

Written Transcript
On The Line Episode 2.3 “Decision Making, and Cognitive Function”

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Charlie Palmer: Episode three, welcome back On The Line. We are joined today by Dr Chuck Dumke from the University of Montana and then we're honored to have as our other guest, Michael Williams Bell from Durham College in Canada. Michael's here for the International Association of Wild Land Fire Conference that's been in Missoula all week and we thought this was a great time to be able to grab onto him since he's in town to kind of talk about some of his expertise and how that aligns with some of the work that's been done at the university since 1990. We lose about 17 wild land firefighters a year to line of duty deaths. There's obviously a very large number of injuries that also occur over the course of a fire season, so it's very accurate to say that wild land firefighting is a high risk occupation. Since it's a high risk occupation. Then that places a real importance upon decision making and since decision making is so key, it's a pretty close and short jump then to cognitive function. So how well do we think out on the line and then what sorts of things impact that cognitive function. So Chuck, what can you tell us about cognitive function and what we know from a research standpoint on it?

Chuck Dumke: Well, I'm going to, I'm going to leave a lot of that to Dr Williams Bell, and I'm going to be calling him Mike from now on, but it's interesting at this conference, you know, we got a lot of information. And there was some presentations about the fatalities and injuries that you spoke to and how they happen at the end of the day and at the end of a 14 day shift. So there is a lot of physiology that can affect decision making specific to the wildland firefighter. Those things can be getting hot, you know, heat related, heat stress. They can be wood smoke inhalation, they can be blood glucose changes going long periods of time without eating. They can be sleep deprivation. We haven't touched on all of those things, but the forest service came to us a couple of years ago and was interested in how perhaps woodsmoke can have an effect on your ability to make decisions and the cognitive functioning and so we designed a study and in fact we created a pulmonary core here at the University of Montana and we made a little bit of reference to this in one of our previous podcasts, but we didn't touch a lot on the sort of cognitive piece from that. So we are able to actually fashion a way for a subject to be walking on a treadmill and inhaling wood smoke from a woodstove that we could control to very specific PM particulate matter, and carbon monoxide inhalation. So we did that and we

mimicked what a lot of wild land firefighters experience both during controlled burns, prescribed burns and actually on the line. And we looked at a lot of different things and we... It was kind of a shotgun approach to be honest with you. We looked at physiology and lung function and oxidative stress and a lot of different things and those were touched on previously, but that's where, you know, you and Dr Williams Bell, Mike over here brought in this measurement for cognitive function. And to be honest, I'm going to hand it over to him to speak a little bit more about those results.

Mike Bell: Yeah, thanks a lot. Chuck. So in terms of what we were measuring and looking at traditional standard kind of cognitive function tests and for the most part what we found was that there were no changes. There's no detriments, following the different levels of wood smoke exposure that you spoke to. So that was, I would say somewhat surprising initially, especially with some of the anecdotal evidence saying that maybe as you mentioned, some of the parameters with sleep deprivation and all the other kinds of physiological variables that go in. My expectation going into it was we would see some decrement. We didn't see any decrement, which I think to me it was quite surprising. Um, and we can talk about later, but what, maybe the reasons about that were, but at least as a whole, initially it was quite eye opening that there wasn't a whole lot going on. And it made us think kind of, well, did it have to do maybe with exposure times durations or exposure levels and maybe you just have to do with, you know, when they actually get out into the actual wild-land event or actually on the line per se, versus a simulated sort of exercise intensity on a treadmill.

Chuck Dumke: Yeah. To give a little bit more information about that study so that we can maybe speak to the why's afterwards. You know, we tried to control for a lot of the things that I just spoke to. They only exercised for 90 minutes because these people were breathing on a mouthpiece, that smokes. So it's not like we could mimic a 12 day shift out in the field. So we tried to mimic a lot of the things that can control cognitive function. We eliminated the blood glucose effect by having them fasted. They only exercise for 90 minutes because they had to breathe in this smoke continuously. They had a break to drink once in a while, but no eating and they were walking at a speed and grade that mimic the energy expenditure that wild land firefighters do out in the field. So we did our best and that's what we can do in the lab and why we went to the lab first was to try to be able to control all those factors that can get into the cognitive function. Now the measurement tool that you guys used, right? The CANTAB is this kind of process by which you can decipher a lot of different things about that. You can speak to better than I, but it's a long test, right? It can be what? As long as an hour...?

Mike Bell: Can be. Yes. I think if you do the entire battery, believe it's upwards to 20 tests can take upwards to an hour to complete.

Chuck Dumke: So you know the process of getting these subjects in and out and the test before and the test after we were doing like for hour trials. Right?

Mike Bell: Yeah. And that's a good point, and in terms of, you talked about the CANTAB and the types of tests, so we can look at things like executive function, which is a little bit more higher level, I guess cognition, reaction time. We looked at attention to how vigilant are you as well as working memory. So how well are you able to process information that's coming in, storing, managing, and then trying to use that to complete a task. Uh, so those were the different levels. So I would say it was a quite a large component of cognition. When we think of cognition, we, we kind of use that term, I'd say open-ended sometimes, but there's lots of factors that go into it. And in the end when the lab based, as you mentioned, chuck, with all the different, of controlled variables that went into it, we didn't see any decrements in each of those different kinds of domains of cognition.

Charlie Palmer: So methodologically again, we talked about it on the Woodsmoke podcast. Chuck, you mentioned that they came in the subjects. We tested them beforehand cognitively then they walked on the treadmill for 90 minutes at three and a half miles per hour at 5.7% grade...

Chuck Dumke: good memory

Charlie Palmer: ...and then 30 minutes after they got off the treadmill we tested them again with the exact same battery. It's called CANTAB, as Michael Just said, there were four subtests from that CANTAB battery, they're tablet based and so those tests are on a computer screen. Basically asked the subjects to do certain things. Hopefully tapping into what Michael said, executive function or cognitive function.

Mike Bell: And that's a great point and you mentioned Charlie there. They were measured 30 minutes post and that might be one of the reasons we maybe didn't see something in terms of something called washout effects or that whatever was happening during the exercise with the woodsmoke. Maybe it happened after 30 minutes. We don't see the same levels of intensities or what was actually acutely going on during that exercise and we've seen that structural firework previously as well.

Chuck Dumke: So one of the reasons why I was 30 minutes after just to explain to the audiences that we were doing other things with the subject, right, we're taking their blood, we did pulmonary function testing that look at how their lungs were working and so it's not like they were just sitting around for those 30 minutes before they did the cognitive test. But you know, to touch on these other factors that could have explained the said no difference, so to speak is something that gets unaccounted for is the sympathetic nervous system effect. You know, a lot of people know of it as the fight or flight mechanism. Right. And the exercise right is going to increase that sympathetic nervous system drive as well as a lot of stress hormones and those can be and equate to heightened awareness. So you know, as a result of doing the exercise and it was not super strenuous, but for 90 minutes they were walking at a pretty stiff pace that could have masked any of the perhaps negative effects of the woodsmoke.

Mike Bell: yeah. Agreed. And Chuck and then I think there's quite a bit of research out there showing that upper end of lighter to moderate exercise that we do see improvements in cognitive function, so that as I mentioned the whole arousal level that you're actually getting more aroused in a cognitive sense and improving your performance to a level that actually going to help you. And we see that in athletes, right? We definitely see that in sports performance too. Where an athlete after warm up and after they're getting into the sport, they are elevated kind of physiology, but they actually perform a lot better and then it gets the point where if you too much arousal with. That's where we start seeing some of those declines. So you make a good point in terms of the exercise effects in the sympathetic nervous system kind of effects.

Charlie Palmer: And one of the other things that we talked about was perhaps the smoke concentration wasn't high enough to elicit any kind of cognitive impairment. There was 250 micrograms per cubic centimeter or 500 micrograms per cubic centimeter. There's some research out there that suggests that wildland firefighters might be and are exposed to higher amounts operationally and as you pointed out, chuck, those operational shifts are going to be much longer than a 90 minute bout like we had in that specific piece of research. So to try and learn some more than about potential cognitive impacts. We did another study of free range chicken type of version or more what's happening in the actual field in terms of what a folks look like pre shift, post shift after they've gone out and worked and are there any impacts on cognitive function in that type of scenario. And so Michael, collectively you and I kind of gathered some data on that and that's why you're here at the conference this week is to present some of those findings. What can you tell us about that field based research?

Charlie Palmer: Yeah, Charlie, it was a study that, you know, looking kind of furthering this, as chuck mentioned with the lab based, we can control for a lot of different things. We can try to mimic the exercise, mimic the workload, but control for a lot of the other factors were in the field. Now it's their daily job. We're not controlling, we're not saying, hey, don't do that, let's do this or you can't do that. We're letting them do their job and we're taking the cognitive measurements. Again, pre work shift and and post work shift and in that case we looked at three different tests. We looked again at the executive function, reaction time, and that working memory task and in this case post shift. We didn't see any decrements and we saw some small improvements in some cognitive factors as well. So again, the thought was after a long work shift, maybe upwards of 12 plus hours, we would see some decrements in terms of maybe fatigue, but we actually didn't see any decrements and small improvements in certain aspects of cognition.

Charlie Palmer: Yeah, in a good sample size, we're talking 57 folks, primarily males, but some females, primarily hot shot crew members, but some type two crew members, a large sample and some pretty good stats in what again, one of those maybe head-scratching findings and that I think there's just this common assumption that at least from many that you go out and you work and you work a long hard

shift. You're not going to be a sharp at the end of it as you were before you came into it and yet from what you described as the findings, pretty interesting. They're scoring even better at times after the end of a long hard shift and what do you make of that?

Mike Bell: No, it's a great point. I would say some of the improvements that we did see were small that you could argue, Is it actually a physiological improvement or just strictly. It's the numbers. It's what statistics come out and show you, but I mean there's a multitude of reasons it could go back again to that the work shifts itself increases that arousal. There's also in the morning they're being tested. I believe it was in the 6:00 AM, 7:00 AM range, so potentially, you know, most people I'm sure when they wake up in the morning, I know, I sure am. I'm kind of groggy. I'm not exactly as alert as I would feel later on in the day. So that could play a role into it. So we might see that just their job demands increase the energy level increased that arousal so maybe they actually are performing better after their shift or you know, throughout depending on what they're doing. But after a shift they may have actually got that sort of improved performance.

Charlie Palmer: Yeah. And encouraging finding I think or an intriguing finding and that wow, again, despite these really difficult circumstances that folks often times end up working in, they seem to be still pretty sharp at the end of the day, which as we all know, is oftentimes commensurate with an increase in fire behavior late in the day. So kind of an intriguing finding.

Mike Bell: Oh exactly. And I think for a lot of times there's researchers were going in, we expect to see a significant difference. We know publishing information is they want to see journals, want to see significant differences and changes, but I agree with you Charlie, that the end of the day, if we don't see a change, it's actually a beneficial thing when we talk about getting out on the line and actually implementing in the occupation itself.

Charlie Palmer: Yeah. And then you mentioned that some of these differences were statistically significant improvements, better performance at the end of the shift, but it equated to milliseconds.

Mike Bell: Correct.

Charlie Palmer: Which in an actual context is quicker than the snap of your finger. So does it really mean anything?

Mike Bell: Yeah. You're looking at in two of the measures, 20 milliseconds and about 60 milliseconds improvement. So when we talk about the time it took to make certain decisions, so you're right from a functional or an operational standpoint, is that a huge improvement? But I think the major thing is that we didn't see decrements. We didn't see any decline in their cognition afterwards.

Charlie Palmer: So how do you think people are able to do that? What comes to your mind then? As far as, okay, we're. We would expect to see decrements maybe, but we didn't. In fact, we see improvements. Why?

Mike Bell: That's a great question. I, I think, as a whole, there's probably a lot of factors that go into that. But there is that argument where being on the job, being on the line in a actual environment, in the anxiety levels, the arousal levels are going up that it could counteract any potential decrements that we think we might be seeing. So just the fact that they're engaged. We see it in the structural firefighting world quite a bit where we provide a task and it might seem like a very remedial tasks, but the anecdotal evidence we get back is that I'm focused. You gave me a task, I'm going to do that task. However hard or easy it seemed, but the attention and the focus seems to be really, really heightened compared to maybe before shift where they haven't gone through that yet.

Chuck Dumke: So as Charlie mentioned, you presented this at the, at the conference here in Missoula this week, and you got some feedback about possible other ways to analyze this and also possible other tests you might perform. So can you speak to that, like perhaps shift type or day of shift or different IHC's do you have any hint as how that might affect those results to that?

Mike Bell: That's a great point. Right now the data that we're discussing today and at the conference was kind of the aggregate of all, as Charlie mentioned, 57 firefighters. So whether they were actually at a burn or if they were doing some sort of special projects that day that's all into one. So the next step would be to to tease out that information, look at different crews, look at time of day, day of a shift that they are on and started of building smaller groups or smaller cohorts and looking at the data that way. Because what happens is maybe we do have, you know, significant difference in one group and an a non-significant difference or an improvement in another group. But when we put them together, It's going to wash out. So it'd be good, now moving forward to kind of look at the different, as you mentioned a check, some of the different groups are some of the different aspects of who was doing what job on, on what day would that they were tested.

Charlie Palmer: Where else do we head in the future, what, what else needs to be done to shed some more light on this?

Chuck Dumke: So, you know, as you pointed out, the limitations of a lab based study, we can eliminate woodsmoke as a potential contributor to cog function. And as Mike just pointed out, you know, a shift, it might depend when that shift is, it doesn't jump out as a, as an obvious effect on cog function, but we can't eliminate it either. Um, you know, it might depend when that shift falls. Another thing that wildland firefighters experiences heat, right? Heat related illnesses. We presented some data here at this conference where the early hike in the ingress hike is potentially when wildland firefighters get the hottest. Of course we do a lot of lab based studies where we have a climate chamber where we heat people up and I can tell you they get really ornery when they're hot. We don't

always have a cognitive measure when we're doing those lab based studies, but I know Mike has done some of this stuff up in Canada and we also know that a lot of times the incident reports of heat related illnesses, correspond with potentially bad decisions and so maybe Mike can speak to a little bit of some of his both lab and field. Um, and he hasn't shared this yet, but he does a lot as well with structural firefighters, which is shorter duration, higher intensity, higher heat, etc.

Mike Bell:

And that's a great point, Chuck. And then that was initially how I got into the cognitive world was that question from the fire service. They were doing training, they were doing air management training. So looking at with their breathing apparatus, how long can we work? They were traditionally thought of as 30 minutes cylinders, but we know different ventilation rates, how heavy you're breathing is going to change and what they were finding. We had captains and training officers coming to us and saying, we have captains who are running out of air going back into a scenario, so that's what brings up that point. You mentioned with there could be injuries happening because of poor decisions and there was why are they making this poor decision? We didn't know and one of the thoughts was heat stress. So we. We did conduct a lab based study in a climate chamber where we looked at how does core temperature, so your body's internal temperature as it increases, does that affect your cognitive function? We actually found with structural firefighters that in terms of their working memory and when they called visual memory or visual learning, so being able to see basically you're seeing an object on the screen and being able to recall where it is on the screen afterwards. We actually saw a decrease or decline in cognitive function when their core temperature at 38 point five degrees celsius and from a physiological standpoint, that's not exactly a level where you're going to see, oh, we need to get you out of a fire. It is elevated. It might be considered a warning sort of level. It's definitely not a red stop. We need to get you out. And yet the firefighters reporting, I still feel fine. I'm hot then to show them that you actually performed worse on those cognitive tests. So that was interesting from a structural standpoint and as you mentioned though, you know, higher intensities that or clothing, they're protective equipment is multilayered, it's thicker, so they're definitely storing heat probably at a higher rate, but it's still a core temperature level that you would see in wild land. And then that translated to some of the work. I collaborated with them in Australia, deacon university where we looked at wild land in very hot conditions, so 45 degrees celsius. And based on the structural work we assumed, oh we're going to see decrements. This is 10 degrees celsius higher, you know it's going to be worse. And what we found that there was no difference in cognitive function. So that was a head scratcher was why is there no difference? But, what we sort of determined was, as you mentioned, the PPE is lighter, the work intensity wasn't as high and also when they were doing the cognitive testing unit, 45 degrees celsius, their body was cooling. And when I say cooling, I don't mean it's getting cold, but just so we had maybe worked up to 38 point five, 38 point seven, but when they're doing the testing, they were actually coming down even in 45 degrees celsius. So that was one of the differences that we thought, well maybe that's the difference in the structural.

They are actually getting hotter as they were conducting the, the cognitive testing.

Charlie Palmer: In that study that you referred to initially with regard to the structural world. Those folks, we're getting audio alarms that they were low air, right? And they were passing that audio alarm and still making poor decisions to go back in in a training scenario, but to go back into a very, very dangerous spot. Despite the fact that they were getting negative feedback from an alarm system, that they were almost out of air. And that kind of prompted the initial question. Correct?

Mike Bell: Exactly, and at that time the low air alarm was 25% of air remaining and in terms of their standard operating procedures and structural, that's supposed to be an emergency scenario. That's not your cue to get out of the building. You should be out before that alarm goes off, so you're right there alarm and it's loud. You can't ignore it. If it gets going off, you hear it, you hear it. If you're a few blocks away basically. So you're right they were getting negative feedback, but yet they were still making some decision to say I'm going to go back and you're right. Even Though it's a training scenario and yes there's no risk of injury or fatality, but they're supposed to be treating it like a real scenario because we all know that if you train incorrectly, when you get out into the actual fire or the actual emergency are probably going to relate to those experiences.

Charlie Palmer: You're going to revert right back to your training. And then the other thing that we've talked about kind of in our pre meeting here, was sleep, obviously getting good quality sleep in a wild land fire setting can be extremely challenging. From some research that we've done a few years back. We know that folks average about six hours of sleep a night, but that there are many who average about three to four hours of sleep, uh, and again oftentimes on the ground in a tent in difficult, noisy, complex environments. And so clearly sleep has got to be having some sort of role to play in, how well we think in our cognitive function. What do you guys have for that?

Chuck Dumke: I'll just add altitude to your list of things affecting sleep, you know, oftentimes wildland firefighters are up at altitude and that can inhibit their sleep. So there's lots of things working against a wild land firefighter, getting good sleep. I however can't speak a whole lot to sleep in the cog function.

Mike Bell: So we've looked at the group I was working with in Australia has done quite a bit of sleep research, so I wasn't involved with the studies per se, but we had a lot of conversation about it and what they found, and they're still looking more into it, is they actually did a three day simulation where they restricted sleep. So some firefighters got eight hours of sleep, others were sleep restricted at four hours and they actually found from a performance standpoint that their work performance wasn't decreased. It was the same. Interestingly though, they actually saw during the rest periods that those that are sleep restricted moved less. So it was almost like a compensatory mechanism or they knew they were maybe tired or they didn't have as much overall to give. So during those rest periods they were compensating. And then from a cognitive standpoint, they

didn't see any declines, but they were looking at attention for the most part. So they didn't see any detriments with sleep deprivation from the cognitive standpoint. But it could be that in attention there isn't. But maybe in some of the other domains that weren't tested, there might be. So I, I definitely would say we don't know the full answer. We have a little bit of an insight and basically what it's done is spurred more, you know, interests to what else can we do to try to figure out what's actually going on in the individual.

Charlie Palmer: Yeah. I think there's probably enough sleep related things out there that we could pull together a podcast just on sleep alone. It's definitely worthy of some focused attention by itself. I will say that I was once in, a three day adventure race and my second night of sleep deprivation, I was seeing gnomes running through the woods and snakes. You know roots on the ground were turning in the snakes and slithering off. So there certainly is an effect of sleep deprivation on brain activity. I can tell you...

Charlie Palmer: The little travelocity guy. Yeah?

Chuck Dumke: Yeah. (Laughing)

Charlie Palmer: Was he faster than you are?

Chuck Dumke: No. No. (Laughing)

Charlie Palmer: You were staying ahead of him?

Chuck Dumke: Just barely! (All Laughing)

Charlie Palmer: Alright. If we're going to wrap this thing up, Chuck, what do you have as far as to summarize kind of what we've talked about.

Chuck Dumke: Yeah. You know, this fire conference, uh, reminded us a lot about some things that we oftentimes don't think about. You know, there, there is a guy who presented a slide that was really good about how technology is still way ahead of knowledge. And we are always going to be relying on human decisions and so fire is changing in the way we fight fire as far as weather information and gps information and where all the firefighters are and putting little gps tags on an micro chipping them or whatever we end up doing.

Charlie Palmer: Drones. Drones here, Applications.

Chuck Dumke: Drones there, but all of that technology is then going to funnel through a team of or at least several humans in order to make decisions from that technology feedback. So decision making processes are huge in wildland firefighting and the sort of risks of them can be huge as well with injuries and fatalities. But from the physiology side, it's really frustrating to try to isolate things that might be affecting cognitive decisions because so many things can and so many things do.

And you know, the sleep, the food, the drink that dehydration, the heat, the woodsmoke, that it's really difficult to get a handle on it. And we're also limited by measurement tools. How do you then measure what you're anticipating changing? And I've learned a lot from you guys and other people at this conference that it's, I've always used this term before and other phenomena of chasing a ghost, you know, it's really hard to capture and put a finger on something that is affected by so many other physiological things.

Mike Bell: And I think that's a great point, chuck. And I think we have to be weary about looking at those measurement techniques and saying, okay, well we don't see a change, therefore nothing's happening. It could be possible. But I think at the same time we have to realize that some of those tasks are novel to the individual doing them. And maybe we have to look at other ways to try to understand the cognition. So one thought that's moving forward is how do we replicate similar types of decisions that wildland firefighters are going through? Whether it be through a simulation in the lab or a simulation on the line that we're not in an actual fire, but we're doing a simulated task, maybe even going, as you mentioned, technology, maybe looking at the technological route of serious games, which for those that haven't heard of that term, it's video games that are meant for education, not entertainment or even virtual reality. So can we recreate the similar types of decisions that a wild land firefighter is going to make and then maybe that's the next level. Maybe that's more complex because maybe what we're using right now isn't complex enough to see these sort of changes

Charlie Palmer: Or just not job related enough to be able to see if it is relevant or makes any sense.

Chuck Dumke: As an example of that, we have a grad student right now who's doing a thesis and he's heating people up and then doing a shooting simulation test. So it's a DOD sponsored study and so basically does your core temperature affect ability to shoot and aim and make decisions that way. So the test this in reference to the specificity of the test is one of the challenges in a decision making a investigation.

Charlie Palmer: I can use that for an excuse during hunting season...

Chuck Dumke: That in your choice of food selection.

Charlie Palmer: Yeah, and the fact that I don't shoot enough. Gentlemen, thanks so much for your time. Appreciate your insights and clearly a topic that we just need to keep investigating as more, gets learned about it, but absolutely something key and vital to the wild land firefighter world, which is decision making and cognitive function. So once again, thanks for your time, Mike, safe travels back to Toronto. when you leave. And Chuck, you're just going across the street. So thanks and same to you.

Charlie Palmer: You've been listening to On The Line, a podcast for today's wildland firefighter, our audio engineer's Mike Matthews, production assistant Joey Moore, and I'm your host, Charlie Palmer. Thanks for listening and We hope to connect with you again in the future. On The Line.

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