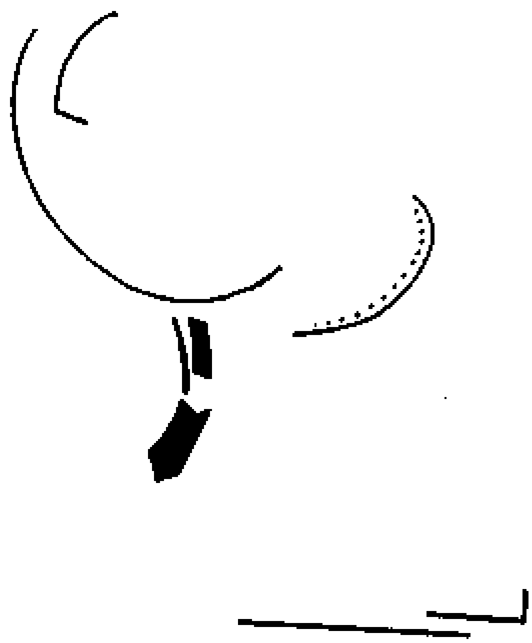
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

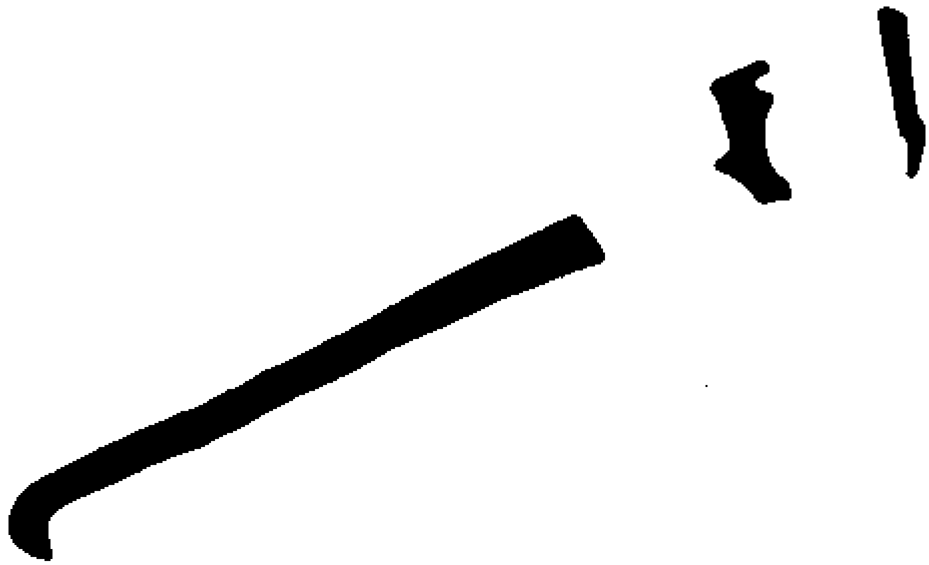
Item 25: Image 025 Incoherent version – TENNIS RACQUET



Fill in the missing letters:

_e_n_s..__c_ue_

Item 26: Image 026 Coherent version – TOOTHBRUSH



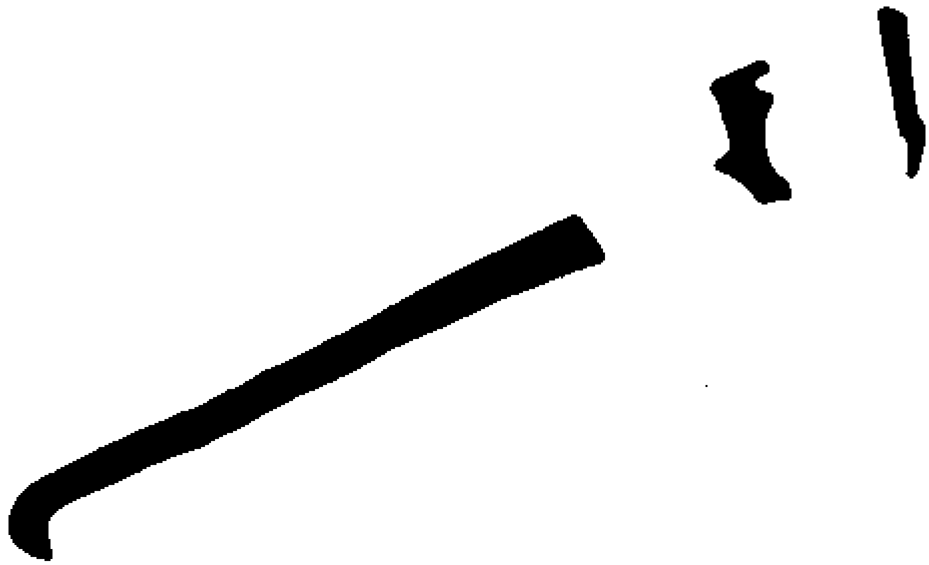
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 26: Image 026 Coherent version – TOOTHBRUSH



Fill in the missing letters:

t__t__r_sh

Item 26: Image 026 Incoherent version – TOOTHBRUSH

1. What is this object?

____

2. How sure are you? _________

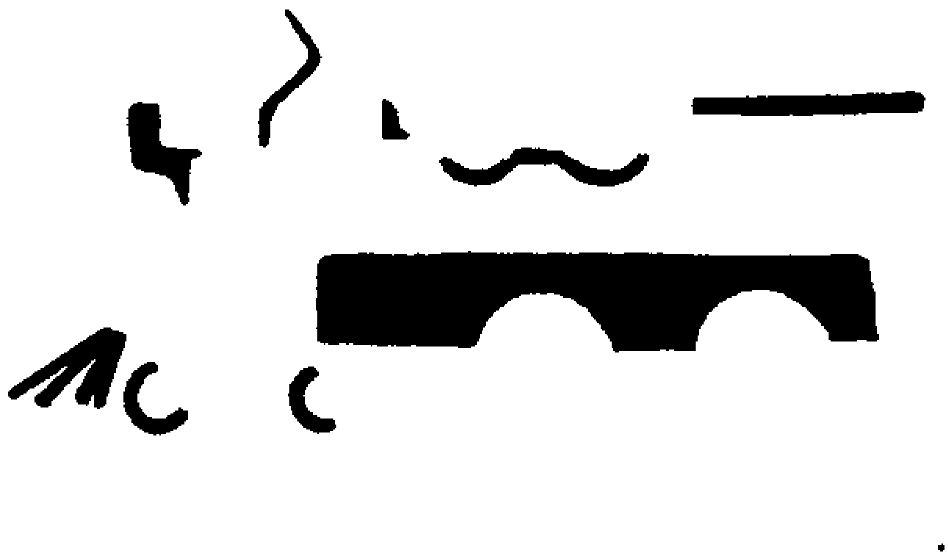
0% 50% 100%

Item 26: Image 026 Incoherent version – TOOTHBRUSH

Fill in the missing letters:

t__t__r_sh

Item 27: Image 027 Coherent version – TRAIN ENGINE



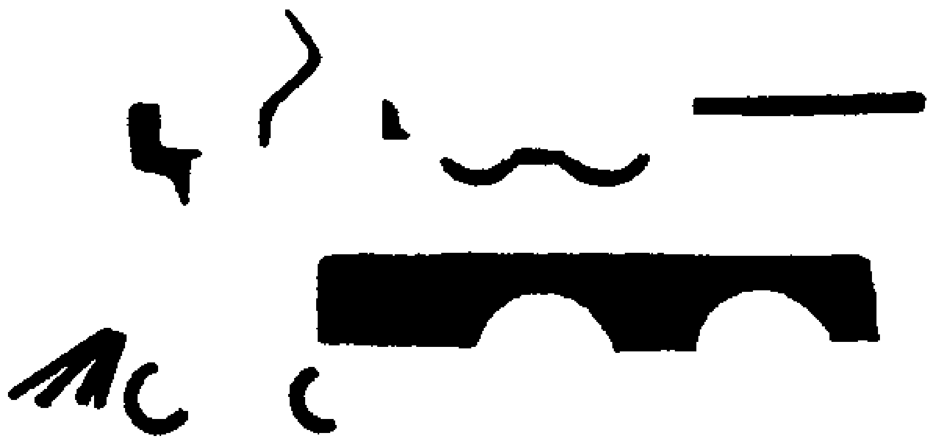
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 27: Image 027 Coherent version – TRAIN ENGINE



Fill in the missing letters:

t__in.._n_ine

Item 27: Image 027 Incoherent version – TRAIN ENGINE

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 27: Image 027 Incoherent version – TRAIN ENGINE

Fill in the missing letters:

t__in.._n_ine

Item 28: Image 028 Coherent version – TURNTABLE

1. What is this object?

____

2. How sure are you? _________

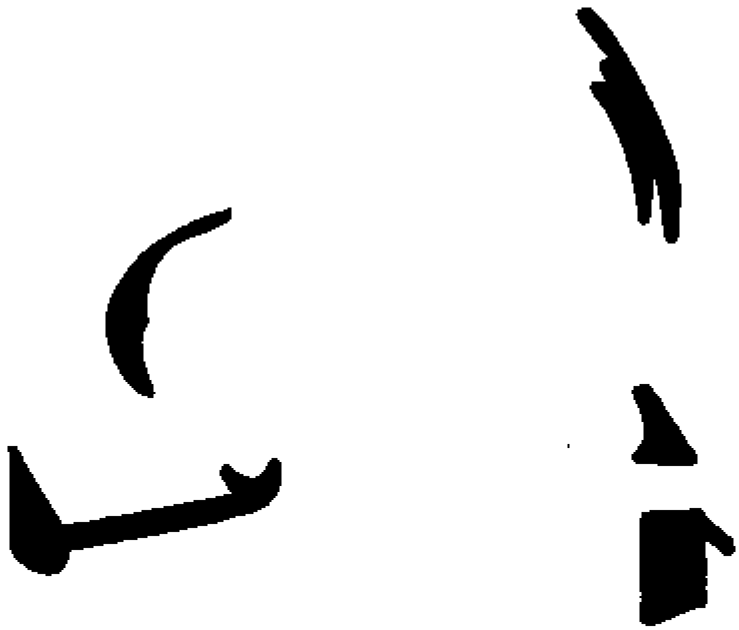
0% 50% 100%

Item 28: Image 028 Coherent version – TURNTABLE

Fill in the missing letters:

__rn_ab__

Item 28: Image 028 Incoherent version – TURNTABLE



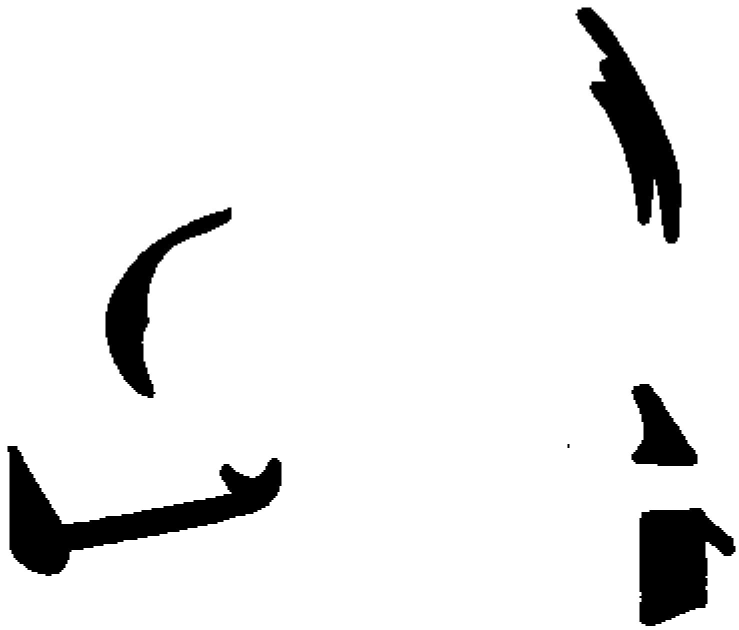
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 28: Image 028 Incoherent version – TURNTABLE



Fill in the missing letters:

__rn_ab__

Item 29: Image 029 Coherent version – TURTLE

1. What is this object?

____

2. How sure are you? ________

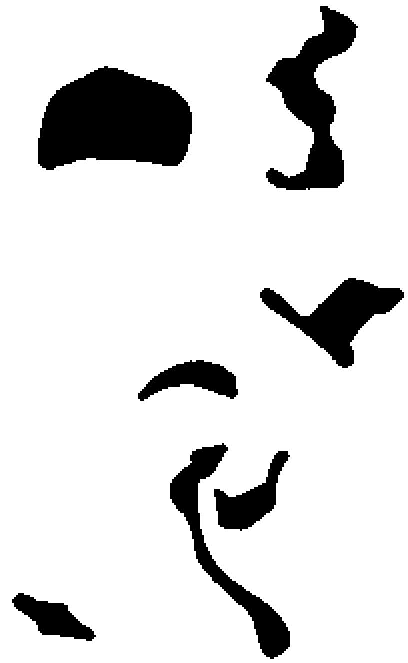
0% 50% 100%

Item 29: Image 029 Coherent version – TURTLE

Fill in the missing letters:

tu_t__

Item 29: Image 029 Incoherent version – TURTLE



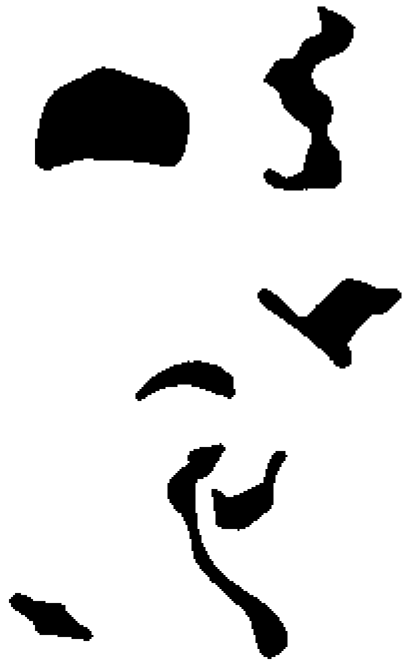
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 29: Image 029 Incoherent version – TURTLE



Fill in the missing letters:

tu_t__

Item 30: Image 030 Coherent version – UMBRELLA

1. What is this object?

____

2. How sure are you? ________

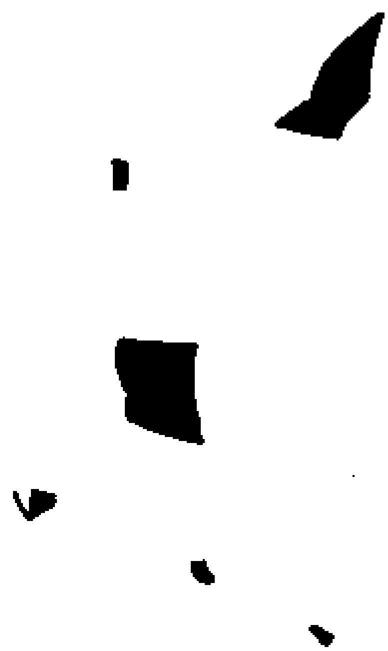
0% 50% 100%

Item 30: Image 030 Coherent version – UMBRELLA

Fill in the missing letters:

_m__el_a

Item 30: Image 030 Incoherent version – UMBRELLA



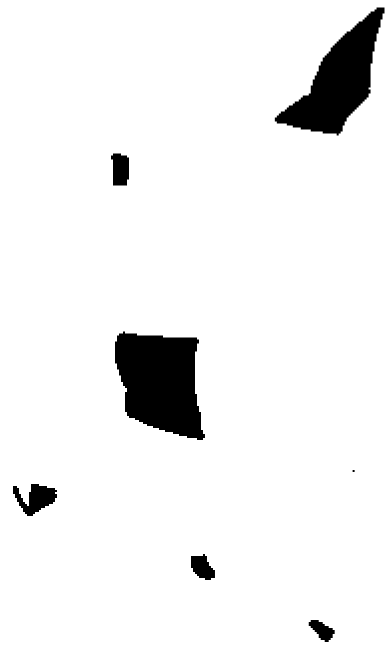
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

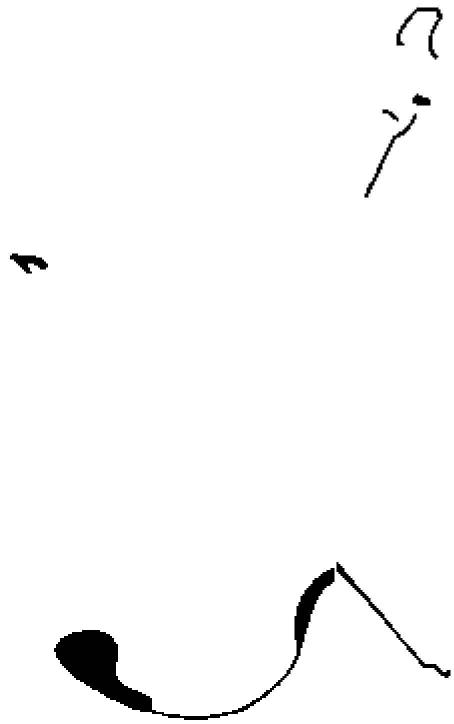
Item 30: Image 030 Incoherent version – UMBRELLA



Fill in the missing letters:

_m__el_a

Item 31: Image 031 Coherent version – VIOLIN



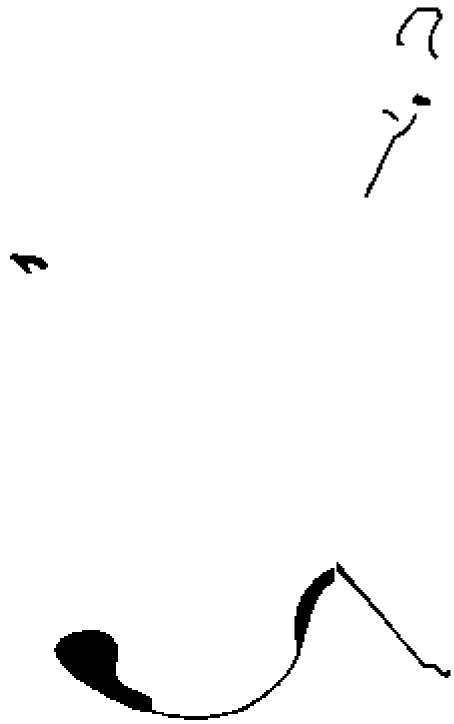
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 31: Image 031 Coherent version – VIOLIN



Fill in the missing letters:

_io_i_

Item 31: Image 031 Incoherent version – VIOLIN

1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

Item 31: Image 031 Incoherent version – VIOLIN

Fill in the missing letters:

_io_i_

Item 32: Image 032 Coherent version – WEDDING CAKE

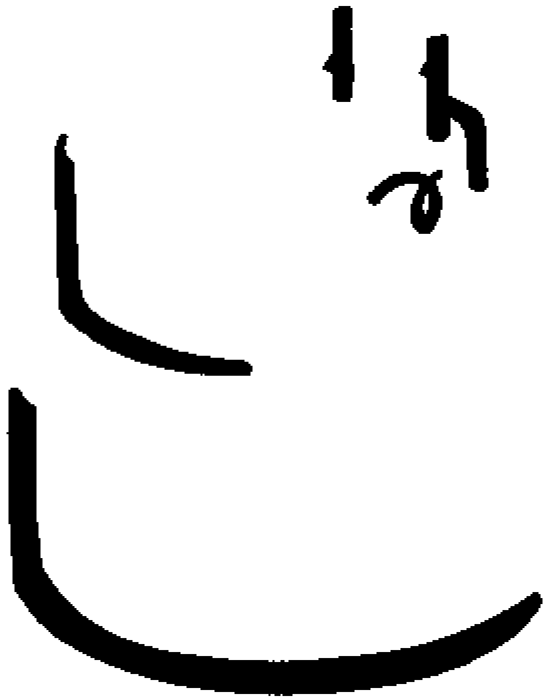
1. What is this object?

____

2. How sure are you? ________

0% 50% 100%

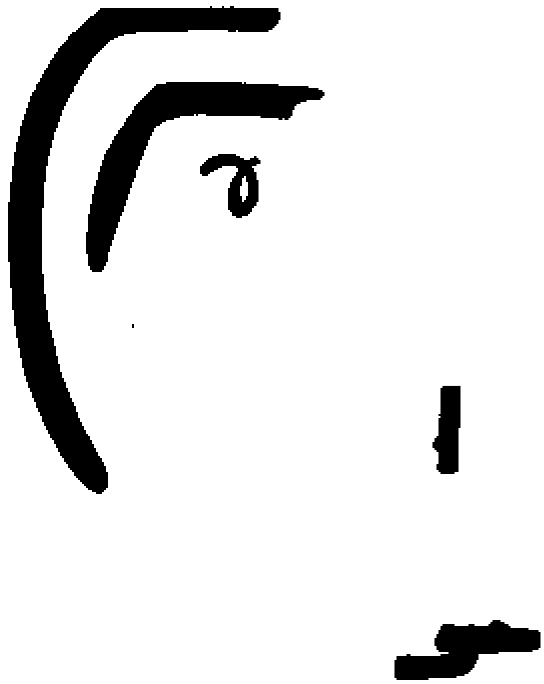
Item 32: Image 032 Coherent version – WEDDING CAKE



Fill in the missing letters:

_ed__n_..c_k_

Item 32: Image 032 Incoherent version – WEDDING CAKE



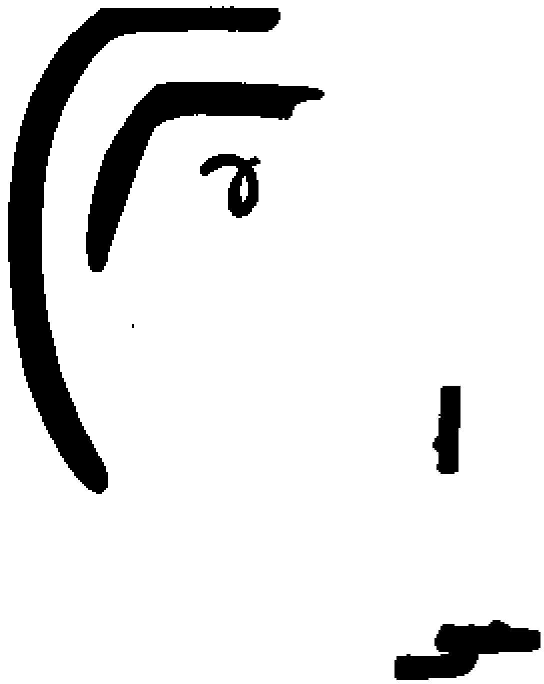
1. What is this object?

____

2. How sure are you? _________

0%   50%   100%

Item 32: Image 032 Incoherent version – WEDDING CAKE



Fill in the missing letters:

_ed__n_..c_k_