PROFESSOR: Information from your surroundings and does stuff with it, uses it to make decisions, uses it to guide behavior, uses it just to remember something. Anyone remember the first day of school when you were in first grade, maybe your first time riding a school bus, right? So information came in, and you've hung onto it for something like 10 years now, right. That's pretty cool. This is the thing that human brains do that's neat.

So thinking about the brain as a knowledge and information processing device as opposed to classic Freudian psychotherapy that talks about drives and subconscious motivations and stuff. This is a different approach and a different focus on what humans are doing. And then the neuroscience part, well, neuroscience science is the study of the nervous system, and in particular, in this case, the part of the nervous system we're most interested in is the brain, the central nervous system where all of this processing is going on.

So historically, kind of the cognitive psychology approach has been kind of prone to treating the human brain as just kind of a black box. We don't care how it's doing what it was, we just care about what goes in versus what comes out, being able to compare these. And there's kind of a history in the neuroscience world of looking maybe at very small scale things, at cellular level changes. How do neurons work, what are the different molecules in them that make them do cool stuff.

But the fun here, the way this is a cool field, is where you get these two things intersecting. So where you take all of this stuff and you say, cool, the brain does all of this stuff. How can we take what we know about how the brain works, the structure of the brain, the function of the brain, and use it to understand how the brain does all of this stuff with information. And vise versa, how can we use what we know about human behavior and human information processing, the stuff that we know brains can do from cognitive psychology, to guide the questions that we ask when we're trying to study neuroscience. So cool stuff.

So that's all going to do. You guys can see in your syllabus it's kind of broken out into weekly broad themes. There's going to be reading assignments each week. The first two are listed there. I have the ones for the first week with me, and I'll get next week's to you tomorrow or Wednesday. I'm not as organized as I should be, which is why they're not spelled out for the rest of this session, and I apologize for that, but I will get them to you. I'm going to try and stay

about a week ahead with those so you have them in plenty of time.

It's less reading. I know that Junction is kind of billing this as undergraduate level class. It's not. It's less reading because I get you guys for seven hours a week. The kind of standard homework for an undergraduate level class metric that is given out is two hours of outside-class time for every hour of in-class time, which would mean giving you guys about 14 hours of reading a week. Anyone got 14 hours to spare, free time, besides what you're putting in your classes? That's what I figured. It's summer, people are working. Most people, many people are working. I'm working.

But I am going to have stuff for you guys to read, and it's going to be related to what we're doing in class. It may not be exactly the same stuff, but it might be another perspective on it or somebody else's explanation. Some of them are going to be online stuff. That Brain From Top to Bottom site is very, very cool, and I'll make sure you guys get the link to that.

And we're going to be doing some writing, just low-key writing. We're going to have you guys right quick stuff in class, take five minutes to do things, and I'll ask you to do a weekly paper. And we'll talk more about those at the end of this week, because the first of those short papers is due on Monday, next week. Questions?

AUDIENCE: Do we get, like, graded?

Do we get, like, graded, that's an interesting question. Do you guys want to be, like, graded?

AUDIENCE: No.

AUDIENCE: Yes.

AUDIENCE: Yeah.

AUDIENCE: I like the challenge.

AUDIENCE: No.

PROFESSOR: So the way I was thinking of it was probably things that I think are important here. What do you guys think are important here? What would constitute doing-- what are the things that would make up a good grade in a class like this, doing well? What's important?

AUDIENCE: Understanding the material that you're teaching us?

PROFESSOR: Understanding the material that I'm teaching you. And how would I know that you're doing that?

AUDIENCE: Class participation?

AUDIENCE: [INAUDIBLE]

PROFESSOR: Class participation is good.

AUDIENCE: You can express that through your writings properly.

AUDIENCE: Writing skills are really important, you guys know this. You hear this from your teachers, you hear this in school, you're going to hear it again when you hit college. Everyone's going to ask you to be able to write stuff down on paper. More practice at it is going to be-- even if it's a pain in the butt at the time-- a good thing in the long run.

AUDIENCE: Asking questions?

PROFESSOR: Class participation and asking good questions. Asking questions. Also, even if you think it makes you look stupid and not smart, it's OK. No stupid questions, et cetera. You guys know the drill. So do we want to be, like, graded? Class consensus, yes, no?

AUDIENCE: [INAUDIBLE]

PROFESSOR: Yeah, probably? What about like on a 10 point scale, is that a reasonable compromise? Like yay, you did a good job, and we'll figure something out. I'm--

AUDIENCE: On the condition that we don't ever have to look at each other's grades or--

PROFESSOR: We can have private e-mails about grades or something, if you want them. Actually, you know what, you've got my email there. Drop me an email if you want me to keep track of what you're doing grade-wise, OK? Tonight. I know some of you don't and some of you do, so this will let you make your own decision about that.

What do we got for time? OK. So let me have-- pass these out to you. These are readings for the week. I probably won't run them off in the future. Everyone's got internet access at home, good, easy? Does that work for everybody? If it doesn't work for you-- is it a problem? Billy, does it work for you, or is it a--

AUDIENCE: Yeah.

PROFESSOR: OK, because what I will probably do is scan stuff to PDF and just upload it so that I don't have to pay for photocopies, because photocopies are expensive, and that way you guys can either read it on the screen, or you can run it off yourselves. So that works, that's cool. Again, if that's a problem for you, catch me after class and let me know, and we'll work something out. So readings for the week, take a glance, put them away. We're not going to work on those now.

So what I wanted to do today-- I wanted to do two things. I wanted to run down a bit more of an introduction to this cognitive psychology idea, these cognitive principles. This is kind of my educational background that are going to lead to what we're doing. And then I want to jump in to look at the journal article we're going to read this week.

So cognitive psychology. Thanks. Yeah, we're missing folks today. We'll see what happens with that. Cognitive psychology, again, is looking at the human brain as an information processing approach, and the way this always starts is by giving a little bit of a history lesson.

And so modern psychology, most people will date it back to kind of the late 1800s. This guy named Wilhelm Wundt opened a laboratory in-- did I write it down? I didn't write it down-- the 1870s. And Wundt was very into this idea of introspection, this idea that if you were properly trained, then you could understand mental processes simply by thinking about how your mental processes seem to you to be working. And so you could consider sensations, you could consider what memory was like, and you could learn a lot about them by considering them kind of from the inside out.

And a lot of cognitive psychologists today will look at this idea and go, um, what? It's not, because by our standards it's a very subjective way of studying something. It's very dependent on the observer. So that was Wundt and a bunch of other 19th century guys, and in the early 20th century, there was a revolution in psychology, and this was the behaviorist revolution.

You guys have heard of Skinner, maybe, and that crowd, and they said, no, no, no, no, no. Introspection is nonsense. It's too subjective, it depends on people, you can't have somebody else confirm your results of introspection because their brain is different from your brain. Psychologists should have nothing to do with introspection, and they should focus on objective, observable behaviors. So these behaviorists were trying to understand.

So we have our introspection, right, in the late 1800s, late 19th century, and so that's 1870s to

1920-ish. And then we have the behaviorists coming in, and so these are the guys who said objective, observerable behavior is the only thing that is worthy of scientific investigation, the only thing you can be truly rigorous about. So you guys have seen your kind of classic rat in a box, right, pushing a lever in order to get a reward, or running a maze to get a reward. These are behaviorist ideas.

And they had this model that said that basically behavior is caused by stimuli in the environment. That is this very simple model where you see a stimulus or you have a stimulus of some sort, and you respond to it. If I give you a reward, then you will [INAUDIBLE]. So for example Pavlov, right, Pavlov's dogs. Pavlov had these dogs and he gave them a little-- he would food deprive them, right. This is classic animal research, you food deprive your subjects so they are motivated to work for you.

So he'd keep them a little bit hungry, and he'd give them a meat powder, tasty and delicious. And every time he did it, he'd ring a bell. And of course the dogs get the meat powder, they salivate, right, reflex response. And eventually through this conditioning, then you get a paired-- the response, the salivation, which was originally paired with the original stimulus, the meat powder.

But if you pair the meats powder and the bell every time you present it, eventually you can ring just the bell and the dogs will start salivating. And this is kind of a classic behaviorist set up where you aren't measuring mental activity of any kind, you're just measuring salivation. You know, you can-- heck, you can collect it in little cups and figure out how much salivation you get and things like that, very rigorous.

And this was kind of how it worked for up into the 1950s, this was the way psychology worked. This was what you did, you worked with white rats, or cats, or dogs. There wasn't a whole lot of human subjects' behavior. And in the 50s people started saying, hey look, this stimulus response model might work OK for rats running mazes, but it doesn't work real well for human behavior. Human behavior is complicated, it's tricky.

Everything that we do requires all of these different factors to be weighed. If you're running late for class, you might have to decide, am I going to try and wait here and catch a bus? Am I just going to run across campus? Am I going to call my teacher and tell them I'm going to be late? And which of those options anyone might choose in a given circumstance is dependent on a wide range of factors-- simple things like weather and how late you are, but also maybe

you know that the bus should come, or you know the bus won't come because the bus system fails. And so human behavior is a lot more complicated than these behaviorist models can really explain.

And at the same time, in the 50s, this was the rise of computers when you started having things, and historically there's been this tradition of modeling the brain and the nervous system as the shiny new technology of the day. In the 1800s, they talked about the brain is a series of hydraulic tubes, because that was the technology that could do really elaborate, complicated things, and around the turn of the 20th century they talked about it as being like a telegraph network. And in the 50s, they started talking about the brain being like a computer, and we'll talk some more about that analogy probably tomorrow.

But one of the things that happened with computers is that you started to have this model of complicated information processing within the guise of being an acceptable scientific thing to think about in kind of the software world. And that and this decision that behaviors couldn't cover everything led to a new growth of people talking about things like memory, like attention, like visual perception. All of these things that we could consider cognitive topics started showing up in the literature in the 50s. So viola, brief history of where this field is coming from.

So the behaviorism actually did a lot for the field. Psychologists now don't work like Wundt did with his introspection and his personal observation of what his mental sensations felt like.

AUDIENCE: Is there a name for the mass movement you described?

PROFESSOR: There were a bunch of people involved right then, a lot of kind of the classic work in the field, so you'll hear some of these names all through the course. This isn't a one-person sort of thing. I'd say Wundt for the classic introspection would be one good name to know, and Skinner and Pavlov are both good names to know for behaviorism. Skinner boxes are still used by people working with mice and rats, the little boxes where you can push a lever and you can program them to do all sorts of stuff. They've got levers, and lights, and speakers, and little pellet trays.

And one of the things I did my junior year at UNH was writing code for an attention task. We were working with the rats, and they had to stare at this panel of light. So you've got a Skinner box, right, box. And these ones had-- here, we have a box. Yeah, that's more or less right. So these ones had three little lights along the top, and they had two levers, and they had a pellet tray in the middle. And this is kind of off topic, but just so you can get a sense of what a

Skinner box looks like.

And what these rats had to do-- pointy nose, whiskers, rat, long tail. That doesn't look like a rat at all, but we're going to ignore that. So what these rats had to do is they had to watch this panel of lights, and the middle light might or might not come on. And it would come on very briefly, we're talking like a quarter second here or less, tenth of a second, [INAUDIBLE], or it might not come on at all.

And after that at the end of the trial, both of the levers would extend, and they had to push one lever if the light came on and one if the light hadn't come on. And if they were right, they'd get a little food pellet right in their little tray, and if they were wrong they didn't get anything. And so the model here is trying to figure out-- so this is what's called a sustained attention task. They've got to sit there and watch that light for a long time. Rats are not, for the most part, very good at sustained attention tasks.

Humans are, for the most part, not very good at sustained attention tasks. So the human equivalent of this task might be like being an air traffic controller, right. You've got to spend your shift watching a little radar screen with little airplanes moving around on it, and make sure none of them are going to bang into each other. You don't really get to take a break. And if you're a rat you take your breaks by grooming or rolling over on the floor. They just goof around in there, it's pretty funny. Air traffic controllers might take a break by looking away from the screen, getting up and walking around, the human equivalents.

So humans aren't good at this sustained attention sorts of stuff. So we were working with these guys, and we were actually playing with some of-- we were changing the levels of certain neurotransmitters in a particular part of their brain, in the prefrontal cortex, to see-- this was three years ago, I don't remember what exactly we were doing-- to see whether lesioning particular areas impacted their performance on both a sustained attention task versus a shorter-term attention task where they had an acoustic cue, a beep, to tell them when the trial was about to happen, when the light was going to go or not go. So comparing their performance on that. Anyway, but that's a Skinner box. They've got levers, they've got lights, they can do all sorts of stuff. Hook it up to a computer.

But one of the things that the behaviorists gave to the field was this idea of really rigorous scientific experimentation, this idea that if you want to measure something, how someone performs on a task, you've got to come up with an operational definition. So if I wanted to

study memory, and I might say that I would consider your memory to be good, maybe, if I can give you-- rather than saying, do you feel like you have a good memory-- do you feel like you have a good memory?

AUDIENCE: No.

PROFESSOR: No? Do you feel like you have a good memory? Yeah? Do you feel like you have a good memory?

AUDIENCE: No.

PROFESSOR: But see, that's all very subjective, right. It's depending on your own personal standards for what a good memory feels like, whereas I could say, I'm going to give you a list of numbers, six numbers. I'm going to give you all a list of six numbers. And I'm going to let you look at them for 30 seconds. That's a really long presentation time, by the way, in the cognitive psychology world. You'd be more likely to see half a second, how many of them can you pull up, or five seconds, how many of them can you remember.

All right. Everybody got to look at them, we're going to make them go away. None of that. And so now I can say my operational definition of a good memory is going to be whether in five minutes or so you can still give me back those six numbers. Who's writing them down, which would be something that would be very classic, which would be an example of-- so maybe you don't think you can remember them, but you can write it down. You assist your own memory.

An operational definition is a definition of-- know what, I don't have a good definition for that for you guys today. An operational definition is defining the thing you want to study-- if you want to study memory, if you want to study attention, if you want to study learning-- in a way that you can experimentally verify. So it lets you take this and say, OK, this is no longer a vague amorphous concept, this is something that I can do.

Time check, OK. These classrooms don't have clocks. I keep being weirded out by this. I am accustomed to all classrooms ever having clocks. I'm going to have to do something about this, like start wearing a watch.

So let's talk briefly-- so we said that cognitive cognition is looking at this idea of acquisition, storage, transformation, and use of knowledge, right. So OK, not yet. So people who are trying to understand theories of cognition-- you can make a case that everything that the brain is doing with cognition is really just biology, and everything the biology is doing is really just

chemistry, and really it all comes down to low-level physics in the end.

AUDIENCE: Math.

PROFESSOR: And physics is just applied math, yes. But this is not terribly useful. Trying to understand cognition in terms of math is possible, maybe, in kind of an abstract way. We don't have the knowledge yet to do it, but it's not going to get you anywhere. It's worth it to try and look at these things at these different levels.

So cognitive theories are looking at this particular level of abstraction that are thinking about information processing, and there's a couple of key ideas that cognitive psychologists use that we should talk about. So one of these is representation. So when we're talking about information processing, we're going to talk about you as having a representation of something in your mind. And a representation is-- actually, when we're talking about a representation of something in your brain, maybe of your representation of the concept of a cat, or the color red, or of your mom.

And a representation is actually a physical state in your brain that conveys the information specific to a concept, or an object, , or a category or a trait of these things, but to something specific. You know, when you're thinking about your mom, your brain is actually in a different physical state than when you're thinking about the color red. This is cool. So there's a physical base underlying these representations.

And we'll talk about the brain as performing different kinds of processes on these representations, so actually taking a piece of information and transforming it. So representations, process, so we'll have cognitive processes that take information, transform it according to some well-defined rules, so that for an input you get a consistent output. So a cognitive process of visual perception would allow you to get certain input coming in, light hitting the retina, and you'll get an output, which with this case would be your perception, kind of your subjective impression of what you're looking at.

And with modern neuroscience and modern techniques, there's been a very strong move in the cognitive psych world to start really looking at the neuroscience, to start saying, what do we know about the structure and function of the brain that can help prove or disprove different theories about how cognition works.

AUDIENCE: So is that when you have a person look at some pictures and then you want monitor the brain

to see where the activity is happening?

PROFESSOR: Yeah, so that would be a very good example of that, and you can say, OK, activity is happening in this area that we know works on these kinds of problems. What does that tell us about what kind of processing is going on there. And depending on who you talk to, imaging is valuable or not valuable in certain ways. We'll talk on Friday about imaging systems and the methodologies that people use in this sort of stuff and what some of the limits of those are.

And there's this tendency in the popular media for somebody to write this careful paper that is like, OK, we saw this, we're very careful about what we claim. And then like the New York Times will be like scientists find sarcasm center in the brain, and the researchers will be like, that's not what I said. And that's partly that the limitations of the techniques the researchers are using are not always clear to the journalists who are writing about it, and it's also the newspaper wanting to write a headline that will sell papers. So it happens, so it's one thing to think about when you're reading the stuff in the paper, in the news magazine, in something that's not really a science publication.

All right, we have 10 minutes before pizza. So one of the things we're going to do in this class is we're going to actually read some of the original research in this field, so this is this week's version. And the general response to seeing one of these things if you've never picked up a journal article before is, I'm not sure this is actually in English. They tend to be very dense, they tend to be kind of jargon heavy, and so I wanted you guys to just have some experience trying to work your way through one of these things before you get thrown them maybe in your freshman or sophomore level college classes and are like, ack.

So title, the title of this one is "Improving Fluid Intelligence with Training on Working Memory." And who's ever actually sat down and read a journal article before, anyone? One, awesome. Two? A couple? Good, OK, that's actually surprisingly high, cool. So

Papers are structured slightly differently depending on what field you're in and what journal they're in, but generally you're going to get at the beginning an abstract, usually 100 or 200 words, describing what the paper's doing. These tend to be very, very, very dense because they're taking the rest of the paper and [SQUISHING SOUND EFFECT] squishing it into 200 words. They're structured kind of like a lab report. The reason they make you write lab reports is in part to kind of familiarize you with this structure.

There's an introduction that's like, this is why we want to study. This is kind of what the

background is, what other people have done. There's going to be a description of what they did, their methods. And this particular one, because it's PNAS and they break it up, they start discussing their methods right there at the beginning of the second page, and they kind of do it very vaguely, and then they have some more of their methods at the very end in more detail. And this particular structure drives me batty, and I'm sorry I pulled it out for you guys for your first one, because I'm like, how do I know what you did, ack. It's all in the wrong order. So I tend to jump around and read the methods kind of out of order there.

Results is a lot of numbers and a lot of stats, and 90% of the time, if you're just reading this-- if you're not like, I'm going to go out and try and duplicate their work, you can entirely skip the results section because you don't actually need to know the stats, and jump straight into the discussion section where they're going to tell you what all these statistics actually mean and what they think they learned from it.

AUDIENCE: What are all the numbers for?

PROFESSOR: The numbers are references. So in the back, there is a list, a numbered list of references. You'll see references in different styles. You've probably seen footnotes in the past. These guys do it with the numbers in parentheses, kind of classic psych journals will do it with a last name and a date in parentheses, and you'll see all of those. So those are referring to-- so the first one they'll say, "fluid intelligence is a complex human ability that allows us to adapt our thinking to a new cognitive problem or situation," one.

And that means that they are pulling that definition from TE Rohde and LA Thompson's "Predicting Academic Achievement with Cognitive Ability" published in *Intelligence* in 2007, and you can look it up. So if you were also studying fluid intelligence, you might say, you know, what, what do they mean? Where did they get that? That lets you know. So one of the things you'll see in papers is that they're very, very heavily referenced. You're really trying to build on, everything we're saying somebody else already said. So fluid intelligence. What is fluid intelligence, what have we gotten out of this so far?

AUDIENCE: The ability to reason and do new things without having known [INAUDIBLE].

PROFESSOR: Right, so it's kind of your performance on a task you've never seen before or a reasoning problem you've never seen before. If you guys think of kind of your classic logic problems like, a guy's found dead in a cabin in the wilderness naked, with 52 bicycles around him. You guys

have run into these things before probably. Ask me yes or no questions until you solve it. No, but that's sort of like-- fluid intelligence is one of the things that allows you to do well at these. Having an obsession with them and having seen most of them before will also help you do well with these, but that's a very different sort of scale. So fluid intelligence. Why are they interested in studying fluid intelligence?

AUDIENCE: It has importance especially for people who have occupations that involve adapting to the situation. So being able to do your job well, even though you're basically doing something you've never seen before.

PROFESSOR: Yep, OK, good. And of course this is closely related to professional and educational success. Everybody wants to be able to improve professional and educational success. And the other reason they're interested in studying it, if you look at paragraphs two and three, is that nobody's really been able to find a good way of increasing fluid intelligence. You know, there's people who want to sell you smart drugs, or there's those video games, the brain workout video games, and--

AUDIENCE: Except that it appears to be hereditary.

PROFESSOR: Yep, there is a strong hereditary component to this stuff, which is interesting. For most intelligence measures, there's a strong hereditary component. It's not the only thing that's going on there, and it's hard to pull it apart from socioeconomic stuff, which is also a strong component, but it's there. OK, so your mission for Wednesday is to read this and come in Wednesday with questions about it. And we will talk about it and probably work through it and figure out what on earth they're trying to study, what on earth they did, why it's important, what they found out. And with that--