



THE UNIVERSITY OF
MELBOURNE

Published on *Up Close* (<http://www.upclose.unimelb.edu.au>)

#368: Decision neuroscience: Emerging insights into the way we choose

VOICEOVER

This is Up Close, the research talk show from the University of Melbourne Australia.

ERIC VAN BEMMEL

I'm Eric van Bommel, thanks for joining us. When you make a decision about which airline to fly, who to hire for that vacant position or how to invest your savings, what's going on between your ears? Psychologists might look at how we form opinions or select actions as driven by our biases, emotions, memories or ability to reason. Philosophers might choose to focus on the rationality of our decisions, or whether we're acting from free will or the lack of it. Or we could ask economists, many of whom would argue it's not what's going on inside us that counts, so much as the outcome, the choice we finally do make that has real world significance.

But our guest on Up Close this episode, experimental finance and decision science researcher Peter Bossaerts, says there's much to be gained by studying the underlying neural activity, in the making of choices. By examining brain function in the moment of decision, with implications not only for economics and finance, but for neuroscience and psychiatry as well. Peter Bossaerts is currently Professor of Experimental Finance and Decision Neuroscience, in the University of Melbourne's Brain, Mind and Markets Lab. Peter welcome.

PETER BOSSAERTS

Thank you.

ERIC VAN BEMMEL

So Peter what's the value of studying how people make decisions?

PETER BOSSAERTS

Decision making defines who we are as humans, we often talk about free will and so we make choices in our lives, and the choices are as you mentioned a few at the very high level. Which airline to take, which investment to buy for retirement, but also the very very low level, what to pay attention to. In fact most of this happens unconsciously, and yet it's a choice that our brain makes whether to attend to one conversation or another at a cocktail party. Whether to, in the morning when you get up, first think about I'm going to brew some coffee, or I'll switch on the radio. All these are choices and we don't really know very much yet about how these choices are being made, and nevertheless these choices define who we are.

ERIC VAN BEMMEL

Now research into decision making has been particularly big in university finance and economics departments. How do economists conventionally investigate how people make choices?

PETER BOSSAERTS

Economists start with the outcome. They look at the choices, the decisions people make and then try to make sense of them. First from a rational theory point of view that if they try to write down what was the choice meant to accomplish, and then they construct a theory, and then check whether the choices correspond to or that normative theory would say. Later on the economists have looked at the deviations from that rational choice as we call this, and try to make sense of those. We do use in economics language that sounds very much like psychology, what's in people's minds.

Like for instance preferences, desires and all that, utility. In fact all this is misnomers for economists. Because at the end of the day it's only about choice, you just try to write down choice in the form of some mathematical formulation that more choice is the optimisation of some function.

ERIC VAN BEMMEL

There's that notion of homo economicus, or economic man, this idea of humans as rational agents, and that they're very narrowly self interested. We know now that it's not the case, but that's often times how the researcher's approaching choice correct?

PETER BOSSAERTS

That is correct and honestly this has helped enormously, to start from a homo economicus, a rational being, writing down first what should happen. If economists had been involved in studying vision for instance, they would first sit down and think what is vision meant to accomplish, rather than how do people see what are [photos] et cetera. So they would never go the photographic route, they would just first sit down and think about, what is it that you want to see. You would then of course derive from that, there is a lot of stuff you don't want to see, and we actually would know that the brain does exactly that.

It decides not to see a lot of things that actually are available, the photos are there, but the brain just doesn't care about those. Same thing with choice, you start with rationale choice, then you look at, do people conform to that, where are the deviations. When you study the brain, this happens to be extremely useful as well to study these parts of the brains are involved in executive function, or prefrontal cortex, or even the emotional parts of the brain, the subcortical structures.

ERIC VAN BEMMEL

So a lot of this conventional economic theory around decision making, seems to be one of the black box, which brings to mind B.F. Skinner and his Behaviorism. Where we're just looking at inputs and outputs and what goes on inside doesn't really matter?

PETER BOSSAERTS

Absolutely, economists are very much the old style Behaviorist from psychology. They only care about the choices and the only value of research is predicting the choices.

ERIC VAN BEMMEL

Yet many decisions in real life don't appear to follow the clean Behaviorist logic and often choices are not optimal. Let's pick apart some of these factors within decision making, risk and uncertainty, what do they really mean? Why are they important?

PETER BOSSAERTS

It's interesting you mention these two terms, risk and uncertainty as if they are different terms, and indeed economists have decided that they are different. Risk is a situation where you know the chances of the outcomes, you can just calculate them, because you can repeat the experiment over and over again. Risk is when you play

roulette game, you know the chance is that red comes up, black comes up et cetera. Economists have found very early on, that in conditions of uncertainty, that is in conditions where you don't see, don't know these probabilities, these chances, or you can't figure them out because the event is for instance going to happen only once. They then behave in a very very different way. Despite the fact that normatively you should just treat it as risk, you just pick a number.

If you don't know what the chance is, just pick any number and as long as your choices are consistent with that number, fine. But it turns out people are not consistent in their choices, and that's where the normative theory as a description of reality, start unravelling. That then leads to trying to merge, observed, irrational behaviour, what the standard normative theory. Trying to stay within the language of that normative theory, maximisation of utility, and writing down utility functions that actually could capture things like ambiguity aversion, or uncertainly aversion. I don't know the [probability], so I don't want to make a choice, basically that enriched the theory enormously. I think the high point of that exercise was Prospect Theory, with Kahneman and Tversky

ERIC VAN BEMMEL

Those two, Daniel Kahneman and Amos Tversky quite renowned behavioural economists. Right they were in fact psychologists. One of them won the Nobel Prize, for economy.

PETER BOSSAERTS

That is correct.

ERIC VAN BEMMEL

That was Daniel Kahneman. So we come now from basically conventional economics to behavioural economics, it's a slight shift here, it attempts to accommodate I guess people's biases and social elements, emotional elements as well, we're moving away from the strict black box model of conventional economics. Which is still out there, but we've now got behavioural economics, and this idea of Prospect Theory. So what are the key findings of behaviour economics, what have we learned from it?

PETER BOSSAERTS

I think the key element of Prospect Theory is the reference point. The fact that when we make decisions, we always compare the decision to some desired outcome or some aspiration point, some reference point. If you make a decision whether to buy

an investment relative to some reference point. Now the reference point could very simply be, I have already an investment for status quo and it's doing well. Whatever I'm going to buy now has to beat that reference point. The fact that we frame things relative to a reference point is key to understanding behavioural economics.

As a result over the last 20 years there's been quite a bit of work on exactly that. Unfortunately it's also the weakness because I can actually explain quite a bit of behaviour by manipulating that reference point, or in every choice situation, finding a reference point that explains what the person is doing, and what the consequences are. For instance in marketing, how you could use the existence of that reference point, to sell more product.

ERIC VAN BEMMEL

A key concept that came out of behavioural economics that uses that reference point is loss aversion, can you explain how that works?

PETER BOSSAERTS

In loss aversion, losses loom larger than gains. First when you talk about loss aversion, you actually have to have a reference point, because you can't define losses if you don't have a reference point. So in the old style utility theory, economic theory, there was no reference point, and so losses were not defined. It was just, you make money so you make less money or more money. Now where does loss aversion come in? Well if you set the reference point very high, so you have very optimistic expectations, then everything that's going to happen in the situation of uncertainty, almost everything is a loss. People stay away from it, they're averse to these losses.

You can manipulate this reference point and try to convince the decision maker, look, your reference point is wrong, you should be a lot more pessimistic to start from. Think about your past, you make the person more pessimistic. Then looking forward, a lot of the outcomes are not going to be losses anymore, they're going to be gains relative to that new reference point. Then the decision maker is going to go along with it and say yeah, I'll take it, because the losses are not there anymore. The focus is now different, it's pure framing. But notice, at the end of the day there is no difference, I didn't change the outcomes, I only changed the reference point. It's an issue of framing.

ERIC VAN BEMMEL

So where do we see loss aversion play out in the real world, can you give an

example?

PETER BOSSAERTS

In fact actually in a certain sense, a lot of banks are exploiting this with their so called structured products. They sell these complex investment vehicles, that promise people are very high yield, let's say 10 per cent, which nowadays is huge. Not more, not less, except in special circumstances if the price of some security, let's say Apple stock drops more than 20 per cent, it's highly unlikely to happen. We do know that it happens, but anyway, so it's unlikely to happen. In that case you love everything. That vehicle exploits this reference point thing, because now you set your reference point and you think about this yield is absolutely great.

The other phenomenon comes with loss aversion, is that in the gain domain when people look at the gains, they are satisfied with high gain like 10 per cent. They don't want to go way beyond that, except for real lottery tickets, when you can get \$1 million or something like that. But just 10 per cent is very nice compared to what you can get in the bank. Then they completely discount this low probability of that huge loss you're going to get. That's what banks have started to offer, already 10, 15 years ago, to real customer and you see this in many countries of the world, is extremely popular. That is where you can see Prospect Theory at work in the real world, when banks start realising that they can actually use that, we can tailor our products to this type of preference.

ERIC VAN BEMMEL

On Up Close, we're speaking with experimental finance and decision neuroscience Researcher, Peter Bossaerts, about how research in to human decision making is evolving. I'm Eric van Bommel.

So Peter we go from these conventional economic models of decision making to behavioural economics and then we add another layer here, the neuro layer in neuro economics, which is seeking a more of a biological basis to these economic theories of choice.

PETER BOSSAERTS

That's correct.

ERIC VAN BEMMEL

Now it's basically a biological approach, so what sort of methods are we talking

about? Are we talking about invasive methods, how do we see inside the brain?

PETER BOSSAERTS

Well most of the research in neuroeconomics is non invasive. So we use a number of imaging techniques, functional magnetic resonance imaging or fMRI for short, and that technique, what we observe is blood flow. Blood flows to parts of the brain that are active, because that's the way those neurons are nurtured after they have activated. Second technique we use is EEG, electroencephalogram, where you record the electric signals around the scalp. It's a technique that does not go very deep in to the brain, but has very good time resolution, so you can actually see brain activation change up to milliseconds. Then there's a related technique which is MEG, magnetoencephalogram, every electric current comes with a magnetic field, and what MEG does is picks up changes in the magnetic field around your brain, that are related to electric activity in the brain.

This is a relatively recent technique and has far better spatial resolution than EEG. These imaging techniques indirectly record activity in the brain. The point at first was to localise where are the decisions being made in the brain and then second how are the decisions being made. Really trying to dissect the biophysical process of decision making. Of course at one point it relates to invasive research as well, once you have animal model of these same choices, it turns out many other species make choices like we do, all the way down to rats and mice, zebrafish, they all make choices. To go left or right et cetera. They actually are trying to get some rewards and avoid losses and as a result there has been very insightful research by looking directly in to the brain of species, and especially monkey research and rats and mice, has been very relevant for neuroeconomics.

ERIC VAN BEMMEL

But when you're looking at things like neuron firing, that has to be invasive?

PETER BOSSAERTS

That is correct. You can do this with humans, you can actually look at neuronal firing in for instance epileptic patients. Because they have often electrodes implanted in their brain to understand better the origin of the seizures. You also have people with the brain implants because of depression, because of essential tremor or something like that. So we can actually take that as an opportunity to understand what's going on in certain brain structures, by looking exactly what these neurons or clusters or neurons are doing locally.

ERIC VAN BEMMEL

When you're doing this imaging, I imagine what, you're giving people tasks and you're observing what's going on inside the brain?

PETER BOSSAERTS

That is correct.

ERIC VAN BEMMEL

When you mentioned epileptics you're looking at people with perhaps abnormal brains, to use a psychology term, not a moral judgment here. Comparing normal to abnormal in terms of damage to areas of the brain?

PETER BOSSAERTS

Correct, in fact we have learned a lot from this. In my field finance, a lot has been learned about the role of emotions in financial decision making, that way I started in neurology in the late '90s, when two neurologists, Damasio and Bechara, looked at some of their patients with particular lesions in the orbitofrontal cortex. They realised that taking risky decisions or uncertain decisions that these patients did not have emotional anticipation of the outcomes. They would take these decisions without reacting to this. We would actually become anxious, we would start sweating, they would not.

At the same time they realised looking at their choices, that they made really bad choices, their financial decision making was very very bad. This is one of the key insights that we learned from biology, namely that emotions and reason decision making, are related to each other. Now that we actually know more about brain structures involved in reason decision making and the uncertainty, we know that indeed emotions are very important component of making the right decisions. When you're making decisions about uncertainty.

ERIC VAN BEMMEL

Would you include impulsivity as an emotion or is that more of a lower down, of a limbic sort of response?

PETER BOSSAERTS

I tend to use emotional language as a translation of some of the mathematics that we see. Impulsivity is discounting, you discount the future more, and maybe a good

reason why you went to discount more.

ERIC VAN BEMMEL

So that notion of discounting, I can offer you a chocolate bar today, here and now, I can show it to you, or I can say I'll give you two tomorrow if you're willing to wait. I suppose the more impulsive people will say I'll take the one now and pass on the two tomorrow?

PETER BOSSAERTS

That is correct, so you can say well, people are more impulsive than others, we will translate that in to a very cool mathematical term, which is you discount more than somebody else. This is true for many other things. If you obtain more chocolate than you expected, you of course are very happy, you're elated, you feel that emotionally. For me this is a positive prediction error, I'm sorry to be so down to earth but that's what it is.

ERIC VAN BEMMEL

A positive prediction error?

PETER BOSSAERTS

Right.

ERIC VAN BEMMEL

Sorry, where's the error?

PETER BOSSAERTS

Relative to what you expected. You had an expectation I will get two chocolate bars and I give you three. If I give you only one then you're going to be disappointed, right, and disappointment is to me a negative prediction error. The interesting thing is when you look at the mathematics of the neural firing in brain regions that are known to be connected with these emotional feelings, that's what is being computed exactly, at those spots. So there are a lot of terms that come out of the affective sciences, that have now been linked to particular mathematical concept. Where we have not found direct links yet is things like attention. Attention from my point of view

is also a choice problem.

Your brain chooses to pay attention to certain things at the expense of others. It turns out to be extremely difficult choice problem, something that would drive even a computer scientist crazy, or his or her computer crazy. Because their competitionally very very complex. Yet we seem to be perfectly capable of making relatively good attention decisions, not always and that we get in to ADHD, Attention Deficit Hyperactivity Disorder and things like that. But overall we are actually pretty good. So all these concepts that have been floating around in the effective and cognitive sciences, now are being linked to the mathematics of standard decision theory, the old economics. That helps us a lot in understanding what's going on in the brain.

ERIC VAN BEMMEL

So what does the role of the neurotransmitters here and particularly in neuroeconomic research, what have we found?

PETER BOSSAERTS

So this is a very surprising thing, personally when I started getting involved in neuroscience and trying to study financial decision making in the brain. Mostly out of curiosity, I want to understand what the biophysical processes are behind decision making and uncertainty. Before you know you're actually talking to people who are involved in understanding the core principles of how the human brain works. In particular neuromodulators, these neuromodulators, modulate the information flow in the brain, dopamine or norepinephrine, acetylcholine, serotonin.

If you're depressed you take serotonin uptake inhibitors like Prozac, well they are all involved in financial decision making. In a certain sense, if you talk to evolutionary neurobiologist like John Allman at Caltech, they will tell you well, but our brain the way it is now is very much shaped by an evolution, that requires us to be very very imaginative in uncertain worlds. A lot of things changed around us, and as a result uncertainty and risk are very much what the brain is about. As a result if you start studying financial decision making, it's not the same thing as studying language processing in the brain, or mathematics. How do numbers get processed in the brain, it's a very small part of the brain, it's almost something on the side.

Whereas financial decision making is really at the heart of the prefrontal cortex, cortical structures and subcortical emotional structures, and even all the way down to the brain stem, where some of the clusters are, where these neurons are, or even neuro modulators. So you start realising that within a couple of years, well I want to study financial decision making and you end up talking to psychiatrist about schizophrenia, Parkinson's disease, a beautiful example. It turns out main medications for Parkinson's disease have very strong side effects on gambling and financial decision making.

Neurologists are realising when they looked at some of our research, and said ooh we have a problem here. Because they are looking at the same neuromodulators, in that particular case it was dopamine, that we are actually looking at as well, for a completely different reason, for a [modish] reason. They started realising that their patients, by taking medication to boost the dopamine, actually had I would say an abnormal uncertainty processing.

ERIC VAN BEMMEL

People were not able to take account of the risks of gambling?

PETER BOSSAERTS

That is correct, a significant fraction of them become compulsive gamblers, or they take risky decisions that they would never have taken before. They would start skydiving and things like that, things that they never would have done before.

ERIC VAN BEMMEL

By removing the medication?

PETER BOSSAERTS

Then the physical problems reappear, but at the same time they stop gambling.

ERIC VAN BEMMEL

I'm Eric van Bommel, experimental finance researcher Peter Bossaerts is our guest on Up Close and we're discussing the emergence and the potential of the new field of decision neuroscience.

Peter, what is the effect of age on the way we make decisions?

PETER BOSSAERTS

To be honest very little is known about the effect of age. We of course know the effect of age on memory, executive function and so, but if you talk about choices, like in a financial context. Do people become more risk averse with age, et cetera, little is known. Although as we are speaking people are researching this, and they have found effects like an increased tendency to avoid risk as you get older. The researchers are trying to figure out where this comes from, there is a relationship,

again with dopamine, in this case it's dopamine receptors. It's on the side of the neurons that receive dopamine inputs as a signal, as to what they should be doing in the prefrontal cortex.

This is also related to genes, because the density of receptors in the prefrontal cortex, dopamine receptors depends on your genetic background. Depends on genotype, it's an area of very active research, but the jury is still out as to what's really happening. Because you can't just compare a 20 year old, 30 year old, a 40 year old, 50, 60, 70 year old today, and say look at their choices. They may have had very different life experiences and as a result you're comparing apples and pears. You would like to follow the 20 year old for the next 50 years, and see how that 20 year olds choices change, given environment, given the opportunities. By understanding the biophysics behind it, that you will be able to say a little bit more about aging in a more speedy way, you don't have to wait 50 years.

ERIC VAN BEMMEL

Peter, I'm interested in decision making in social context as well. I imagine a lot of these experimental tasks in decision making are about individuals performing tasks and being examined, observed or scammed. But what about in social contexts, where things like cooperation or competition come in to play?

PETER BOSSAERTS

Most of the research in the visual decision making, indeed is make people play games. A person is basically playing with a computer. However we try to bring in the social component in various ways. For instance by having another person make similar decisions outside the scanner in the room next door, informing the person in the scanner while his or her brains are being scanned, about these choices. Well there is no other interaction except that you see the other person make particular choices. We do know that indeed, as you suspected, that does affect your choices, in fact risk aversion changes dramatically depending on what other people around you do.

Risk aversion in the sense of your choice moves, it's not that your personality changes I think, it's just that when the subject is taking on a gamble, that he or she did not want to take on, after having observed somebody else take on those gambles. Then in fact we've started to understand neurobiology behind this, it turns out when you see somebody else make risky decisions, this changes your risk signals in the brain. That is your evaluation of risk changes dramatically. It's not that you see okay, this must be much more rewarding, no it's actually the risk that is being affected.

ERIC VAN BEMMEL

You've learned, you've observed the consequences?

PETER BOSSAERTS

Yes, exactly.

ERIC VAN BEMMEL

Now just going back to this timeline of decision sciences, from sort of conventional economics to behavioural economics, to neuroeconomics, to this new emerging field of which you are a founder of decision neuroscience. Where are we going with this? How does this emerge from neuroeconomics?

PETER BOSSAERTS

So in many respects neuro economics was a little bit of a curiosity, we wanted to understand how decisions are being made, but in the back of our mind was always the question is it going to be important for economics. Is it going to change the way economists think about the world. In the first generation of results, 10, 15 years ago, what we learned was that a lot of the mathematics that economists were using, maximisation of value function to represent the value of completely different objects. That this is actually almost literally what the brain does. So the mathematics that an economist would use to predict choice, is what the brain uses to make choice happen.

That's a very nice finding, but most economists would shrug their shoulders and say yeah, very nice, you spent all this money trying to figure this out. But you have not told us anything about choice yet. I think here is where things are shifting though. Because since we've gotten so much involved in biology, you talked to biologists, you start appreciating a part of biology that developed kind of in the pattern of economics, which is animal learning. In that literature, they look at choice from a very different point of view. Their theory is very closely related to biological processes that they can see. For instance dopamine, we talked about neuro-modulated dopamine before. It is known to be involved in approach behaviour in animals. When an animal, a mouse sees a reward, it provides a dopamine boost and it leads that animal to approach, to go towards it literally. Irrespective of any other inputs, it's almost like Pavlovian reaction.

This phenomena appears beyond what economists and psychologists observe that humans are doing, that actually humans are doing the same thing. But it's something that was not on their radar screen. For instance one study of risk aversion, we see some people not go after certain gambles, we would call them risk adverse, a psychologist would explain that as part of your personality, an economist would say this is because your margin [unclear] is decreasing, I mean it's all very

mathematical view on this. Lately we have realised in fact, that's got nothing to do with it, in fact it is because these people have less of a Pavlovian approach. Ageing comes in there as well, it turns out Pavlovian approach, goes down with age, people are not as much impulsively after the rewards. It also is related to your genotype, the genetic basis of risk aversion, does not have to do much with what psychologists and economists thought risk aversion was.

But it's what this biological concept of approach behaviour and the relationship with dopamine. Dopamine of course is where the genes come in, and as a result biology now becomes much more central to this and becomes an integral part of the research. So you will not understand people's behaviour, people's choices if you don't understand the biology. In other words you can't sit down there anymore and think about the way I start out this conversation. By saying, okay an economist when trying to study choice, you first sit down and think what is choice meant to accomplish.

From there you kind of do natural philosophy, you find out what the theory should be, and then you look outside, and go oh yes my theories are partially right. Where do I have to change my theories and you go from there. No, you actually want to start from observing, you see animals do certain things that you think this is really interesting, and this is related to biological processes. That aspect of it has to be brought back in to economics and behavioural sciences, and that's where decision neuroscience comes in to play.

ERIC VAN BEMMEL

Yet you work in a business studies department?

PETER BOSSAERTS

That is correct. But I think what we have learned, in terms of human decision making is of extreme importance, to people working in businesses. I mentioned a few examples earlier about how banks have understood Prospect Theory, and actually are exploiting this. Maybe not consciously but subconsciously. How market can use behavioural biases in order to improve their businesses et cetera. I want to be a little bit more constructive and actually hopefully one day we'll be able to use what we have learned, in this decision neuroscience, to teach people to overcome some of the cognitive biases in relationship with financial decision making.

I'll give you one example, we have a study now on the disposition effect, which is the tendency for people to hang on to losses and realise the gains too early. We are starting to find deep biological reasons why this is. Now you have to train people to get out of this, we think we have to do the same thing with traders, with investment managers, so that they are not subjective to disposition effect anymore. We've come to the point now after about 13 years of research on this, that we can go to the

practical implementation in thinking about development of tools and training techniques, using gamification, to help people in making better financial decisions.

ERIC VAN BEMMEL

Peter Bossaerts, thanks very much for joining us on Up Close.

PETER BOSSAERTS

Thank you, it was a pleasure.

ERIC VAN BEMMEL

I have been speaking with Peter Bossaerts who is Professor of Experimental Finance and Decision Neuroscience in the University of Melbourne's Brain Mind and Markets Lab. You'll find links and more details on the Up Close website, together with a full transcript of this and all our other programs. Up Close is a production of the University of Melbourne Australia created by Eric van Bommel and Kelvin Param. This episode was recorded on 20 April 2016 and was produced by Eric van Bommel with audio engineering by Gavin Nebauer. Thanks for listening I hope you can join us again soon.

VOICEOVER

You've been listening to Up Close. For more information, visit upclose.unimelb.edu.au. You can also find us on Twitter and Facebook. Copyright 2016, The University of Melbourne.

© The University of Melbourne, 2016. All Rights Reserved.

Source URL: <http://www.upclose.unimelb.edu.au/episode/368-decision-neuroscience-emerging-insights-way-we-choose>