PSYCHOLOGY 354 MIDTERM EXAM
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Part I: Choose any TEN of the following terms, and write a short (2-3 sentences) definition for each. The definition should indicate what the term means, and should also indicate why the term is important to cognitive science. Remember, ONLY 10 DEFINITIONS are required. Each definition is marked out of 3 points.

Physical Symbol System	Ryle's Regress	Cognitive Architecture
Functional Analysis	Disembodied Mind	Strong Equivalence
Linearly Separable Problem	Processing Unit	Multilayer Perceptron
Cognitive Scaffolding	Affordance	Situatedness

Part II: Choose any ONE of the following questions, and write a short essay (3-4 pages) to answer it. Make sure that your answer is clear and concise, and also make sure that you deal with the question directly. Your answer will be marked out of 35 points.

1. Compare and contrast core elements of classical cognitive science to those of connectionist cognitive science, particularly in the context of 'embodiment'. Is connectionism a more embodied approach? What are the implications of this to cognitive science in general? Illustrate your answer with relevant examples from the lectures and from the readings.

2. Embodied cognitive scientists might claim that a key problem with classical cognitive science is that when the latter studies the mind, it does not know where to look. What are the implications of this claim? Do embodied cognitive scientists have advantages over classical cognitive scientists with respect to this issue? Illustrate your answer with the relevant examples from the lectures and from the readings.

3. Compare and contrast two approaches to studying cognition: cognitive science and experimental cognitive psychology. Illustrate your answer with relevant examples from the lectures and from the readings.

In the pages that follow I provide three different kinds of information. First, sample answers for each definition are provided; any comments in italics in these definitions are some additional points that I want to make. Second, sample answers for essay questions are given. Note that the sample answers for both definitions and for essays are taken from students. The marks ranged from 61 to 32 out of 65, with an average of 50.3.

Example Definition Answers

Physical Symbol System

The concept "physical symbol system" defines "a broad class of systems that is capable of having and manipulating symbols, yet is also realizable within our physical universe". That is, it is a physical device that applies rules to manipulate symbolic expressions. Examples of physical symbol systems are modern digital computers, the universal Turing machine, and the production system. By hypothesis, the human brain is also a physical symbol system. One reason that physical symbol systems are important to classical cognitive science is because these systems show how finite physical mechanisms can bring to life an infinite variety of behavior. When classical cognitive scientists assume that human cognition results from a physical symbol system, they are proposing a materialist theory of cognition that refutes Cartesian dualism. An alternative reason that classical cognitive science endorses – and may be defined by -- the physical symbol system hypothesis: "the necessary and sufficient condition for a physical system to exhibit general intelligent action is that it be a physical symbol system" (Newell, 1980, p. 170). By necessary, Newell means that if an artifact exhibits general intelligence, then it must be an instance of a physical symbol system. *(Usually associated with classical, but could be with others. Importance? Physical is critical – move from dualism to materialism within the classical camp!)*

Ryle's Regress

Functional analysis involves decomposing algorithmic functions into simpler subfunctions. Ryle's regress is a problem that emerges because this decomposition can go on infinitely – whenever you want to explain a subfunction, you decompose it some more! This means that functional analysis will never explain anything, because the analysis never stops. It is also called the homunculus problem. It is important to cognitive science because it motivated researchers to consider how to get out of this problem. This led to the notion of causal subsumption, where you decompose functions into simpler functions until you explain the bottom level (the architecture) physically instead of functionally. The functional architecture is needed to escape Ryle's infinite regress.

Cognitive Architecture

The architecture refers to the basic building blocks that an information processor can use to perform calculations. These building blocks are basic in the sense that they are primitive functions that cannot be broken down into simpler functions, and are built physically into the device. The cognitive architecture is the same, except it is the architecture for human cognition – the basic set of processes wired into the brain that defines the 'programming language of thought'. The cognitive architecture is important to cognitive science because one explains the functions of the architecture in terms of physical laws, and therefore defining the architecture provides a way to escape Ryle's regress. *(NB: Common problem for this term was not getting its importance across: materialism, escaping Ryle's regress, producing cognitive explanations.)*

Functional Analysis

Functional analysis is one of the most common methodologies used in cognitive science. It involves trying to understand a complex phenomenon or function by decomposing it into a organized set of simpler subfunctions. It is common in experimental cognitive psychology, for example, when experiments are used to analyze 'memory' into a set of organized memories ('short term memory', 'long term memory'). Functional analysis seems to explain a function by describing as a set of other functions. This leads to a problem called Ryle's regress, in which functional analysis fails because it produces an infinite explosion of subfunctions. This has lead Cummins to propose a solution to this problem by having functional analysis try to subsume the bottom level of functions (explain them as simple machines, not as functions).

Disembodied Mind

This idea is central to classical cognitive science. It is the idea that the mind operates independently of the body that it is placed in. This does not at all fit into embodied cognitive science and is the result of the cognitive sandwich which focuses too much on thinking and, arguably, not enough on sensing or acting. It does not take into account the physical makeup of the brain, like connectionism does, or the environment around the individual. It is important to cognitive science because by being disembodied, it permits cognitive science to focus on the functions that make up classical cognition, instead of on the physical makeup of these functions, which makes computer simulation studies of cognition possible.

Strong Equivalence

This level of equivalence is when both agents compute the same input/output function using the same algorithm and using the same architecture. If two agents compute the same input/output function in different ways, then they are only weakly equivalent. Strong equivalence is critical to cognitive science because it is too easy to create weakly equivalent systems, as Weizenbaum demonstrated with his conversation system ELIZA. Thus the Turing test is not sufficient for cognitive science, and cognitive scientists must strive for a more powerful test of their models: strong equivalence.

Linearly Separable Problem

A linearly separable problem is a pattern recognition problem that can be solved by making one straight cut through a pattern space. This cut separates all of the patterns that belong to a category from all of the patterns that do not belong to the category. This type of problem is important to cognitive science because it can be solved by a simple network that does not include hidden units (the perceptron). However, humans can solve more complex problems that perceptrons cannot, which means that connectionists have to find an architecture that is capable of solving other kinds of (linearly nonseparable) problems that are beyond the capacity of the perceptron.

Processing Unit

A processing unit is a key component of the connectionist architecture. It is a simple device that sums signals being sent to it, converts this signal into internal activity, and then sends this signal on to other processors. In modern connectionism it usually converts the signal into activity using a nonlinear activation function. It is important to cognitive science because it is analogous to a neuron in the brain, and therefore demonstrates connectionist cognitive science's goal of creating models of biologically plausible information processing. (*Note that this is clearly a connectionist term; a generic definition of 'processing unit' that applied to all three schools of thought lost marks.*)

Multilayer Perceptron

A multilayer perceptron is a prototypical network of modern connectionism. Like the simpler perceptron, it has a set of input units to represent environmental inputs, and a set of output units to represent responses to these inputs. However, it also has one or more layers of hidden units that stand as intermediate processors, and which are capable of detecting complex features present in the inputs. It is these hidden units that give the multilayer perceptron its exceptional power: to be an arbitrary pattern classifier, a universal function approximators, or to be equivalent in power to a universal Turing machine. The discovery of learning rules capable of training such powerful networks have led to the emergence of the connectionist alternative to classical cognitive science.

Cognitive Scaffolding

Cognitive scaffolding is a key idea in embodied cognitive science. It involves using or exploiting the environment to assist cognition. For example, using notes in the world as an external memory is an example of cognitive scaffolding. Using tools like the nomogram uses the world not only to store information, but to also manipulate it. Scaffolding is important because it offloads computational demand from the mind to the world. In fact, embodied cognitive science uses the existence of scaffolding to argue that the mind extends into the world, and is not just in the skull, because it manipulates representations that are part of the world. *(If you defined scaffolding as being the extended mind, then you probably lost marks. The two are related, but are different.)*

Affordance

In general terms, the affordances of an object are the possibilities for action that a particular object permits a particular agent. Affordances are not defined in terms of external objects alone, because they depend on an agent's embodiment – the structure of an agent's body. The affordances offered by an object depend on what actions are possible given the structure of an agent's body. Affordances are important to the embodied approach of cognitive science, because they make explicit the role of the environment, and they also highlight that the environment interacts with the body of the agent. Also, the affordances of the world define the different types of cognitive scaffolding available to an agent.

(You had to talk about possible action here. If you just talked about 'possibilities' or 'cues' you likely did not get full marks.)

Situatedness

In very general terms, situatedness is the ability of an agent to sense its environment. In general this means to detect environmental information. However, this notion is central to embodied cognitive science, and to it situatedness means detecting environmental affordances, which depend not only on sensors, but also on the embodiment of an agent. Situatedness is required if an agent is to be able to use the world as its own model, or to use the world to scaffold cognition. If the world cannot be sensed, then the mind cannot be extended into it. (*Common problem here was to define situatedness as if it was the same as embodiment; the two are related but are different.)*

Sample Answers To Essay Questions

1. Compare and contrast core elements of classical cognitive science to those of connectionist cognitive science, particularly in the context of 'embodiment'. Is connectionism a more embodied approach? What are the implications of this to cognitive science in general? Illustrate your answer with relevant examples from the lectures and from the readings.

The following answer a grade of 32 out of 35. I liked it because it didn't make the easy assumption that connectionism is simply more embodied. Instead, it focused on the relationship between the two approaches, including some similarities (like parallel processing) that moved the answer away from topics that were treated in class.

Part 2:

1. In the context of 'embodiment' I would argue that connectionism is a more embodied approach than classical cognitive science. Although both approaches show the sense-think-act cycle in their machines, I believe that because connectionism holds biological plausibility in very high regard, that it is more embodied.

Not only did classical cognitive science develop from the Cartesian philosophy of a disembodied mind but it still doesn't acknowledge the biological processes occurring in the brain. When we look at connectionism, it acknowledges that the brain is the device that carries out cognition and so cognitive models should be modelled after it. Most classical models use serial processing without considering if this process would be possible in the brain. The production model does however add parallel processing as well as serial processing because Newell & Simon were modelling it after the brain. Connectionism has always used parallel processing because it models its networks after neuronal processing that we know exists in our brain. This is important because in order for an approach to be embodied it has to show how cognition can be related to our bodies so that they can interact with our environment. Connectionism does this by using artificial neural networks that are plausible systems for our brain to carry out cognition and therefore be able to control our body when acting on the environment

and using sensory information.

Another reason classical cognitive science is less embodie than connectionist cognitive science can be seen by looking at the Turing Machine. Connectionists argue that the Turing Machine is too slow to be a plausibl device for cognition because it uses serial processing. Connectionist networks combat this issue by implementin parallel processing in their networks that allow for quick processing even with slow componentry. Turin Machines are also very brittle in that they can brea down very easily or their output won't reflect ~~the~~ it the data being input is wrong. On the other hand connectionist networks are not brittle at all, they degrade very gracefully. If part of the system isn working the network will still be able to solve the problem. Also if the data ~~&~~ given to the network isn't entirely correct or it is 'noisy' the network will reflect this noise in its output. All of these components are important when looking at whether a ~~device~~ device would ~~to~~ be plausible biologically. When interacting with the environment our body may not get completely correct information, yet we are still able to make logical decisions with the information given. This point ~~the~~ reflects another ide when relating these two approaches to embodiment, that classical machines can answer well-posed problem but not ill-posed ones. Connectionist networks can solve ill-posed problems, making it more embodied

approach in that it is more applicable to cognition in our everyday world. The problems we face aren't always straight-forward and these networks reflect that.

Connectionism being more embodied than classical cognitive science causes implications to the field because connectionism in a way came from classical cognitive science. Cognitive science began because of the common idea that information processing is modelled after the digital computer. If connectionism is heading in the direction of embodiment due to its central idea of biological plausibility, then the unifying thought of the field of cognitive science is no longer unifying. This could cause this once unified field to fragment, ~~as with~~ just like what happened to psychology. Unless cognitive science can find a way to continue to be unified, whether it's through a common methodology or maybe rethinking their unifying belief then a similar crisis to the 'crisis in psychology' will occur. I think science can learn a lot from these two fields in terms of unifying thoughts for the field, in the sense that as technology advances and discoveries are made we may have to go back and look at original beliefs and alter them in some way. The computer was the first technology that paralled our ideas of cognition, but maybe the field has to step back and see if this is still the idea that reflects the work, advances, and future of cognitive science.

2. Embodied cognitive scientists might claim that a key problem with classical cognitive science is that when the latter studies the mind, it does not know where to look. What are the implications of this claim? Do embodied cognitive scientists have advantages over classical cognitive scientists with respect to this issue? Illustrate your answer with the relevant examples from the lectures and from the readings.

The following answer received a grade of 32 out of 35. I liked it because it was well written, introduced ideas for comparing the approaches that went beyond our class discussion, and then came up with a position indicating that both approaches needed to improve their approach in order to understand 'mind'.

Part II: Essay (Topic 2)

classical cognitive science has roots in cartesian philosophy, in the way which it separates structure from process (like how descartes separated the processing mind from the structural body). this distinction between structure and process (dualism) is unique to classical cognitive science, making the structure / process purely symbolic, and not something which has actual semantic meaning or analogous ties to anything human (such as the brain). Because of this, classicists believe in nativism for the source of the symbols / computations which are manipulated (structure) and the processes which do the manipulating. For this reason, it could be said that classicists not only "don't know where to look", but literally have nowhere to look. The source of cognition is nothing but the mental states themselves (methodological solipsism) which were initially / came into existence through innate means, without reference to any external information.

On the other hand, embodied cognitive science looks to the world for the source of cognition, and the feel for the mind. While some embodied cognitive scientists are somewhat sympathetic to classical cognitive science's idea of "mental representations," they still believe that these representations are definitely not at the forefront of cognition, and only serve as a way to perhaps organize information from the environment. (other cognitive scientists discard mental representations entirely, as they are more radical).

For the reasons discussed in the previous two paragra embodied cognitive science does have advantage over classical cognitive science ~~in the with respect~~ in regards of "where to look." while embodied cognitive science can look to the environment, the embodied-ness and situatedness of an agent as a source of behaviour (therefore insight to cognition), classical & cognitive science can essentially only look to itself and its innate symbols, which don't really tell much (as they are symbols, not subsymbolic) other than how ~~co~~ the mind may abstractly function through computation.

The implications of this claim may include classicists needi to consider more external stimuli, or relate more to biology if trying to understand human cognition. Implications around embodied cognitive scienc may be that it now, with a source of "where to look" must also consider more mental aspects and how the source of much of our information scaffolds thinking, but doesn't replace it entirely. If classicists were to consider states of information other than mental states themselves, ~~they~~ then they would have a concrete, diverse source of "where to look" when it comes to how symbols come to exist, and how processes are selected to manipulate them. If classicists also looks to a more biologically-considering approach (such as in connectionism) they also may have a source of "where to look" when it comes to the computation

source. Finally, if embodied cognitive science considered more representational thinking, then it could probably come to explain all aspects of cognition, and not just reflexes or natural behaviours, or behaviours which don't seem to be a reaction towards a changing environment. like a how wasps build nests, we react to changes to our environment and in turn, make changes to it. the difference lies in the fact that we are not completely like wasps (or any insect of that nature) and exhibit behaviour unique to humans (such as studying, working jobs, paying taxes, etc). therefore, shouldn't more than just the environmental stimuli be considered? But on the other hand, the environment still plays an essential role in where to look as the primitive source of anything cognitive.

in conclusion, though certain schools of thought (embodied) have advantages over other schools (classical) in terms of "where to look," the implications of this fact are not that one is better than the other, but that certain aspects should be combined for the strongest approach.

3. Compare and contrast two approaches to studying cognition: cognitive science and experimental cognitive psychology. Illustrate your answer with relevant examples from the lectures and from the readings.

Only three students answered this question, so I am not going to provide a sample answer for it. What I was looking for was a comparison between some of the new ideas that you are being exposed to in this class and old ideas that you would have already taken in a cognitive psychology class. For instance, you could talk about cognitive psychology being a subset of cognitive science that focuses on the algorithmic level of analysis, or you could talk about cognitive science being far more interdisciplinary than experimental cognitive psychology is.