89| Neuropsych Bite: Driving Simulators – With Dr. Tom Marcotte

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Speakers: Tom Marcotte, John Bellone, Ryan Van Patten

🔊 **Intro Music** 00:00

John Bellone 00:17
Welcome, everyone, to Navigating Neuropsychology: A voyage into the depths of the brain and behavior, brought to you by INS. I'm John Bellone...

Ryan Van Patten 00:26

…and I'm Ryan Van Patten. Today we give you our second episode with Dr. Tom Marcotte. Tom is a Professor of Psychiatry at the University of California, San Diego, and co-director of the Center for Medicinal Cannabis Research. This episode dovetails well with our most recent conversation with Tom, which was about cannabis and driving and was released on February 1. This time, we go into additional detail on driving simulators and their use in research and clinical work in neuropsychology.

John Bellone 00:58

This is our third episode that has addressed driving and neuropsychology, with the first being a conversation with Dr. Jennifer Davis on driving assessment and management in older adults with cognitive impairment. You can find that one at navneuro.com/07. The second episode on driving is the one that Ryan just mentioned on cannabis and driving with Tom. We're going to jump right into the content for this conversation without another introduction. So now we give you the discussion with Dr. Tom Marcotte.

🔊 **Transition Music** 01:29

Ryan Van Patten 01:38

So Tom, tell us about your research program using driving simulators.

Tom Marcotte 01:43

So I've been doing this for a few decades now. It actually started way back when I came to UCSD. It turned out, as you're probably aware, Bob Heaton is very interested in everyday functioning and the impact that cognitive impairments have. And I was at this research center and there was someone, I think it was at Scripps, who happened to be doing a real rudimentary simulator. When I joined UCSD, Bob Heaton said, "Hey, you should check that out, see what that looks like." [laughs] And that started a really strong interest in what driving can tell us about the effects of different cognitive disorders, including, in our case, it was HIV at the time.

So, over the years, we've built this program of research in which we get increasingly advanced driving simulators. Because driving involves, although it's very overlearned and rudimentary on many things, boy does it involve a lot of cognitive abilities from scanning, to paying attention, to sustained attention, etc. So it really is an interesting everyday functioning task, and something with profound

implications if you're not good at it. So, over the years, we built this. I did some on road studies where we took HIV positive people - so HIV is associated with cognitive impairment in a subset of individuals. And we actually took them on the road with a rehab instructor to see how they did on the road. Did some cognitive tests and did just driving simulator testing. So we sort of built that over the years and then in the last few years, the particular focus has been in looking at the effects of cannabis on driving performance.

John Bellone 03:22
I'm glad you mentioned the complicated nature of driving because it seems obvious, but I think it's underappreciated for many of us just how complicated of a task it can be. We forget about it. We forget about how complicated it is because we've made it routine. Often this comes up in feedback sessions with older adults, if we're talking about driving safety and they say, "Well, I've been driving since I was 16 years old" or however many years and decades they've been driving. It's not until we talk about the details of making a left turn and judging speed and the shifting attention that's needed, all these different cognitive abilities. It is a complicated task.

Tom Marcotte 03:57
Yeah, the human brain is amazing. [laughs] When you really think about it - you're doing 75 miles an hour down the freeway, and you're merging lanes. It probably gets driven home by all of us who've tried to teach our teenager to drive for the very first time. It's like, "Oh, my God. Look there! Look over there!" [laughs] Try to start teaching your brain to absorb these things, you start appreciating how complex it is.

Ryan Van Patten 04:20
Right. It's a risky activity. I think we, as a society, often underestimate that risk. Like, if I'm going on a trip and I'm going to take an eight hour drive to go on vacation, I consider that a somewhat physically medically risky thing to do as a relatively young, healthy person in my life right now. It's one of the riskier things that I might do with my time. Of course we can talk about clinical populations with cognitive impairment and how that affects their ability to drive, but a lot of people get in car accidents and are seriously injured or die. I don't want to preach but I think we sort of get used to it. We get accustomed to certain threats, driving being one of them, and the danger of it can be underappreciated.

Tom Marcotte 05:08

Yeah. One of the challenges is, in general, crashes and particularly severe crashes are just rare events. They're very low frequency. So one of the challenges of doing simulator testing is to do a lot of exposures to the types of things that will put you at risk. You can't necessarily map that on to someone having a crash because they are so rare, but it puts people in a lot of dangerous situations. So you want to try to help people avoid that. I will comment, now I can't think of the questionnaire or whatever, so this is just us talking, but there are some interesting instruments out there in terms of older adults and people in general, and trying to covertly get at whether they seem to be an impaired driver. Because sometimes we're either defensive or we're unaware that our driving has declined. So there's questionnaires that talk a little bit more about bumping into curves, if people ever told you maybe you're not driving as well as you could, and trying to get at these in subtle ways. If you're just interviewing a patient one-on-one or with a spouse who may or may not feel comfortable talking about these, you can do all these secondary indicators that maybe there's been decline that the person just may not be consciously aware of.

John Bellone 06:21

Right. Are there more dents and scratches on the car than there used to be? That kind of thing.

Tom Marcotte 06:25

Yeah.

John Bellone 06:26

How similar are the simulators to real world driving? How accurate is the simulation just in general?

Tom Marcotte 06:33

So the studies have shown pretty good concordance between driving simulators and on road. Now one of the challenges when we talk about driving simulators, there are a lot of different types of simulators. I mean, I've seen studies where they talk about driving simulation and it's just a projection on a screen and someone has to hit a pedal to break. We do more fully interactive ones but then our outcomes could be different than what other people are looking at. But, in general, when people look at things like swerving, there's not a one to one correspondence, this doesn't map directly on to what the real world is like. But I think simulators do a valid and good job of correlating with on road performance. To some degree, they may be a little more sensitive in some areas because, for example, using steering

wheels that are more sensitive, you may get more swerving than when you're driving a car that's more forgiving. So there are some differences, but I think the concepts hold true.

Ryan Van Patten 07:29

Can you describe what your simulator looks and feels like in more detail? Some people might wonder, is this a virtual reality experience? Or, in my mind, in some people's minds, they might picture some of the arcade racing games. Is that what this is? What does it look like?

Tom Marcotte 07:47

So ours has evolved over time. So I commented that I started many years ago. When I started, it was an old CRT that was, I don't know, 13 inches and the mountains were triangles and the cars were squares.

Ryan Van Patten 07:59

[laughs]

Tom Marcotte 08:00

One of my favorite anecdotes is our early research was on HIV, sort of highly educated gay males. People would come in and be a little disparaging of my new toy. They would say, "This looks ridiculous. You gotta be kidding me." [laughs]

Ryan Van Patten 08:15

[laughs]

Tom Marcotte 08:15

They would drive and within five minutes, I know I commented earlier that in five minutes they'd be looking over their shoulder to see if it was safe to pass. So as long as you get the feel and there's not a lag, the mind tells you you're driving. The people know they're not going to get into a crash and hurt someone, so that's a different aspect. But we started from those CRTs, we then went to a big screen TV, now we're in a three monitor system that kind of wraps around the person. So it's a console system where you have the three monitors, you have a chair that you sit in that feels like a car seat, and so your legs are at the same angle you'd be at in a car. It is interesting, when I, again, started, we'd do things at the desktop and [there was] pretty minimal risk of simulator sickness, or simulator adaptation syndrome. But once you go into our new simulator, boy, when you sit down in that and you just

start hitting the brake - it's a fixed base model, there's no motion, but your body feels you stopping. You can feel yourself lunging a little bit. The more you get closer to feeling like a car, the more your body believes that you're in a car.

Ryan Van Patten 09:26
That makes sense. What are the pros and cons of driving simulators compared to on road tests and a naturalistic assessment of driving?

Tom Marcotte 09:34
Yeah. So the obvious one is no one's going to get hurt so you can put people into risk situations. You can have them have to go through yellow lights, you can have some objects go out in front of them to see how quickly they break. There's certainly overall a lower cost than having to pay for a car and a rehab instructor to go out on the road. The limitation, of course, is that they're not the real world. People know that they're not going to get in a crash, that there isn't going to be damage. So they could be riskier drivers, potentially, by being behind the simulator. The simulator helps us do multiple sampling. We can test people however long we want, how frequently we want. Again, we did some on road - we didn't do a fixed track, we actually took people into city streets and on freeways because they all had valid licenses, even though they may have some declines in functioning, in this case, due to HIV. So it really lets you do a lot more intensive experimentation under controlled conditions.

John Bellone 10:35
Are there any challenges in demonstrating validity of simulators?

Tom Marcotte 10:41
One of the issues is that the ultimate negative outcome is a crash on the road and that is so rare. So it's hard to - you have to have huge sample sizes to do a simulator and then relate that to if someone is at greater risk on the road. Increasingly, we're getting better at developing instrumented vehicles where you can actually tap into the computer system of modern cars for like a decade now and get information on swerving and acceleration and speed and so forth. So some of that research is starting to be done but we don't have a lot of that. Kind of related to this I can say that I did a study a number of years ago, this was in HIV again, where we tried to predict on road performance. So the rehab instructor would take someone on these fairly complex drives and score them and also determine whether or not they thought they were impaired and not a good driver. We did a comprehensive neuropsych battery. So at our research center, we do many tests of

seven different domains and we also put people on a simulator. What we did find in that one study was that the simulator provided an incremental added explanation of the variance we saw in non-road performance. So all of these individual cognitive tasks were, "Hey, I'm going to look at learning. I'm going to look at, you know, Digit Symbol. I'm going to do all these individual tasks." That told us something about who would be at risk. Cognitively impaired people did worse on the road. But the simulator added to that. So there's something about the complexity of pulling that all together in a driving performance and making it somewhat real world that helped us better identify who was going to be impaired on the road.

John Bellone 12:20

I see. Do you remember which commonly administered neuropsych measures were most able to predict driving?

Tom Marcotte 12:28

So, in this case, we did a number of measures. So that's a great question. It's often an unanswerable question. In this case, it tended to be executive functioning. In terms of real world performance, executive functioning was the strongest predictor of people who had trouble with that. The challenge is that identifying an individual test depends on the disorder you're looking at and what kind of patterns they show. It depends on the outcome you're looking at. So, in this case, it could be an overall drive score, but if I looked at something specific, visual attention, scanning, etc, that might map better on to neuropsych. In general, I'd love to say, "Oh, it's Trails B." Or, "It's the Rey-O", or something like that. And some reviews have concluded that those are the best, but they're unfortunately by no means diagnostic in terms of identifying who's going to be at risk on the road.

Ryan Van Patten 13:19

Yeah, we're talking about driving and you mentioned ecological validity, real world application. We should let our audience know that you are a good person to be talking about this. You co-edited the book "Neuropsychology of Everyday Functioning" with Igor Grant, with a new edition coming out soon with Maureen Schmitter-Edgecombe. This idea of real world functioning coming from the perspective of neuropsychology is something you've worked on for a long time, especially driving.

Tom Marcotte 13:49
Yeah, my own bias is, obviously, it's one of the most important outcomes we care about and it's one of the most challenging, which also makes it one of the most interesting as well.

Ryan Van Patten 13:58
Yep.

John Bellone 13:59
Can you describe a few typical driving scenarios used commonly in research?

Tom Marcotte 14:03
So the most common ones are fairly mundane, but they work well because they're easy to standardize. We all kind of do our own thing. So one common outcome seen in driving simulators research is called the standard deviation of lateral position, basically swerving in your lane, a fancy word for saying that. One reason why people look at that is, first of all, there's been some really good research out of the Netherlands over the years that looked at different blood alcohol levels, looked at different effects of drugs. So they have a whole program of research looking at this in the real world on the roads of the Netherlands. They monitor how much people swerve. One thing that makes it nice is you get a nice continuous variable. It's very sensitive. So people look at this SDLP as a primary outcome. In our research, we've added a divided attention during that. So people have to look away from the roadway to do a task, like we all do, whether you're grabbing a cheeseburger inappropriately or looking at your phone, etc. People do that. So how well do people monitor their safety while they're driving? Another commonly used scenario is something called car following where there's a car in front of you and it speeds up and slows down very subtly, you can't really see it. We monitor how well you correlate with those car changes. So it gets to your ability to sustain attention. It also has a nice outcome because it's nice and continuous. One of the challenges in driving, but even more generally in everyday functioning, is that failures so often are sort of yes/no things. The more you try to get something that's analyzable and a nice variable to work with, you want to get away from just dichotomous yes/no. These outcomes I just described work well. We also look at things entering the roadway. I look at people merging onto a freeway. We put people into situations where a light turns yellow, we call it the amber dilemma. And should I go through? Should I stop? You have a split second to make that decision. So those are some of the things we look at. But for consistency usually the SDLP and car following are the standards that people look at.

Ryan Van Patten 16:13

We had a previous conversation with you about driving simulator research in cannabis users. Are there particular clinical populations where this tool, the driving simulator, is especially useful?

Tom Marcotte 16:24

So I don't work with a number of other populations but I know there's a lot of research going on in aging, normal aging as well as issues such as MCI and Alzheimer's disease. It's been a robust area of research in terms of subcortical disorders - Parkinson's disease and multiple sclerosis. It just happens that a lot of people I know use similar simulators in those. So there's been a couple of areas that it's been most robust. Obviously, there's a strong interest in the effects of medications, both illicit substances or even prescription medications. I know there was talk that the FDA was going to require all new medications to do some kind of driving real world evaluations. I don't know how that panned out or not, but really trying to get at, "Okay, do people become impaired?" Because there are many medications that affect us and we often don't appreciate it. There have been studies looking at people starting antidepressants and showing very early on as they acclimate to their antidepressant they have reduced driving in those first few weeks. Drugs such as Ambien actually have a blackbox warning. If you take long acting Ambien, you shouldn't drive the next day. Most people don't follow that, I'm sure. But I think there's a growing appreciation of the effects of the medications we use to treat different conditions on affecting safety.

John Bellone 17:47

Yeah. It doesn't even have to be a substance or a condition, it could just be being under slept.

Tom Marcotte 17:52

Yeah.

Ryan Van Patten 17:52

That's a great point.

Tom Marcotte 17:53

Fatigue is huge. Yeah.

John Bellone 17:55

Do you have any pearls of wisdom for clinicians who are having those difficult feedback sessions with patients talking about driving safety?

Tom Marcotte 18:05

[laughs]

John Bellone 18:06

I'm putting you on the spot here. [laughs]

Tom Marcotte 18:08

Well, I mentioned earlier, perhaps even doing these questionnaires where some patients may suspect it and some people may be in complete denial. Doing these kinds of questionnaires where both the person talks about their own experience, whether or not people are starting to say things to them, whether they're having little fender benders, whether they're hitting the shopping cart in the mall, etc, may help give people guidance. The more they can see it for themselves or get feedback from significant others is helpful. I know one thing that occupational therapists do is use these simulators to let people actually then play back and see how they did. Many of our simulators have that capability. So we may use it for research, etc, but people can use it for interventions both to improve driving but also to have people see that maybe they're just not paying attention or not aware that they're having these problems. In a simulator, you may think, "Oh, my gosh, that came out of nowhere. That was not fair." And then if you play it back, you could show the person that, "Well, no, actually, you should have been able to anticipate that this was going to happen." I know a lot of neuropsychologists don't have access to that. I don't know what the status is now in terms of OT, but certainly the rehab centers that are here in San Diego I know a number of them use the driving simulator.

John Bellone 19:30

Yeah. I'm also connected to a rehab facility and there are occupational therapists doing these evals. So I very commonly refer for a formal occupational therapy driving evaluation. Do you know, not just in your facility but in general, what those OT evaluations look like? The types of simulations they use? I know this is such a broad question.

Tom Marcotte 19:53

I don't have those details. I know they tend to use a simulation and of course they do real on road driving. I've driven with some of them. Some of them, for some reason, kept critiquing my driving, [laughs] which is a little upsetting.

Ryan Van Patten 20:06

Uh oh.

Tom Marcotte 20:08

As I drove people around to say, "Okay, this is the route we want to use", they kept reaching over to the steering wheel. [laughs] So maybe that maybe that's a sign but I'll push that down and ignore it.

Ryan Van Patten 20:18

[laughs]

John Bellone 20:19

I hope you weren't high at the time. [laughs]

Tom Marcotte 20:20

Well, no, no, no, I was not. [laughs]

Ryan Van Patten 20:22

[laughs]

Tom Marcotte 20:23

No, it's, anyway. But, yeah, I know they try to do multimodal, real world driving, some testing, etc. But, yeah, I'm not well connected to that group.

Ryan Van Patten 20:35

I'm curious about your thoughts on the timeline of automation, self-driving cars. How long will driving research be relevant to society as we move toward AI driving?

Tom Marcotte 20:47

As of right now, I don't have to worry about my career, about it coming before I'm long retired. You can hear news stories that it's supposed to be here this year. I mean, the big companies [are] saying it's going to be here in 2021. Now people are

talking| about 2023. The reality is that I think it's decades away because, ultimately, for it to be widespread and get widespread use, you have to have interconnectedness with all these cars, communicating with each other, etc. I do think that driver assistance is terrific, and the things starting to warn you that you're crossing lanes and how to park and all of those. I think those will be really helpful for impaired drivers, and maybe help people stay on the road longer. They may have ultimate self-driving cars for a small segment of society. But I think before it becomes really widespread and we can not worry about this, we're probably decades away.

Ryan Van Patten 21:42
That makes sense.

John Bellone 21:43
You had said something earlier about, with the Internet of Things we're more and more connected and getting more data from different devices - the refrigerator telling you how many times you opened it, and cars are going to also give us more and more data. So I can also imagine that that will be incorporated into our considerations about driving safety. There might be a measure, it'll be an app on our phone that tells us how much we were swerving or how fast we were going relative to the speed limit and others around us.

Tom Marcotte 22:14
Yeah. So that 's actually a great point. That brings up another issue, which I know some groups are starting to talk about because of the information you can get from your car, that perhaps the more we can monitor that we might be able to detect people starting to suffer impairments or decline earlier than, "Hey, I pop into the physician once a year and get a mini mental." We'll have to deal with privacy and all these really important issues, but perhaps over time that might be something that's a complex cognitive task that you could wire into better well before we have self-driving cars. It may indicate where people are starting to show some declines.

John Bellone 22:54
Right.

Tom Marcotte 22:55
So I posit this has been put out there.

Ryan Van Patten 22:57

There are other applications of that, too. Natural language processing might be checking your text messages or phone calls. Obviously, like you said, privacy is a big issue here, but there could be ongoing monitoring through technology machine learning to detect early cognitive decline, for example. Car driving would be another way to implement that.

Tom Marcotte 23:17

Yeah, at the risk, and you can cut this out [laughs] but yeah, at the risk of self-promotion, the second edition of our book has a new thrust going that way. We have a number of new chapters talking about naturalistic studies and biosensors and so forth because that really is the wave of the future. I think it's really important and still problematic. It takes a heck of a lot of work to analyze all that data and make sense of it and so forth. But, clearly, this is something that I think will help us much better track when people are declining or hopefully improving based upon different treatments.

John Bellone 23:53

I can see simulators still being useful, though, because you're able to manipulate the environment and standardize the environment too for research purposes. So even if we are getting more data, the simulators probably will be here as long as we're actually doing the driving.

Tom Marcotte 24:08

Yeah, I absolutely agree. I mean, I think naturalistic driving where you not only take what comes from the car but you can add some other instrumentation that tracks how people are doing is really important. But, again, as you know, without standardization, ultimately you end up quite often with just anecdotal findings. You can talk about certain situations that happen. To actually do group comparisons, etc, it takes an awful large sample size.

Ryan Van Patten 24:35

Agreed. Well, thanks again so much for your time. This has been awesome.

🔊 **Transition Music** 24:43

Ryan Van Patten 24:43

Well, that does it for our conversation with Tom. Be on the lookout for upcoming content on autism with Sir Simon Baron-Cohen, culturally informed neuropsych evaluations with Daryl Fujii, neuropsych interventions after acquired brain injury with Dana Wong, working memory with Alan Baddeley, and additional clinical case presentations. And, as always, thanks so much for listening, and join us next time as we continue to navigate the brain and behavior.

🔊 **Exit Music** 25:13

John Bellone 25:37

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Ryan Van Patten 25:49

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