Welcome. You are listening to the UC Davis Center for Poverty Research seminar series. I'm the center's deputy director, Marianne Page. This series brings scholars and policy experts from around the country to discuss their work on poverty and poverty research. In December, 2013, the center cohosted Peter Gianaros with the UC Davis Center for mind and brain.

Gianaros is an Associate Professor of psychology at the University of Pittsburg. Where he and his colleagues use neuro imaging to understand the links between stressful experiences, and risk for cardio vascular disease. Here is Gianaros presenting his seminar. Neuro Biology of Socio Economic Health Disparities.
>> It really is an honor to be here part of what I've been trying to do over the last few years is, get social scientists who are interested in disparities research to be more interested in the brain and what neuroscience has to offer.

And part of what I've been trying to do is get neuroscientists more interested in socioeconomic health disparities. So for me to be able to speak essentially to two audiences, would share interests, you know, at the interface of what I've been trying to do is something I've never had the experience to do before.

So I, I, I'm very, very grateful to to be here. Okay. So, as Paul mentioned, today I'm gonna be talking a little bit about some ideas and questions and some findings, from a program of research that I started a little over five years ago, where the interest has been to try to better understand some of the neurobiology of socioeconomic health disparities with a particular focus on heart disease, atherosclerotic heart disease, which is still the leading cause of death among men and women adults in this country and other developed nations.

So to do this, what I've done is I've organized today's talk around five themes. So what I'd hope to do is just spend a few minutes talking a little bit about the broader context, that has contributed, and kinda fostered some of the questions that we've been asking. Then I'd like to talk, a little bit, kinda make a plug for neuroscience, and what I think, neuroscience might have to offer, in the way of kind of understanding neurobiology of health disparities.

Then kinda switched gears a little bit and talks about some of the conceptual issues that we've been struggling with, you know, in, in trying to apply neuroscience methodologies to understand these health disparities. Number one to talking a little bit about some findings from our own work, particularly of what we've been up to recently, and and then finally I'll talk a little bit about where I hope to see things going in the future, and that'll mean our, in our own work, but also in trying to figure out what we can do to get more people talking to each other about about these issues.

I should say I'm perfectly happy with fielding questions along the way. I know that I'm speaking to two audiences. So I know, you know, we have one group of people in here who are neuroscience and neuroscience methods that might be a little foreign. If, so if I'm slipping into jargon and something doesn't make sense, feel free to, you know, raise your hand and I'll define the field questions.

And then we have another audience of neuroscientists and psychologists who might not be used to thinking about disparities. There'll be plenty of opportunities for me to over simplify things and make a fool of myself. So I'm, I'm again happy to fill questions in along the way. So as as Paul mentioned, I, I am a psychophysiologist by training, and for about the last 13 years, I've been doing frame imagining research in neuroscience research, that's aimed at understanding how stress related processes instantiated in the brain relate to risk for after risk sporadic heart disease, particularly in, in two two lines of research.

So in one, one line of this research, we've been using functional magnetic resonance imaging and functional imaging methodologies, to characterize some of the brain circuits and brain systems that are involved in generating acute changes in cardiovascular activities. So like rises in your blood pressure, rises in your heart rate during acute stressful experiences.

So the question here are like, what are the brain mechanisms that generate these acute stress responses? The reason that we're interested in this particular kind of question, is because these acute changes in cardiovascular activities. So acute surges in blood pressure, you know, when you're angry or when you're stressed out, the magnitude of those changes actually predict your, your risk for developing hypertension in the future and developing, coronary heart disease.

having, you know, a stroke or, or a heart attack. So in that way, what we're trying to do essentially is understand the brain systems that link stressful experiences to a person's stress related vascular heart disease. In another line of this research we've been using structural imaging methods, so here we're not looking at brain function, we're looking at brain structure.

And the goal is to characterize aspects of radian morphology, so for example, like tissue volume, the integrity of white matter tracts that connect different parts of the brain, so we're, we're characterizing these aspects of morphology and we're relating them to more chronic stressful experiences, so, things that don't happen you know, on a moment-to-moment basis, but things that you might endure for years.

And we're also looking at aspects of brain morphology in relation to biological and behavioral risk factors for heart disease. Such as systemic inflammation, hypertension adeposity, and obesity. Then I'll talk a little bit more about how these lines of research kind of led to where we're at right now, and how we're still using these approaches, particularly in the context of, of socioeconomic health disparities.

Okay, so, my favorite slides. with, with, with respect to the, the first line of the search, the goal again has been to kinda characterize non neural circuits that are involved in centrally generating changes in the outflow of autonomic nervous system activities, to peripheral target organs particularly in your heart in your vasculature, that lead to changes in blood pressure and heart rate and redistribution of blood to different organs, that in short term might be adaptive.

In that they provoke you know, things like the fight or flight response which some of you might be familiar with. And in the short term these kinds of cardiovascular changes can be adaptive, they you know, can facilitate behavioral actions that might promote survival. But again as I mentioned earlier, if you're someone whose prone to showing exaggerated rises in blood pressure or heart rate and and you show these repeatedly over time, there's evidence to suggest that these kinds of cardiovascular changes cumulatively over time, can either initiate or exacerbate damage to the cardiovascular system that might promote or accelerate or exacerbate some of the inflammatory events, that lead to an accelerated progression of, of atherosclerosis over time, which is the major disease process that contributes to like late stage events.

Such as mild cardio infarctions that can be fatal, or non fatal. And in this line of research, what we've been trying to do essentially is better characterize some of the circuitries. We don't have to get into the details of this, but I'm happy to talk about the, this work a little bit later.

But essentially, what we're trying to do is identify neurocorrelates of acute changes in blood pressure and cardiovascular activity during imaging protocols, so, you know, we put the people in an MRI machine, and have them do stressful tasks and you monitor their blood pressure and their heart rate. You look at their brain activity and then we identify areas where, you know, brain signal changes relate to the magnitude of the stress response.

And then we focus on a couple of areas in particular, because these are areas that are involved not only in processing stressful information, but also regulating peripheral physiology, do their projections to mid-brain and brain stem areas that, that regulate autonomic nervous system outflow perfectly. And in work that we're trying to do now, we're trying to predict the multi-year progression, longitudinal progression of atherosclerosis based on, MRI signal changes that we can evoke in the scanner, or with our stressor tasks.

So that's kind of one, one line of my research and you know, one, one focus of my research. So, in addition to trying to understand some of the neural correlates of acute stress reactivity, another line of research that I mentioned earlier, is interested more in kind of like bottom up questions.

So for example, how we risk factors for heart disease, such as obesity, and adiposity, hypertension, and then markers of systemic inflammation. How do they relate to the morphology of brain are, particular brain areas, that are involved in mediating a diverse range of cognitive and emotional processes. And there's a lot of evidence accumulating to suggest that, that, these kinds of indicators of, of, chronic health, can come to impact the brain through bottom pathways that involve you know, the influence of prone inflammatory and markers of systemic inflammation, that can

come to be cedar toxic, can result in remodeling of brain areas.

Hypertension can have effects adverse effects on the brain as well, and so a lot of the, the work here is, is, is kind of more focused on these kind of chronic influences on brain function and structure. Any questions so far? Okay. All right. So all the while that I've been doing this, this, this imaging research on cardiovascular disease, I've been perfectly happy to ignore, you know, the elephant in the room that, again I think half the audience is, is very familiar with.

And this elephant is the fact that chronic illnesses, like coronary heart disease, mortality by, by chronic illnesses, and even risk factors for chronic illnesses like heart disease, they're not randomly distributed in the population. All of these things track a socio-economic gradient. And we've known about this for decades and as well, as, as I mentioned some of you are, are very you're very familiar with this.

There are huge disparities in chronic illnesses particularly heart disease. The black report in the UK put this, I think, you know, squarely on the map and, you know, led to a whole, whole, a whole field of research concerned with, with socioeconomic health disparities. And what, what I'm gonna be talking about for the rest of, of today's presentation is, essentially what I consider to be an oversight on the part of, of neuroscience, in terms of maybe not appreciating these, these existing disparities and kind of paying attention to what neuroscience might be able to offer this field, and what the field of disparities research might be able to offer to neuroscience.

So this, this slide is kinda for the other part of the audience. This is a typical example of a replicated finding, that's been shown in a number of countries. But this is kind of what what the nature of the relationship is that I'm broadly referring to. So this is the relative risk of premature death, plotted as a function of of family income in the United States where premature death is age and sex adjusted relative risk of dying before the age of 65 for, for any cause.

And what you can see is a clear gradient, such that the relative risk of dying prematurely increases as a function of lower levels of, of family income and the relative risk of premature death declines as the function of increasing family income. You see relationships like this with other indicators as socioeconomic status, that I'll talk about a little bit later, such as educational attainment and so forth.

And you can measure this in, in multiple ways, at multiple levels of analysis. But it's not only true for indicators, hard health indicators such as premature mortality, but there're disparities that track a socioeconomic gradient, for leading chronic illnesses. Particularly chronic illnesses that pose the greatest burdens to public health right now, with coronary artery disease being the at the top, stroke, functional GI disorders, arthritis chronic bronchitis and strep pulmonary disease, asthma, and Type II diabetes.

All these chronic illnesses track a socioeconomic gradient. And then what's, what's even more interesting, I think, for me is that even the non-random clustering of multiple chronic illnesses, tracks socioeconomic gradient. So what we're looking at here are prevalence rates of having, two or more of nine chronic illnesses, including hypertension, coronary heart disease, diabetes, some forms of cancer, stroke, bronchitis, emphysema, asthma, and kidney disease.

That having two more of these, diseases, the probability or the prevalence rate of having two or more of these, illnesses increases, the further below the poverty line and you go. And so the green bars here indicate prevalence rates from 1999 to 2000 and, and 2009 to 2010. So what you can see is over this kinda ten year period overall there's a, there's an increase in having two or more chronic illnesses.

But again you see kind of gradients existing for the non random clustering. So in a sense, it's, indicators of, you know, so this economic disadvantage can be taken as kind of indicators of, of fly paper essentially for, for having multiple chronic illnesses. And, and as I mentioned earlier, it's not only chronic illnesses, but it's risk factors for chronic illnesses that also track a socioeconomic gradient and this exists for, for multiple risk factors, many of which I'm interested in because they're known to predict or Contributing risk for, for heart disease so, high blood pressure, hypertension, glucose distragulation, markers of systemic inflammation, which I'll talk a lot more about a little bit later cigarette smoking, physical activity, sedentary lifestyle, overweight, all of these tracks socioeconomic And as I mentioned earlier, so we've, we've known about these disparities, and we've known about these gradients in health and

risk factors for poor health for many decades.

And this has primarily been the focus and interest of economists sociologists, health psychologists, social epidemiologists. But for the most part, these disparities have, you know, kinda been relatively ignored by neuroscientists, cognitive neuroscientists, social neuroscientists. And I think that's an important oversight for reasons that I'll elaborate on next.

So what I wanna do now is just talk a little about where, where I see neuroscience fitting into this, this area of research. So I should say, it's, it's not, it isn't entirely fair to say that, that neurosciences has, has not been interested in disparities. It's just not true at all.

There has been an emerging interest, growing interest on the part of neuroscientists in disparities that exist in terms of cognitive function that emerged early. And I know a lot of that. That work is being done here, and there's a lot of interest here on campus. So for example it's well known that disparities exist in executive functions, working memory.

Memory fairly, fairly early in life, and these tracks assess economic gradient and they predict very important things, like academic achievement and attainment later in life. And again, there's, there's kinda a growing interest on the role of the brain in kind of linking indicators of disadvantage to be used in earlier cognitive experience.

But at the same time people who are like me are interested in physical health and doing their science research on physical health. I can, I can honestly stand up here and say that there's little to no interest in outside of like what we've been trying to do in understanding the connections between, you know, socio-economic disparities, brain function, and brain structure.

And how they relate to, to chronic illnesses that represent major public health problems today. So well is this even, so if I, if I'm saying that this is an oversight the, is this, is, is there really any are there any reasons to care? Like so, so, so what that neuroscience you know, hasn't been doing work on physical health.

Why is that important? well, one reason why I think it's important, like why neuroscientists I think should care is that there's a growing body of evidence in, in the field of like neuroepidemiology for example, showing that things that physical inactivity indicators of heart disease. Markers of systemic inflammation which Time, Time Magazine's not the silent killer.

It's actually some people might think that, I don't know. But this was a, Time Magazine issue on systemic inflammation, but there's a lot of work in neuroepidemiology showing that all of these risk factors and all of these chronic health conditions relate to adverse changes in the brain. Function and brain structure and the goal in this, in this work in neruoepidemiology is to really kind of follow up on this long standing body of evidence showing that chronic illnesses predict premature cognitive decline.

So like for example risk factors for heart disease predict later risk for dementia. And the goal there, in this, in neuroepidemiology, is to kind of understand the neural pathways liking these risk factors for chronic illness and chronic illnesses to later life cognitive decline. But, as I mentioned earlier you know these, these risk factors and these chronic illnesses, they all track a socioeconomic gradient.

So I think even in this field of neuroepidemiology, I don't think you're gonna have a complete ideological understanding of how these can kind of come to influence brain and later in life dementia and risk, unless you fully account for the social patterning of the social patterning of these risk factors and these health conditions.

So, I think it, it helps in terms of, you know, building your ideological understanding of, of basic pathways that you're interested in by accounting for known disparities as well. The sec, one of the second kind of broad category of, of reasons why I think neuroscientists should care is that.

Many of the social processes and cognitive processes, affective behavior. Even visceral control processes that I'm interested in, a lot of these, a lot of these processes track a socioeconomic gradient. And, also at the same time from

the perspective of sociology and epidemiology and even like behavioral economics. A lot of these processes that neuroscientists are interested are considered as mediators in between socio-economic disadvantaged and health behaviors and even risk factors that are known to track a socio-economic gradient.

So, I think in this way neuroscientists has a lot of room to contribute to informing, epidemiological models of disease risk that are, you know, prevalent in, in health disparities research. So I think that there's there are rich opportunities to do cross disciplinary work in this area. Any questions?

Okay, all right. So it's in, it's in this context that we've been doing work in this area and we've been, we've been doing functional imaging work and structural imaging work with the goal of trying to understand. The role of the brain in, in linking this economic disparities to these chronic illnesses and risk factors.

So, what I'd like to do now is to say a few words about some conceptual issues that we, you know, that we've been struggling with, particularly like definitional issues. As we've, as we've kind of like built up this, this program of work. And then, after this, I'll start talking about how we've, we've been trying to integrate some of these conceptual issues with some work that we've, that we've been doing.

So this is more for the nurse science audience as we kinda move forward. In, in doing this work we, we take kind of the definitional approach that that socioeconomic status is multi dimensional construct and it's also multi level construct. In general what, what how we think about socioeconomic status is that it refers to a person's relative standing in some social hierarchy or social position, some social position or hierarchy, and that this standing is closely linked to access to physical social, material resources and also life opportunity.

So this is kind of like our broad, kind of conceptual approach to defining how we go about measuring and thinking about STF. SES is, is multidimensional in the sense that it can be measured along the lines, along dimensions of educational attainment. Over the life course it can be measured from a financial dimension.

You know, where you're measuring things like family income, personal income and so forth. Occupational prestige, occupational status. And the measures that we use and that other people use in this field of research these can be subjective or objective. So they can be subjective in the sense that you can use measures.

For example like the McArthur scale of subjective socioeconomic status. Where you give someone a, a visual ladder. And we say something like the people at the top of the ladder are the best off in society. They have the best jobs the best incomes at highest levels of education and the people at the bottom are the worst off.

They have the worst jobs worst education, little to no income and so forth. And then you just ask people to say where would you rank yourself in relation to other people on this ladder. A very subjective scale. It correlates someone but not very highly with object measures but interestingly this objective measures predict hard health outcomes.

And health status and we've used some of those in our research as well. And then as you can imaging these measures can be objective in a sense you can, you can ask someone how many years of schooling have you completed, what was your highest degree earned? Fairly objective indicators.

And, all these measures are, are correlated with each other. Sometimes more strongly in some populations than others. But there certainly not redundant and they're not interchangeable. So it's not like socioeconomic statuses, it's like one thing and you can just like average all these things together. I think you're obscuring a lot of important conceptual information when you do something like that because other people have argued really convincingly.

But also from my perspective, something important to keep in mind is that, all these dimensions and all these indicators of socio-economic status can relate to health through very different pathways, right. So if you trace a pathway from income to, to coronary heart disease, the mediating factors might be very different.

Then if you're looking at something like education for example, I mean intermediate factors that might link to something like heart disease. So multi dimensional in this sense. Socio-economic status is also something that's multi

level okay? So you can take indicators of socio-economic status and measure them at the individual or person level.

You can measure them at the level of household at the level of the neighborhood which is something that I've been focusing on actually more and more recently over the last year, so, and you can do this by taking a person's street address and then looking at information that might be available.

Based on census databases or publicly available databases and looking at, you know median household income on that block percentage of people who are unemployed, percentage of people who are on public assistance, and then measuring SCS at this level of analysis. And then you can go beyond the neighborhood, you can go to counties and states, and, and higher social assemblies as well.

So it's multi-level in this sense. And so I guess in, in, in thinking about this multi-level and the multi-dimensional beast of a variable wha, what we have been trying to do, essentially, is relay these kinda different indicators in socioeconomic status. The aspects of, of brain function and brain structure in an a attempt to kind of understand some of the different neurobiological pathways that might link risk factors for chronic illnesses spanning multiple levels of analysis to health.

Across the life course and we've, we've only really kinda scratched the surface on a lot of the questions. You know that you can, you might be able to ask in this line of research and we've been trying to do it in, in multiple ways. But I think this you can probably come up with all kinds of complicated figures and this isn't the best one.

But I think this is kind of where we're at at this point, and this is where I find, see a figure as, as something that might be kind of capturing the different disciplinary approaches where you get a neuroscientist and people who are interested in this varies can kind of come together and start filling in different parts of the cubes.

And asking questions in different search bases within this within this area. Okay. So time is flying. So what i'd like to do now, is talk a little bit about just some example findings, from a recent study that we did. And again, if there, there are questions that come up as I go along, I'm happy to talk about this, and I also have, I have a total of like 100 slides.

So I'm not gonna go through, I'm not gonna go through all of them, but if I get through this one and some of you guys are interested in the functional work that we do. I have lots of backup slides that I can talk about like other studies that we've did that we've done during the question and answer period.

Okay. So as I mentioned earlier, I'm I don't know why that just happened. I think I did something on the plane I didn't do. Anyways, so one, as I mentioned earlier, one of my areas of, of interest is in understanding. Risk factors for coronary heart disease, particularly in biological behavioral measure of systemic inflammation.

Might play a role in the linking heart disease risk with aspects of brain morphology that might in turn relate to aspects of cognitive functioning and emotional functioning across the life course. So, for example in studies that, that that we've done before, my colleagues and I have shown that markers of systemic inflammation such as things you might heard of before like, C reactive protein, six, indicators of like pro-inflammatory states.

We've shown that those relate to decreased integrity of white matter tracks in the brain. We've shown that markers of systemic inflammation relate to reduced cerebral blood flow. And we've also shown that they relate to markers of cortical atrophy. And regional brain tissue volume decline. We've shown the same thing for markers of hypertension, so we've, we've related hypertension to reduced white matter, reduced cerebral blood flow, brain atrophy.

And I'm doing more work with my colleagues at Pitt on adversity and obesity and trying to understand. Some of the neurocorolites and kind of possible some adverse you know, neuro-consequences of of states. And there's a lot of evidence to suggest all of these, all of these risk factors and indicators are related to altered cognition and altered emotional functioning and set a goal here is try to understand some of the neural pathways that link these risk factors to it's altered states of cognition and behavior.

I also wanted to say here that again, going back to a point that I made earlier is that like all of these health conditions

and risk factors are known to track a socioeconomic gradient.
>> As well. So we have a, a good base of evidence suggesting that they're related to brain function and brain morphology, and we have a separate body of evidence suggesting they track socio-economic gradient.

So, as an example of, you know, one study that we've done in, in this area, we've asked the question of, whether coronary heart disease risk factors that are known to tracked the socioeconomic gradient link indicators to socioeconomic inequalities to the structural integrity of, of brain, brain networks. And this is a study we published earlier this year.

So more specifically in this study we asked whether in conceptualizing SCS as a multidimensional construct. We asked whether different multi-level indicators of SCS relate to the integrity of, of white matter tracts in the brain. And then, if so, so essentially, like is there a main effect, is there relationship communicators of SCS and, and white matter integrity.

And then if there is this kind of relationship, what, what, what are the possible mediating factors. So here we turn to behavioral and biological risk factors for coronary heart disease, particularly those that are known to be associated with systemic inflammation. We ask whether these play a mediating, role, whether these serve as mediators.

So to address these questions we used available measures from a study that I've been conducting since 2008. So this is Pennsylvania. This is my county, Allegany County. And then this is Allegheny County blown up. And, these are all the different census tracts. And so, what I did in the study is we sent out randomized mass mailings to residents of, of census tracts in Allegheny County to try to get a representative of socio-economic distribution.

The initial wave of data collection was from 2008 to 2011. And we've been funded up through the end of 2016, to do longitudinal work. So, essentially my goal is to try to track the progression of, of pre-clinical atherosclerosis, and try to predict this progression. Based on a lot of stress related indicators, and brain function, stress physiology.

But, we do a comprehensive kinda socio-economic status assessment in all the participants who come through, so we're able to ask questions, with respect to you know, social disparities as well. This is called the Pittsburgh Imaging Project, or PIP, for short. It was my first RO1, and I had great expectations, so I called it pip.

>> It's true. So as part of, as part of pip, subjects complete like a multi-part protocol, they complete a lot of psychosocial inventories. So we get a socio economic status life events, personality and so forth. They do a num, they give a lot of blood. We take a lot of blood and that's because you know we're looking at standard cardiovascular risk factors like lipid levels, proinflammatory cytokines you name it fatty acids antioxidants, a lot of blood.

They do, they also complete a carotid artery ultrasound imaging protocol. So this is a non-invasive way to measure severity and extent of pre-clinical atherosclerosis in the carotid artery.
>> so, in this way, this is what we're viewing kind of repeatedly over time, to kinda track the progression of atherosclerosis as well.

And then finally, they complete, a fairly long battery of functional imaging tasks, a lot of which are meant to induce an acute stressful state. And then they do a lot of, we do a lot of structural imaging as well, to look at regional brain tissue volume and white matter tract integrity as well.

I should say a couple of other things that are important to keep in mind about this sample all of them are unmedicated. So we do, we want the healthiest people possible to rule out a lot of confounds of disease causing you know, something first and medication status. So all of them are unmedicated, none of them have any history of heart disease so none of them have been, ever been diagnosed with hypertension.

They never had a heart attack, never had a stroke. They go through psychiatric screening, so none of them have a confounded psychiatric disorder. We have, fairly okay African-American representation in the sample, even though Allegheny County is predominantly Caucasian. About 23% of the participants in pip are African-American. And then

I'll provide as I mentioned earlier.

You know, they provide blood. And they complete a lot of psychosocial inventories as well. Yes, question?
>> Given what you were saying about the non random distribution of cardiovascular risk factors, etcetera. This incredibly healthy group of participants from a representative distribution of Allegheny County, including the district. Aren't you potentially pulling for people who are extremely either genetically or, or behaviorally resilient against early signs of cardiovascular disease, because, they're up to 50 years old and they haven't shown signs yet.

>> Yeah, I would, I would say yes, yes and no. So I, I definitely believe that we're excluding, you know, people well below the poverty line. So in that sense I think, in terms of screening we don't have we don't have a truly disadvantaged, I think group of people represented.

So I think that there are like, some threshold issues. At the same time, these, these, the people who end up getting into the study tend to be relatively well educated, and of higher SES. Probably because you know, they've had opportunities you know, to engage in health behaviors, and you know, so forth.

The, the other end of ex, the other side to my argument though, kind of countering this is that, you know, you still see gradients across the SCS spectrum. So even, so we have a lot of people looking who have never completed high school, and you know, are kind of well below the poverty line, and we do have some people in there who were very well above the poverty line, and you know, were principles of schools, and have you know, are MD's and so forth.

So we're still able to see like linear trends but probably at the extremes of the distribution. We're losing a lot of those, those kinds of people. So I definitely like our inferences I'd say are limited in that respect. Yeah, good question.
>> You mentioned that Allegheny county is predominantly caucasian, but you wanted to account for diversity in your study.

>> Yeah.
>> Did you happen to include grad, socioeconomic gradients within each racial categories?
>> Yes, and no. So it's not a large sample, so this is 155 people. And also for you know, for unfortunate reasons Allegheny County is, is still fairly residentially segregated.
>> Mm-hm.
>> So, at the neighborhood level poverty and race are still compounded.

In many respects and we don't have the power to look at, like, within neighborhood, or within ethnicity gradients. Often times what we try to do to account for that is to see, like, whether the effects still hold only if you analyze you know, the caucasian, caucasians in the sample.

Does that make sense?
>> Mm-hm.
>> Good questions. Okay, so the main measure that we were interested in, in here is a measure of, of an indirect indicator of white matter integrity. So for those of you, this is for the one part of the audience the economists and so forth in the group.

We are using diffusion tensor imaging, which is a kind of structural imaging, a approach the quantifies the direction that water molecules go, flow in, in the brain. And DTI provides some indicators of the, essentially like the structural connectivity of white matter tracts that connect different parts of the brain.

And I'll explain a little bit more of this in the next slide. But the most common measure of tracked integrity, again, in quotes, is this measure called fractional anisotropy. So these, imagine these as like water molecules in the brain. If if water molecules, like in a particular part of the brain or in a particular voxel, or volume element which is, you know, that basically space in the brain that you can image.

Water molecules are going in all different directions it means that, there are not a lot of structural, boundaries or structural integrity like neural filaments an axons and milan. To prevent them from going in all different directions. And as water molecules start to flow more uniformly in one direction, that means that there are a lot of intact constructional barriers preventing them from flowing in all different directions and keeps them going in one direction.

So a lower FA value a value of zero would mean that water molecules are just you know randomly kind of diffusing in all different directions. And then high FA value a value of like one and would mean that the integrity of these white matter tracts is just relatively strong.

And there's some animal evidence showing that like milan damage and so forth kind of reduces FA values. And you can have some, some degree of confidence that, that these indicators are, provide kind of diffuse or gross indicators of white matter traffic integrity. And I should say, a point I'll return to a little bit later, is that, all of the risk factors that I've been talking about earlier like, like smoking, adiposity, systemic inflammation.

These have all been related in neuro-epidemiological studies with reduced tract integrity before. So this is kinda one reason why we were interested in using diffusion tensor imaging in this study. And our SCS indicators we looked at education here we're using years of schools as I mentioned earlier this is a fairly well educated sample, so most people completed about 17 years of school.

With the range being 11 to 24, still a fairly good range. We looked income as well. So, we did, annual household income adjusted for the number of occupants, the range, oh, I'm sorry, the medium was, medium bracket was 50-65k, with a range being less than 10,000 a year, so well below the poverty line for a lot of participants, and then above 185 for some, some participants as well.

And then again as I mentioned earlier this is, I'm becoming fascinated by what we can do with geocoding and geographical information analysis, but this is kind of, one our first is that kind of expeditions into doing kind of higher level SCS assessment. But what we did is we used geo coding to look at census tract information about, the median household income, in the census tract, where we're drawing our people from percentage of people on public assistance, percentage of people who are poverty line, percent unemployed, and then a percent without a high school diploma.

I think as most of you guys know, if, if you do a factor analysis, you get one score, you know, it all loads onto essentially like a deprivation factor. So these were the SCS variables that we were using in terms of the mediators what we looked at we looked at smoking status.

So a lot of our participants were never smokers some were former smokers, and then some were current smokers. We looked at waist circumference as a measure of relative adiposity. About half the sample was obese, with a pretty, standard range that you see in community samples in terms of waist circumference.

And then as a marker of stomach inflammation we looked at c reactive protein, a lot of you are familiar with this, it's a, it's a unique and very robust predictor of heart disease. And it contributes to kind of the independent prediction of and stroke, aside from standard risk factors.

All of these factors for the most part are strongly interrelated with one another, and smoking and waist circumference are thought to be kind of inflammatory stage of things that can contribute to systemic inflammation as well. In terms of results, as you can imagine our, our indicators of SCS were fairly intercorrelated with each other.

So education correlated fairly strongly with income, a little bit less with community SCS. And then income as you can imagine was, was fairly related, very strongly related to community SCS. In terms of, correlations between socioeconomic status and our risk factors, we see with lot, what a lot of other people see.

So, smoking was inversely related to education, income and community SCS. Waist circumference was negatively related, and marginally for income. But negatively related to our indicators of SCS. And then C-reactive protein as other people will we've shown. Other people have shown that it was inversely related to, to all of our indicators of, of SCS.

In our analyses, we used a toolbox that I was involved in developing with Tim Verstynen at Penn State. But this is an open source toolbox that any of you on the neuroscience side, if you guys are interested in this. It allows you to do mediation testing on boxilize basis with your imaging data.

And it uses the preacher and hayes approach. And we're extending now to allow you to do more kind of sophisticated path analyses as well. So in using the Bravo toolbox here's what we found. See there are, so these are cross sectional voxelized mediation maps. So what we're doing is we're looking at the indirect effects of education, income, and community SCS, on fractionally and exstrophy as mediated by smoking status and adiposity.

So smoking, if you can see, if kind of in red. Adiposity is in blue, and then this kind of magenta color is where they kinda overlap together. And there are a couple of take home messages here. One is, every single indicator, so education, income, and community SCS. All of those were positively related to white matter integrity.

So the higher your SDS on every, every one of these scales, the higher your white matter crack integrity. Okay, and conversely like, the lower the SDS, the less the white matter integrity. Both smoking and adiposity serve as mediators, statistical mediators of these effects, so essentially, like lower SES was related to lower white matter integrity through smoking and through adiposity [sp?], as mediated, and there were some areas where there was an overlap in these mediated effects, so if you do like a.

For the neuroscientists there's like a conjunction in their There were some parts of the white matter tracks but these effects did not converge. We looked at these all in independent analysis. When you put them all kind of in the same model you get a lot of competition and multi colinearity here, so it's, I can't make any inferences about directionality.

Because these cross structural data and I, I don't know who's the strongest predictor yet because we don't have enough power to, you know, proper multilevel modeling. Each of these, each of these indicators were related to white matter integrity and they were mediated by these factors. This is kinda of, breaking it down and not getting too bogged down into the details, which I am happy to go into.

Back up slides. But when, we looked at, relative effect sizes. the, the thickness of these, arrows is coded essentially by the percentage of showing these mediated effects, and it appeared that smoking status had, there were greater percentage of voxels showing mediation by smoking status to FA than there were for race circumference per se.

And this is when you put those smoking and race circumference in the same model. What was even more interesting is in kind of path analysis is we see reactive protein that was accounting statistically accounting for the effects of smoking on FA. Way circumference on FA in these white matter areas that we're showing meditative effects by all these SES indicators so essentially what we've done is we've kinda established at least a cross section of half way that those firms like SES that have opacity to smoking and see reactive protein.

To, to fractionally white matter integrity. So, if think these are interesting to me because as I mentioned earlier, we know this factors, so just to take one example is smoking status. There are lots and lots of studies showing the smoking status tracks gradient. You can do this with education, you can do this with income, these things emerge kind of fairly early in life, and persist, but I think with the setting I just showed you, kind of adds a neuro component to this, so what might be the consequence of neuro /u, gradients like this, and where is the brain scan.

In these risk factors, so just kind of an example of the, of the work that we're doing, I know kind of running out of time here so what I want to do is talk a little bit about some of the next steps and then open it up for, questions.

So I basically want to conclude by raising some questions and then talking about where I hope to see things going. So why care on the part of neuro science I think that it's important to care because chronic illnesses as I mentioned neuro cardiology has shown this chronic illnesses and risk factors for chronic illnesses might have a negative impact on brain circuits and we know that these chronic illnesses are socially patterned.

So I think, you know, to have a complete ideological understanding of things that neuroscientists and neuro-

epidemiologists might be interested in. I think it's important to account for this social patterning and same thing goes, I just kind of mentioned this, but even the risk factors, like smoking status, adaposities, stomach inflammation.

Those might have an impact on brain circuits, and we know that those factors are especially patterned. A lot of the processes and outcomes that neuroscientists, social neuroscientists, affected neuroscientists, cognitive neuroscientists, a lot of the processes and outcomes that are of interest exhibit disparities as well, I think it's kind of important to keep these in mind.

We're doing more and more. From a developmental and life course perspective, a lot of these associations merge early in life they persist late into life. So I think from a developmental and life course perspective it's also important to keep these disparities in, in mind. And then also, at a very basic level, you know, as a neuroscientist, I think accounting for disparities has implications for subject selection, generalizability of your findings, and even, you know intervention work that is being done in affective neuroscience and psychiatric imaging work, psychiatric neuroscience work.

so, oh yeah, and I think there's a point I made earlier, I think neuroscientist have opportunities to create. Ya know, to help build up models, to understand a, a major social problem as well. why, care on the part of disparities? You know scientists are why, why my sociol-,

sociologist's, and economist's and health psychologist's care. Well. Risk factors emerge from the brain, you know, so something like smoking status, there are brain circuits that contribute to habit formation, you know determining value of cigarettes and things. So, a lot of the risk factors that people are interested in from a behavioral perspective can be thought of as emergent from the brain and they can be considered along the pathways from socioeconomic status to brain to behavior to health.

So I think it's, in this way, that you know, caring about the brain, caring about neuroscience can contribute to a more mechanistic understanding of these pathways and two, two related points. I don't know if we're quite there yet, I think we need a lot more work in this area.

One is, I think, adding neuroscience evidence can also oftentimes be used, to better understand some of the preclinical ideology of disparities before, you know, disorders have kinda crossed the clinical horizon. So you might be able to see changes in the brain before you actually see, you know, a change or a prevalence or an existence of a full blown disease condition.

So my offer opportunities to kind of you know, aid in risk gratification and prevention. Daily, I don't know how quite yet. But I know we've been talking about this over meals, you know, maybe neuroscience evidence can, can sometimes help with policy justification, so if you can add You know, evidence that risk factors in chronic illness are impacting the brain, and you see these maybe early in life, maybe that kind of evidence can be more persuasive, sometimes to legislators and people involved in policy making.

So, what can we do? What can I. Well ultimately what I hope might happen some day, is a I'd like to see more encouragement of neuroscientists to have a greater interest in health disparities. I think it will be great if theres some mechanism like we, we're here together today.

If there were more opportunities like this to encourage disparity researchers to have a greater interest in neuroscience. Science. I think that would be wonderful. And I think what we need to be doing is thinking about you know, training grants and interdisciplinary opportunities for training for graduate students and post-docs who can speak multiple languages, you know, and understand the jargons of both fields.

I think that these are important because disparities are not going way any time soon, so these are life expectancy rates among Americans. At age 25 my education level, from 1981 to 2000. So this having any college and this is high school or less. 1981 all the way through 2000.

And what you can see essentially is, you know. Growing disparities that are expected to keep widening as inequality is continued to rise as well. So it's not like this problem is going away. I think anytime soon. So I think in these regards

there's a lot of room, for, for neuroscience to kind of contribute to our mechanistic understanding of some of it.

You know, the different pathways that are kind of considered. Along the way from this disadvantage to disease. So, think I'm out of time. With that, I'd like to thank my colleagues and collaborators and students who have all done wonderful work to help me. Made what I talked about possible.

I'm very grateful for the funding that I've received over the years for this. Okay. .
>> I'm Anne Stevens, the director of the Center for Poverty Research at UC Davis and I want to thank you for listening. The center is one of three federally designated poverty research centers in the United States.

Our mission is to facilitate non-partisan academic research on domestic poverty, to disseminate this research, and to train the next generation of poverty scholars. Core funding comes from the US Department of Health and Human Services. For more information about the center, visit us online at poverty.ucdavis.edu