SYMSYS 130: Research Methods in the Cognitive and Information Sciences (Spring 2013)

Homework #1 – Instructor's Responses
May 1, 2013

Please respond to the following questions with short essays (300-500 words, not more). Answers will be scored out of 25 points total, based on the following criteria (5 pts each):

- informativeness (interesting, nonobvious),
- correctness (sound, accurate),
- thoroughness (convincing, rigorous),
- coherence (consistent, well constructed), and
- conciseness (clear, succinct).

1. Consider the problem: “How do we know that an object we are looking at is a chair?” Explain, in one paragraph for each method, how this problem might be addressed using philosophical, formal, empirical, and computational analyses.

For the philosophical method, markers are “claims, arguments; evidence based on introspection or common knowledge” (slides, 4/3). Philosophers “Define concepts, and refine understanding.” A philosopher might begin by claiming that an object is a chair if and only if it is built or modified by people for one person to sit on. To establish the adequacy of this definition, we could apply to different types of chairs: a rolling office chair, a Lazy-Boy recliner, a beanbag chair, a stump with a carved-out seat area for sitting, and a beach chair. Each of these is built or modified by people to allow one person to sit. An unmodified stump that someone sits on, the philosopher might argue, would not be called a chair by most people and therefore fits the definition of chair which excludes it, as would a couch (fits more than one person).

A formal method would attempt to “represent propositions and arguments rigorously enough so that no rational person could disagree that the conclusion follows from the premises.” The above analysis could be turned into a formal theory by converting the definition into a logical statement, i.e. “FOR ALL x, x IS Chair IFF [(x IS Built-by-people OR x IS Modified-by-people) and (FOR ALL y, IF y IS Person THEN y Can-sit-on x)]”. From this we can derive the lemma: “FOR ALL z, IF z IS NOT Built-by-people AND z IS NOT Modified-by-people THEN z IS NOT Chair”. We can formalize the background knowledge/assumption that “FOR ALL w, IF w IS Stump THEN w IS NOT Built-by-people”. This can be combined with our lemma to prove that “FOR ALL v, IF v IS Stump AND v IS NOT Modified-by-people THEN v IS NOT Chair.”

The formal argument would likely be accepted by people who can follow the logical statements in it, but it is not quite a computational theory, because the proof has missing steps, and axiom schemas that have not been defined but are part of the background knowledge of formally trained researchers. A computional approach would “automate the derivation of output data from input data”, by specifying rules of inference and axiom schemas in a working programming language. The program, taking the formal premises described above as inputs, would combine these with rules (e.g. based on regular expressions) for converting a string of the form “p IFF q” into “IF NOT q THEN NOT p” and “IF NOT p THEN NOT q”, as an example of the knowledge that would need to be explicitly represented for a computer to prove the conclusion statement automatically.

An empirical analysis can be either experimental or observational. To test the definition of a chair we have been considering empirically, we could give a set of photos of objects to human subjects and ask them to classify each object as either a chair or not a chair. This would allow us to test whether the philosopher's intuitions about whether objects are chairs are shared by a majority of neutral observers.

2. Choose an argument from the Chomsky-Foucault debate, and analyze it using the concepts we discussed in the class session on “Argumentation”.

Chomsky makes the following argument that behaviorism is not a science:

“It seems to me that the fundamental property of behaviourism, which is in a way suggested by the odd term behavioural science, is that it is a negation of the possibility of developing a scientific theory. That is, what defines behaviourism is the very curious and self-destructive assumption that you are not permitted to create an interesting theory.

If physics, for example, had made the assumption that you have to keep to phenomena and their arrangement and such things, we would be doing Babylonian astronomy today. Fortunately physicists never made this ridiculous, extraneous assumption, which has its own historical reasons and had to do with all sorts of curious facts about the historical context in which behaviourism evolved.

But looking at it purely intellectually, behaviourism is the arbitrary insistence that one must not create a scientific theory of human behaviour; rather one must deal directly with phenomena and their interrelation, and no more something which is totally impossible in any other domain, and I assume impossible in the domain of human intelligence or human behaviour as well. So in this sense I don't think that behaviourism is a science.”

The key to this argument seems to be how Chomsky is defining “science”. He does not give an explicit definition, but rather uses physics as a prototype (slides, 4/8) for science, and then makes an argument by analogy between physics and behaviorial science. Applying Toulmin's framework for analyzing arguments, his claim is therefore supported by data from history: physics did not develop by ruling out “an interesting theory.” He doesn't define this either, but it constitutes a subargument backed by unstated reference to the fact that behaviorism does not allow theories based on unobserved mentalistic concepts whose existence must be inferred from observations. The warrant to Chomsky's argument seems to be that if the prototypical science (physics) has an essential characteristic (e.g. theories about concepts that cannot be observed directly) which is ruled out in some field of endeavor (such as behaviorism), then that endeavor cannot be a science. Chomsky qualifies his claim with the phrase “in this sense”, referrring to his implicit definition of a science as something that, like physics, posits concepts whose existence must be inferred from observable data. He does not provide what Toulmin would call a “rebuttal”, or a statement of under what circumstances his claim would not apply.

3. Nagel and Newman claim (p. 78) that the system of arithmetization that they define for the logic PM assigns unique Gödel numbers to each expression (formula or sequence thereof) of PM. Can you give an argument proving this?

Proof: Assume e is an expression of PM. Then e is a sequence of one or more formulas of PM. If e is one formula f, then it is composed of a sequence of s signs in PM. Every sign of PM is either one of the 12 constant signs (mapped onto natural numbers 1 through 12) or a variable sign x,y,... (mapped onto successive primes beginning with 13) or a sentential variable (mapped onto the squares of successive primes beginning with 13^2) or a predicate variable (mapped onto the cubes of successive primes beginning with 13^3). It follows from Euclid's theorem (pp. 37-39) that there is an infinte number of unique primes, so this mapping can accommodate all variable signs of PM with a unique assigned number. All sentential and predicate symbols are also assigned unique numbers, because no square is prime (it can be factored into its square root squared), no cube is prime (by analogous argument), and no cube of primes can be factored into a square of primes or visa versa, by the Fundamental Theorem of Arithmetic (p. 79). By definition, the Gödel number of f is the product of the first s primes each raised to a power equal to the Gödel number of the corresponding sign (p. 75): 2^G(s1) x 3^G(s2) x 5^G(s3) x ... x Prime(s)^G(ss), where Prime(s) is the sth prime number, and G(si) is the Gödel number for the ith sign in f. The Gödel number for f is not prime because it is composed of factors, so it won't conflict with any of the numbers assigned to signs of PM. The number m assigned to f will be unique among all nonidentical formulas of PM, because for every other formula f' that is not identical to f, its number will be composed of prime factors whose exponents must differ in at least one case from those of f, resulting in a number different from m. If e is a sequence of two or more (say j) formulas of PM, then by definition (p. 77) its Gödel number k = 2^G(f1) x 3^G(f2) x 5^G(f3) x ... x Prime(j)^G(fj), where fi is the ith formula in e and G(fi) is its Gödel number. The number k must be different from the number assigned to any other sequence of formulas e', because any distinct such e' must differ in at least one formula fh, which would then contribute a distinct exponent for the hth prime factor and hence lead to a distinct Gödel number.

4. Give an “everyday life” example in which people exhibit what Hume called the “habit” of expecting that “instances of which we have no experience must resemble those of which we have had experience”, and in which this habit leads to a false expectation with significant consequences. Could another “habit of the mind” be cultivated that would lead to a better outcome in this case without sacrificing the benefits of inductive inference?

I have been told that motorcyclists often have serious accidents only after having a lot of experience as motorcyclists. What happens is that they get complacent about sudden obstacles that can appear with too little time to react at high speed, but which do so rarely. A motorcyclist can induce a generalization that any obstacle they encounter can be manouvered around at the speed at which they learn to travel. But a rock can appear on the highway that can cause them to crash and be unavoidable if the motorcyclist is going too fast. In the early stages of their driving career, the motorcyclist is likely to travel more slowly, at a rate at which such obstacles can be safely manouvered around. Only with experience does the driver get confident enough to increase their speed above this threshold. To avoid this pitfall, motorcyclists should be taught about black swan events such as these, about which their accumulated experience will not give them guidance. The mental habit that follows is always going slowly enough to avoid obstacles that typically appear eventually in one's driving career.