

CS 6795 Introduction to Cognitive Science

Spring 2012 Midterm Exam

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Problem Statement: *A Scandal in Bohemia is often regarded as one of the best Sherlock Holmes stories written by Sir Arthur Conan Doyle. The story can be accessed from the pull-down menu on the top left at the Sherlock Holmes Museum at: <http://www.sherlock-holmes.co.uk/home.htm> (Many other websites also contain links to this story.)*

1(a): Analyze this story in terms of the six (6) representational/inferential accounts in Thagard's book: logic (and probability), rules, concepts, analogies, images and connections. That is, for each of these six (6) types of representations/inferences: enumerate the instances in the story where it occurs, and describe why the instance is an example of the specific representation/inference. (Note: If there are more than three instances for a type of representation/inference, then you need to describe any three of your own choosing.) (Note: There are six (6) sets of responses to this part of the question. Maximum possible score: $6(\text{weight}) \times 3 \text{ rubric points} = 18 \text{ points}$)

1(b): Please identify two different (2) instances of representational/inferential accounts in this story beyond the six described in the first part of the book? (Hint: consider the accounts in the second part of the book as well as in other readings in the class). (Note: Maximum possible score: $1(\text{weight}) \times 3 \text{ rubric points} = 3 \text{ points}$).

1 (a)

1.1 Logic

Explanations are regarded by Paul Thagard to be a form of logical deduction (Thagard, 2005). With a character such as Sherlock Holmes, who makes many kinds of deductive and inductive inferences, one can be assured that many examples of the logical form of mental representation exist in the stories he is involved in. The relevant situation that occurs in *A Scandal in Bohemia* is that Watson has six parallel cuts on his left shoe and Holmes deduces that Watson has been in bad weather and has a careless servant girl. Several mental representations can be derived from this single event. One instance of a logical mental representational is where Holmes infers that Watson had been in bad weather and has a clumsy and careless servant girl. Holmes sees that Watson has parallel scratches on his shoe. Knowing that Watson was unlikely to have any other reason for this, Holmes uses modus ponens: if Watson has scratches on his shoes, then they were cleaned of mud. Another inference made is: if Watson has parallel slices on his shoe, then they must have been carelessly cleaned. A third inference made by Holmes is: if Watson's shoes were cleaned carelessly, then it must have been done by his servant girl.

There is another explanation of observations that Sherlock Holmes makes in this story. Holmes also notices that Watson has begun again to practice medicine since they had last met. Inductive reasoning is said to be an argument in which the premises only provide limited grounds for accepting or rejecting the conclusion (Goel, Gold, Kapur, & Houle, 1997). Some forms of inductive reasoning require establishing causal relationships (Kemerling, 2001). From a logical representation, we may consider the inferences made by Holmes as being inductive reasoning of this type. Holmes notes the following premises: Watson smells of iodoform and has a black mark from nitrate of silver on his finger. Holmes also takes notice of a bulge on Watson's top-hat, which he makes the deduction that he must've been keeping a stethoscope under the hat. These clues, or premises, collectively allow Holmes to make the logical argument that Watson must have gotten back into the medical practice.

A third example of logical mental representation lies in the situation where Holmes notices the two horses and carriage the king is riding in. Holmes states that the horses are beautiful and implicates that they may be worth 150 guineas a piece. He then concludes that he will be able to turn a significant profit from the case the king is bringing to him. Again, we can see this as modus ponens: if the horses the king has drawing his carriage are worth 150 guineas, then a significant profit is in store if he solves it. So since the horses appear to be worth this much, it follows by modus ponens that a significant profit will be rewarded to him.

1.2 Rules

A rule-based representation can be seen in some aspects of the Sherlock Holmes story as well. According to Thagard (2005), rules can “represent general information about the world.” One instance of this is when Holmes observes the phrasing of the note he had received from the king. Holmes recognizes a peculiarity in the structure of the sentence where the verb is at the end. Perhaps Holmes has formed the rule: if the phrasing of the sentence entails a carelessly placed verb, then a German must have written it. Or perhaps a more general one such as: if one is a German, then they do not understand the grammar involved in verb placement in English.

Rules follow the very simple structure of: if *condition*, then *action* (Thagard, 2005). Another rule that Holmes seems to have for himself is that if he does not yet have any data about a problem, then he should not form a theory. Goodwin et al (2012) defines executive control as the ability to tailor information processing in the brain to rules, goals, or context. A final example that fits this idea of executive control is Holmes’ reassurance to the king that if Irene Alder simply has letters for the king, then the king should not worry since one would also need to prove their authenticity. Holmes appears to have processed the situation to the form of a rule. Also since these statements fit into this form, one can say that these could form a rule-based representation in Holmes’ mind.

1.3 Concepts

Margolis and Laurence regard concepts as “the most fundamental constructs in theories of the mind,” (Laurence & Margolis, 1999). This seems appropriate since in many narratives, one can see many, many different concepts represented. A schema is defined by Thagard (2005) as being not a strict definition or definitive list of features of an entity or situation, rather it is a subset of features that define it. The characters in the Sherlock Holmes narrative describe multiple concepts that we are able to point out. From the structure of the king’s lower face Watson forms an internal representation of the man and gives him features such as strong character and resolute to the degree of obstinacy. One could link these descriptions to the idea of a concept in Watson’s mind. For example, the concept of *obstinate resolution* is attributed to a man who has a straight chin and who looks as the king does. Or the concept of a man of strong character can be thought of as the schema made up of traits such as a thick, hanging lip.

Holmes forms a mental model of the cab driver’s internal representation of himself. Holmes makes the assumption that if the cab driver looks at him in double take in a certain way then he assumed he was shabby. Here, the concept of *shabby* is attributed to Holmes by the cab driver. Watson describes Holmes’ appearance as being that of an amiable, simple-minded clergyman. The

concept of *clergyman* in Watson's mind has the features of amiability, being Nonconformist, and benevolent curiosity. These different features make up what Thagard (2005) calls properties of the concept.

1.4 Analogies

According to Thagard (2005), "representation of analogies needs to include representation of causal relations." When we describe something new to us, we often use words such as "like" and "similar to." On this same chord, novel thinking can be described as application of analogical reasoning. In the story, many analogies are used in describing potentially unfamiliar concepts, or to convey more information about a relationship than might be apparent otherwise. One such example is when Watson describes what would happen if strong emotion were to be introduced into a mind such as Sherlock Holmes' as being like "grit in a sensitive instrument," or "a crack in [a] high-power [lens]." Watson uses this analogy to state the catastrophic effect falling in love would have on Sherlock Holmes. Another example is when Watson describes Holmes as "the most perfect reasoning and observing machine." When making the analogy, one must relate the source, which one presumably already understands and has a concept of, to the target, the new concept (Thagard, 2005). There is the idea of case-based reasoning, wherein cases, or analogs, are retrieved from long-term memory and adapted when someone must come up with a solution to a previously unexplored problem (Holyoak, Gentner, & Kokinov, 2001). Here, the target is Holmes and the source is a machine, since one presumably is aware of the precision of a machine. Watson forms the analogy of a machine and Sherlock Holmes to describe his keen observation and preciseness in reasoning. Later, upon their first encounter, Watson describes the Bohemian king's chest and limbs were described to be "of a Hercules." This analogy gives light on the apparent strength and powerful appearance of the king.

1.5 Images

Many descriptions of things are made in an imagistic mental representational form. A distinction must also be made about what is meant by a mental "image". Mental image does not necessarily constitute a picture, but instead are "experiences we have in imagery," i.e. we do not necessarily limit the term to mean just pictures, but smells, sounds, tastes, etc (Block, 1983). When Watson and Holmes first meet the king, a very descriptive feature set is given. This rich description could be thought of as Watson's mental image of the king. Statements like, "Heavy bands of astrakhan were slashed across the sleeves and fronts of his double-breasted coat, while the deep blue cloak which was thrown over his shoulders was lined with flame-coloured silk and secured at the neck with a brooch which consisted of a single flaming beryl," are very imagistic.

Another instance of images, although not nearly as rich, is the Watson's interpretation of the king's visual mental model of Holmes. The description states that the king, "glanced with some apparent surprise at the languid, lounging figure of the man who had been no doubt depicted to him as the most incisive reasoned and most energetic agent in Europe." Another imagistic representation is the description of the king's bag: "a heavy chamois leather bag." Although not as descriptive as the other image examples, many inferences can be made from the description about the bag. Clearly a mental image could have been formed by Watson to come up with this sentential form.

1.6 Connections

Horgan (1997) describes a connectionist system as a neural network and a structure of processors called nodes, or units. Each unit is connected to other nodes and can send either excitatory or inhibitory signals to one another. When a problem is encountered, a pattern is activated in the input nodes and then various nodes send and receive signals simultaneously until the system settles into a stable state. The pattern in the output nodes is the answer to the problem (Horgan, 1997). The connectionist model of mental representation also appears throughout the story. Watson first regards the letters woven into the paper as the name of the paper maker. Watson then revises his internal representation once he realizes that the letters do not form a readable word or name and he regards the symbols then as a monogram. This process seems to be representative of a connectionist network described above. The unit of 'word' is connected to the arrangement of letters. As Watson takes in more percepts, the activation of the 'word' node becomes successively more inhibitory. Watson begins to form a new connection where the arrangement must instead be a symbolic monogram of the paper maker. Since clearly if the unit is not in the form of a word then it cannot be a word and something else, i.e. there exists a symmetric inhibitory link.

Watson states that Holmes had, for many years, utilized a system of storing a brief biography of people and things he had come into contact with. Watson then states that it was difficult to name a subject or a person that Holmes could not give any information on. One can think of this mental process that Watson goes through as another connectionist mental representation. Watson forms the units in this connectionist model of pieces of information and Holmes. Watson makes the connection that, given pieces of information in Holmes' docket, Holmes can provide information.

Another example is where Holmes determines that if Irene is in love with Norton then she will no longer bother the king. One can think of this deduction as a connectionist network. In

Connectionist Models and Their Properties, Feldman and Ballard state that one may evaluate many hypotheses in a connectionist model just as Holmes does here (Feldman & Ballard, 1982). Each attribute of Irene can be thought of as a pattern of activated units. The pattern of units activated, such as Irene is in love with another man and also that she would blackmail the king if he was to marry another woman because she was in love with him. Forming this complex relationship uses the technique of synchrony as described by Thagard (2005) in which packages of units or vectors form these complicated relations. The different units combine to form a pattern of connected nodes in network which leads to the implication that Irene Adler will no longer bother the king.

1 (b)

1.7 Brains

When Holmes performs the accident of getting hit he is performing a complex array of action that can be described as functions of different parts of the brain. Thagard defines the frontal cortex (high-level thought), the amygdala (bodily information), and the hippocampus (memory) (Thagard, 2005). To form the entire plan, Holmes accesses his frontal cortex to reason through the best possible method in finding the photograph. Holmes first looks to the men fighting to assist Irene Alder. He must access his hippocampus to determine what the men are doing to realize that they are fighting and also to determine what his next step must be to work out his plan. When close enough, he appears to have been struck. At this point, his mind is given information as bodily inputs to let him know that he has been struck and can deploy his fake blood.

Holmes' account of the actions of a woman once she believes there is a fire can be described in terms of processing using different parts of the brain. As noted by Lang et al (2000) in *Fear and anxiety: animal models and human cognitive psychophysiology* when the person, or in this case a woman, gets scared, they are activating a "primitive subcortical circuit, including the amygdala and the neural structures to which it projects." In addition to heart rate changes and startle reflexes, this circuit promotes survival. Holmes states that the woman rushes to the thing which she values most. Irene Adler's desire for self-preservation leads her to pursue the photograph, a key to her future financial security since it is worth so much to the king that she does not use it against him.

Watson's account of his return home after visiting a patient seems easily described by processes going on in his brain. Watson sees Holmes' door on Baker Street which results from

percepts from his eyes to be sent to the visual cortex of his brain. The interpreted image of Holmes' door is sent to the prefrontal cortex which then triggers his memories from his hippocampus. His curiosity leads him to knock on the door. A signal from the prefrontal cortex is then transmitted to the motor output part of the brain (stiatum) (Thagard, 2005).

1.8 Emotions

Emotions play an important role in human decision making and should be accounted for in any cognitive model. Thagard notes that often times people must choose between many conflicting goals where emotions provide for a summary appraisal which allows for focus which is critical when cognitive resources are limited as in the human mind (Thagard, 2005). There are several examples of emotion influencing the decisions of the characters in *A Scandal in Bohemia*. Irene Adler states that she could not think evil of the clergyman and helped him in spite of her better judgment. When she believed there was danger of fire, she immediately sought to retrieve the incriminating photograph of herself with the king. Thagard (2005) describes this behavior as "readiness for action," where Adler forgets her concern of the true identity of the clergyman and instead of being lost in thought, springs immediately for the photograph.

Yet another example of emotional influence is where Holmes used the fact that fear would elicit Irene Adler to try and save the item most precious to her. Irene Adler's action in the situation could most appropriately be described as the influence of emotion. At the impending doom of death by fire, logic deems the most appropriate response to be to preserve one's own life above all else. Here, Adler seems to be preoccupied by something of lesser worth: her financial well-being. Adler's mind produced a summary appraisal of the situation and she acted according to this appraisal wherein she moved to retrieve the photograph.

Another example is when Watson regards Holmes' account of Irene Adler is of very strong feelings. As Lang (2000) puts it, Holmes seems to have some type of qualia associated with his memory of her. Although, presumably not a feeling of love or anything like it, the associations evoked are strong in that Holmes regards Adler as *the* woman. This consideration is akin to a kind of respect. No rule-based or logic-based account of mind could describe this feeling that Holmes seems to possess from Watson's perspective.

2 (a) Cognition

Cognition refers to the processes involved in many aspects of thought behavior, and in this paper, we emphasize the process of problem solving. A solution to a problem such as this requires

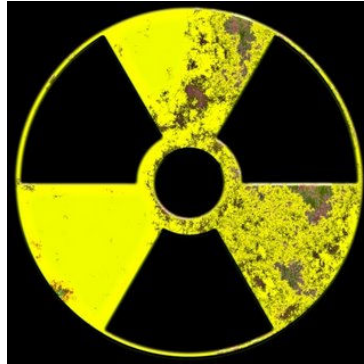
features that cross cultural, technological, and political bounds. A field of particular interest then would be cognitive science. Paul Thagard (2005) explains cognitive science as defining a theory to explain when people “make bad decisions.” Thagard talks about politicians and educators becoming more successful through understanding the mind, which is a key feature of the study of cognition and mind through cognitive science. Politicians must communicate ideas across many cultural boundaries to have widespread appeal. This is especially true in countries like the United States where diversity in culture is a hallmark. Therefore, it is conceivable that the study of cognition would be an excellent choice for determining a message that can cross such bounds.

According to Cruse (2003), a system with the ability to plan ahead is considered to be cognitive. If this is the case, then humans, having the ability of foresight and future-planning, are inherently cognitive beings. To analyze humans, or other intelligent beings of the future it seems prudent to consider cognition in this design.

In *Cognition and Communication* (1996), Schwartz describes the 4 maxims that make up the general cooperative principle of communication. Although the principle seems primarily geared toward spoken conversation, it also has applications to communication in general. The maxim of manner states that one must be “perspicuous” and avoid obscurity and ambiguity while being brief and orderly. We may make use of the idea of brevity by using images or pictorial representations. We can also benefit from the idea of avoiding obscurity and ambiguity in our message by instead of using symbolic representations, use actual images on whatever signage we may create.

2 (b) Design





These images in addition to a sign with the following warning of exposure to liable harm:

English: Danger – exposure to liable harm

Arabic: خَطَر (ar) (khaTar) m

Armenian: վտանգ (hy) (vtang)

Bulgarian: опасност (bg) f

Catalan: perill

Chinese:

Mandarin: 危险 (zh) (wēixiǎn)

Croatian: opasnost (hr) f

Czech: nebezpečí (cs) n

Danish: fare (da) c

Dutch: gevaar (nl) n

Esperanto: danĝero (eo)

Finnish: vaara (fi), uhka (fi)

French: danger (fr) m

German: Gefahr (de) f, Risiko (de) n

Greek: κίνδυνος (el) (kíndinos) m

Haitian Creole: danje

Hebrew: סכנה (he) (sakaná) f

Hungarian: veszély (hu)

Indonesian: bahaya (id)

Irish: contúirt (ga) f, dainséar (ga) m

Italian: pericolo (it) m

Polish: niebezpieczeństwo (pl) n
Portuguese: perigo (pt) m
Romanian: pericol (ro), primejdie (ro) f
Russian: опасность (ru) (opásnost') f
Scottish Gaelic: cunnart (gd) m
Slovak: nebezpečie n
Spanish: peligro (es) m
Swahili: hatari (sw)
Swedish: fara (sv) c
Turkish: tehlike (tr)
Vietnamese: nguy hiểm (vi)
Welsh: perygl (cy) m
Persian: خطر (khatar)

An old fan of sorts could be used to generate the 18Hz acoustical wave.



2 (c) Cognitive Account

Paul Thagard regards emotions as an “efficient way to guide action” (Thagard, 2005). Emotions, such as fear, allow for efficient allocation of mental resources. As reported by Lang, Davis, and Ohman (2000), the effects of fear resulting from processing media stimuli in humans promotes survival in dangerous situations. Lang et al argues that “unpleasant” emotions are driven by a defensive system that is associated with withdrawal, defensive aggression, and escape from pain. Commonly, this might be called a “fight or flight” response. Considering the problem at hand, where one must convey danger across cultural, technological, and political bounds, primarily we want to isolate the “flight” response to fear. Thus, a combination of both inducing apprehension and fear would be appropriate. The system would need to have sub-sensory percepts, visual, and textual communicative properties to convey such an important message.

Sub-sensory Perception

In this system, we employ the “ghost in the machine” effect as described by Tandy and Lawrence (1998) in “The Ghost in the Machine.” The effect is an explanation of ostensible haunting via previously undiscovered natural phenomena of low frequency acoustics and its affect on humans. The idea is that infrasonic, or sounds below human audible levels, induce feelings of fear and anxiety in humans. This idea is linked with large animals being known to produce these sounds, such as a tiger (American Institute of Physics -- Inside Science News Service, 2000, December 1), a rhinoceros, an elephant (von Muggenthaler, Stoughton & Daniel, Jr., 1992), and

many other large animals. These external stimuli produce a seemingly inherent feeling which induces a cognitive response of preservation.

When coming into contact with this phenomenon, the response is key to ensuring the person will experience fear. Our hypothesis is that this fear is a natural and perhaps subconscious indicator for the person to stay away from the area of the source. Employing a generator of this sound, said to be at around 18Hz (Tandy & Lawrence, 1998), one should be able to sufficiently scare the person of interest. Lang et al (2000) also indicate a so-called “startle effect” that potentiates fear which is induced by loud sounds in mice as well as humans. If this same rule can be applied to infrasonic sounds, then hypothetically at high enough amplitude, the sound can induce the startle effect and ultimately induce fear.

Visual

As stated, the response to fear is one of survival. Other considerations must be made to elicit the danger for any thrill-seekers. According to Thagard (2005), the understanding of language is dependent upon internal rules of grammar. Thus, we also employ a number of textual cues to appeal to logic and rule-based thinking. These cues are in the most dominant languages of today in addition to psychologically inspired symbols to convey danger. A panel led by Carl Sagan, for the Voyager interstellar Golden Record, chose to use 55 different Earth languages to convey greetings to intelligent extraterrestrial beings (Voyager Golden Record, 2012). Our message could be conveyed in a similar manner with warnings or phrases meaning “danger” or “keep out”.

In *Cognition and Communication* (1996), Schwartz describes the 4 maxims that make up the general cooperative principle of communication. Although the principle seems primarily geared toward spoken conversation, it also has applications to communication in general. The maxim of manner states that one must be “perspicuous” and avoid obscurity and ambiguity while being brief and orderly. We may make use of the idea of brevity by using images or pictorial representations. We can also benefit from the idea of avoiding obscurity and ambiguity in our message by instead of using symbolic representations, use actual images on whatever signage we may create. First, we depict people in a cave, a fire, and then dead people (a less graphic skull is used as opposed to actual dead people). To attempt to invoke an analogical mapping, we then depict people and a normal human arm, a radiation symbol, and a resulting image of dead people and a radiation-afflicted arm. Both of these imagistic stories apply to logic, wherein we have

created a symbolic syllogism. The premises are people and the radiation symbol which leads to the conclusion of death and the people and fire which leads to death.

2 (d) Cognitive Critique

At the time of the writing of the Tandy paper, in 1998, the “ghost in the machine” effect had not been documented prior. Since the effect on humans is a relatively unexplored area, it seems prudent to acquire more data. Another concern is that the effect may, instead of encourage fearful flight, encourage the person to explore further, just as Vic Tandy did in the presence of the same phenomena (Tandy & Lawrence, 1998). Also, the use of such a device would require a power source. No known power source could work for a 10,000 year lifespan. One could perhaps devise a rotating fan-like structure or rotating piston device that utilizes both the force of gravity and neodymium magnets that would work for the entire lifetime of the magnet.

The visual cues also have some problems. As Johnson-Laird (1980) put it, there are always an “infinitely many valid conclusions” one can make about a scenario. Although we may convey that a person will die from fire with our pictorial representation, a mental model formed by the person may not correlate the danger depicted to the contents of the area, i.e. there may be an issue with inciting the analogy between fire and the radiation-ridden materials. From a connectionist perspective, the links that need to be activated in making a decision could be considered a “winner-take-all” network (Feldman & Ballard, 1982). In this network, coherent decisions can be made wherein a single unit (in a set of units) with the highest potential will be the only unit with an output above zero after a setting time. Hopefully the context of the message can alleviate these potential downfalls and the analogical mapping is clear.

3 References

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