Just Footwear Impressions on Fabric.wav

Introduction [00:00:01] RTI International's Justice Practice area presents Justice Science.

Introduction [00:00:10] Welcome to Just Science, a podcast for justice professionals and anyone interested in learning more about forensic science, innovative technology, current research and actual strategies to improve the criminal legal system. In Episode eight of our case study season, Just Science sat down with Brian McVicker, a forensic footwear and tire examiner at the Federal Bureau of Investigation, to discuss developing shoe and tire impressions on fabric using ninhydrin. When a victim is stomped or run over the transfer of skin cells onto the inside of the victim's clothing can leave an impression of the shoe or tire that was used. Due to the valuable information this can provide to investigations the FBI laboratories footwear and tire group performed a validation study exploring the efficacy of an anhydride to develop footwear or tire impressions on the inside of clothing, especially focusing on using an iron as a heat source and dark fabrics. Listen along as Brian describes how the study has expanded existing ninhydrin processing procedures, scenarios in which ninhydrin processing would be helpful to a case, and the value of involving interns in this type of research. This episode is funded by the National Institute of Justice's Forensic Technology Center of Excellence. Some content in this podcast may be considered sensitive, and they evoke emotional responses or may not be appropriate for younger audiences. Here's your host, Jaclynn McKay.

Jaclynn McKay [00:01:25] Hello and welcome to Just Science. I'm your host, Jaclynn McKay, with the Forensic Technology Center of Excellence, a program of the National Institute of Justice. On today's episode, we will discuss a validation study performed by the FBI Laboratory Footwear Tire Group to test ninhydrin's efficacy to develop footwear or tire impressions on clothing. Here to discuss this study is Brian McVicker. Welcome to the podcast, Brian. Thanks for talking with us today.

Brian McVicker [00:01:53] Thanks for inviting me.

Jaclynn McKay [00:01:54] So you work for the FBI laboratory wearing various hats with regards to the footwear and tire discipline. Can you walk us through your roles and tell us a little bit about your background?

Brian McVicker [00:02:05] Sure. My background in forensic science came in 2001. After graduating from the University of Florida, I was hired by the Georgia Bureau of Investigation in 2001. Initially, I was a forensic document examiner, so primarily looking at handwriting inks and things of that nature. But in 2006, the Trace Evidence unit had been performing footwear and tire analysis, and they were overwhelmed. And so we were underwhelmed in the documents section. So I got trained to do footwear and tire analysis. Then a couple of years later, in 2009, I was hired at the FBI laboratory where I am working today. So I'm an examiner. So I do analyze evidence, issue reports, review others casework, and then testify as necessary. And I also serve other two more leadership roles. One is the technical leader. So in that role, I have technical oversight of the footwear tire discipline. And so the primary focus of the technical leader is to handle quality assurance matters. And then in addition, I'm also the research tech program manager for the footwear tire discipline.

Jaclynn McKay [00:03:11] As we all know, footwear and tire impressions are a common type of evidence found in crime scenes. However, I think it's less common to actually process clothing for footwear and tire impressions. So in cases where a victim was

stomped on or was involved in a hit and run, can you discuss how and why footwear and tire impressions may be developed on the inside of the clothing worn by the victim?

Brian McVicker [00:03:37] Yes. So in those types of situations where somebody's stomped or being run over by a car, there's significant force applied to the victim and he or she will likely be wearing clothing. And so what happens is when the force is applied, it causes the skin cells from the victim to transfer to the inside of that innermost layer of clothing. And when that happens, there's a chance that those skin cells can be visualized, either they're patent. That means that we might have a dark colored sweatpants. They get run over on the leg. And if we turn the piece of pants inside out, we might see some light colored impressions on the inside. But then also there's latent impressions where we've got a maybe a light colored undershirt and you can't see any impressions. And so we'll have to use alternate light sources or chemical means to try to develop those impressions. So I would say that processing clothing is less common than processing other types of evidence. You can use various chemicals, but the specific use of chemicals for clothing sort of dates back to 1993, when the Journal of Forensic Science Society had published a paper by Price, which were documenting their results of developing footwear and tire impressions on the inside of clothing.

Jaclynn McKay [00:04:51] Can you expand a little bit on why developing these impressions is important to investigations and what information can be gleaned from it?

Brian McVicker [00:05:02] So shoes and tires that could be used as weapons. So maybe inadvertently or intentionally so a lot of times. If something stopped. There's no evidence of that shoe coming in contact with the clothing. And so we need a way to try to link that suspect, his shoes or his tires to the victim. And so in a case where there's impressions are on the inside of clothing, that may be that link that we're looking for to help make that connection.

Jaclynn McKay [00:05:27] So, Brian, circling back to the research hat that you wear at the FBI, the validation study that you participated in, involved ninhydrin . Can you explain what that is and how it is typically used?

Brian McVicker [00:05:42] Yes, it's a it's a chemical reagent that reacts with amino acids to produce a deep purple color. And that has been coined the Ruhemann's purple and it's been long used in the friction ridge fingerprint community to develop fingerprints on porous substrates such as paper, wood and even fabric. And the ninhydrin reaction can be catalyzed, meaning you can make it turn purple quicker if you use a heating chamber which has heat and humidity. And then secondarily, you could use a steam iron to also catalyze reaction. If you were to leave the evidence that had been processed with ninhydrin, if you were to come back in the lab the next day, you would likely see that same level of development, but oftentimes were in the middle of lots of other things. So if we can do it quicker, faster and see that reaction, we're going to. And so that's where the the heating and steam come into play. And it's normally used on light colored substrates, white T-shirt, light colored paper, cardboard, because the purple color contrasts well with those particular substrates. But it's not normally used on dark colored substrates.

Jaclynn McKay [00:06:49] Could you talk a little bit more about the purpose of the validation study and why the FBI laboratory chose to pursue this specific research?

Brian McVicker [00:06:58] Me and my colleagues in the footwear and tire group at the FBI laboratory, we didn't have any SOPs related to processing evidence with ninhydrin, and so

we wanted to bring it online because we know it's got benefits to developing these tire and shoe impressions on the inside of clothing. And so in order to do that, we wanted to sort of test out some of the parameters that we might be using with respect to this chemical. So latent prints might use it a little differently than we do. And so for that reason, we went through this sort of abbreviated validation study. We know this works, but we sort of wanted to be able to test the parameters that we might want to incorporate into our SOP. So it was this sort of opportunity also to refine what we would do with a steam iron, specifically since most of the time it's being used in the humidity chamber and there wasn't much literature published on what you do with the steam iron. They said you can use it as an alternative, but nobody really specified how or what to do. And so we thought this was a good opportunity to test that out. And then we wanted to also test out dark colored fabrics to see if ninhydrin was also a viable solution for those types of clothing. Since I stated earlier, light colored works best with the purple color, but as an alternative to DFO and Indian diode, I thought it would be neat to see what we could do with ninhydrin. And so we incorporate that into this validation study. Also another happenstance was that we had FBI interns coming on board right about this time when we were going through the validation study. So I was approached by my manager saying, Hey, would you like an intern? And so thinking with my colleagues, I said, yes, it seems like a good opportunity to get them some good laboratory experience. And then also being able to benefit from that from an operational standpoint. So that was really exciting. It was fun to work with some young people, juniors of seniors in college, and so most of them had chemistry backgrounds. And so it was really fun to see what they would do with the sort of the instructions I gave them, but then also coming up with different ways to maybe approach the problem.

Jaclynn McKay [00:08:56] That's really exciting that you guys were able to take this validation study for ninhydrin to kind of use the chemical in a different way than it's typically used and try to adapt the standard operating procedures for how it would be used to develop footwear impressions on fabric. And then I also love that you were able to incorporate interns, because I know, at least in my experience in a government lab, the interns can't touch casework and just getting them involved with research and actually having hands on experience with how this will work in the practical environment is really exciting. So if any of our listeners are interested in the FBI Honors internship program, could you provide a little bit more information about that?

Brian McVicker [00:09:41] Yes, it's a great program. So it's targeted for juniors or seniors, undergrads and then also those pursuing master's or doctoral degrees. And you have to be a U.S. citizen. Normally, the application period opens from the end of August through mid-September. So it's a real short period of time. So you have to be watching FBI jobs.gov to make sure you're on that. But I would be looking in August and September for that application process to open. And it's nice now the internship is paid. There was a period of time where it wasn't. Which provides maybe a little more incentive for them to jump on board. If a top secret security clearance wasn't enough. And so the process is really you have this initial interview, you fill out the application they select based on your qualifications. And then after doing the interview, they're going to make their final selections and then they'll offer the students a conditional offer. So it's conditional on their background investigation. So talked about having a top secret security clearance. So all FBI employees have that clearance level, including the interns. And so that involves the background. And at the completion of the background investigation, what happens is that the interns offered the job and they will have the top secret security clearance that all other FBI employees have. So it's really nice at the end. Recently, they made a big push to try to rehire or bring them on online as more than an intern after their completion of their studies.

So we're trying to find jobs during their internship that might give them exposure to various things in hopes that they can see where they fit in the FBI upon completing their education.

Jaclynn McKay [00:11:18] This sounds like a really exciting opportunity, and I'm happy to hear that the FBI tries to find jobs for the interns and they can progress internally within the agency. So pivoting back to how the validation study was conducted, could you talk a little bit about the preliminary testing and evaluation that the interns did in order to prepare for the validation?

Brian McVicker [00:11:42] Yes. So we used a acetone based working solution of ninhydrin, ninhydrin comes in crystal form. And so it's very simple. You mix the acetone and the crystals together. They eventually dissolve. And now you have what we call a working solution. That was pretty standard. I told them what what the solvent was going to be. They prepared it. But then where they had some liberty was to look at different fabric types. And so after letting know what the objective of this was, we want to find they were looking for clothing that might likely be worn on the inside. We had things such as sweat pants, gym shorts, t shirts, khakis and jeans that they selected as representative of things that people might wear direct contact with their body. Then they had the iron and they were thinking about we're going to have to iron the fabric. And so they went and tried to find a sample size that would fit under the iron for best exposure to the heat and humidity. And so they ended up with a 4.5in by ten inch swatch. And in that surface area, they were able to squeeze in ten impressions. And so we have these ten impressions. And what they did is they used a depletion series so manually applied from an amino acid reference pad. So this is sort of the control, you know, that if the solution is working, it should produce this positive purple color. And so they did that and you ink it once and then you make ten impressions using that reference pad matrix and you have this depletion series so that the first one is going to be more concentrated than the 10th. And so it gives you sort of an idea of how concentrated it might be to be able to make the reaction occur. Then they also are looking at optimal conditions for catalyzing the reaction using a steam iron, which was less published. And so they worked with one particular sample. It was the lab coat, which is a white lab coat. So they were testing the sort of three factors the time it took to apply the heat and humidity, what temperature he should put the iron at, and then also what level of humidity should we expose it to? And so based on lots of testing, they determined that using the heat setting for cotton blend, which on this particular iron was setting for, and then keeping the iron at the lowest steam setting after giving it one quick burst of steam at the onset and then iron in the sample for about 30s that tended to develop a nice purple color on that white background and it didn't have overdevelopment, indicating that there might be some purple standing on the background. And so based on that, that's what we went with and that was really their recommendation. So it's nice to be able to see them sort of use their scientific knowledge and lab work experience in college to help refine this process. And so the chemical it's it's a solution. And so in order to apply it, they used an aerosol sprayer. So it's kind of like a can of spray paint. But you can put any solution, whether it's paint or chemicals in the vial, and then it gives you a nice fine mist that you can apply on to the sample. So after they have these samples, they've got the purple color. Now we need to record it. And so I wanted them to test out some different imaging options. And so it's very easy to image light color things. So they used a standard dSLR camera and white light to image those samples, but we knew that we weren't likely to be able to visualize the impressions on the dark colored fabric. And so we looked at different options using an ALS and things of that nature. But recently, the FBI lab had purchased a phase one rainbow imaging solution. So this is a combination of filters on the lens of the camera and then also a myriad of colored light sources at various wavelengths. And so it's really nice because it captures sixteen narrowband wavelengths going from 365 to 940

nanometers. It's on a copy stand connected to a computer. And so they did some testing to see what conditions might be optimal for developing these impressions in dark colored fabric. So the initial testing proved that there were some successes seeing these impressions on the dark colored substrate. So we thought this would be the easiest option. It ran a huge number of wavelengths and it was very easy. So you could just sort of hit go in. 20 minutes later, he had 16 images. We could then further process with Photoshop if needed.

Jaclynn McKay [00:16:07] I know you mentioned that in traditional fingerprint processing, when ninhydrin is used, the item is placed inside of a heating chamber. While you guys wanted to test out how a steam iron would do since that's less published on. So can you talk more about why you opted to use the Steam iron and kind of elaborate on the process differences between using a steam iron versus using a heating chamber?

Brian McVicker [00:16:38] We thought it was a good opportunity to use the iron since it's it's well published. Well, use the heating chamber works. And so we wanted to really try to see what settings might be appropriate to develop these these impressions, how long it would take. And so it was a little bit of an investigation and might be beneficial to the community since the for our entire discipline generally they're not using heating chamber. So depending on the size of the agency, they may not have access to it. I could have gone down to the latent print unit and use one of their chambers, but I thought this is a good opportunity just to use something that we had in house and wasn't costly. And so the difference between the heating chamber is when you use the heating chamber, you're simply applying the process sample into an oven with humidity. So you open the door, you stick it on a shelf, kind of like an oven, and then over time it will develop, provides nice, even heat throughout the chamber. But the challenges with using the iron is it's hard to apply even consistent heat. And so what you have to do is constantly move the iron over the substrate in order to provide even heat across the substrate. But we had said that 30s were optimal for this lab coat, but in some cases it could develop much quicker. And so depending on the the amount or the concentration of the amino acid and maybe the fabric, it could take less time. It could take more time. And so what you have to do is when you're ironing, you're putting a piece of filter paper in between the sample and the bottom of the iron because having a solvent and ninhydrin, it could be flammable. And so in order to reduce the likelihood of that, the sample dries, put filter paper in between and your ironing on the filter paper. But when you're doing that, you can't see the development. Whereas in the heating chamber usually it's got a clear glass front. And so you just go look at it periodically and see the development. So what we had to do is you just have to take away the iron, peel up the filter paper and keep checking it. So it really helps if you do it quite frequently because you want to avoid overdevelopment and you really can't go back once it's developed. So if it's all the backgrounds, all stained, you're kind of stuck with that. So it's important that you look at that periodically, but it also gives you some extra control that maybe you don't have with the humidity chamber. So that's why we did that.

Jaclynn McKay [00:18:56] Based on your validation, what are your conclusions and recommendations for processing fabrics with ninhydrin?

Brian McVicker [00:19:02] So the results showed that in all the samples provided, there were about 1 or 2 impressions on each of those different substrates, which would be the ones with the highest concentration impression one and two. But there were definitely varying results between the different samples, the light color samples they performed. As expected, the development happened easily. You see the purple color, but when it came to the dark colored substrates, there was a wide range of wavelengths that worked,

depending on the material and depending on the color of the clothing. In some cases, visualizing those impressions on dark colored fabric were better enhanced with Photoshop. And so you could that combination of chemical processing within then adding Photoshop in there, we were able to see more than we would have if we just use the chemical. And the specific wavelengths that we found to be useful in visualizing the impressions were 395, 400, 630, 660, 730 and 850. So it was a wide range between the ultraviolet and the the infrared. And so we also found that the steam iron is a suitable option for applying heat humidity to the. The samples, the testing we did. I said it before, but that 30s it worked well in this particular case. But it also we only tested the the lab coat when we were doing sort of developing that particular metric we were going to use. So I think in hindsight I might have used other fabrics at the initial testing, but it didn't seem to impact significantly our results. And so what I recommend is that you test a non evidence portion of the particular clothing that that you have in evidence and process that and see how. How quickly the reaction is taking place. And you can do that before you then go and process the samples. Sort of give you a control. And also we had a particular gym short that was polyester athletic shorts. And they they burned when we were applying the heat. And so it kind of distorted the fabric. You might want to use the particular fabric setting on the iron in those cases or just to be safe you can also use a lower setting on the iron. And the difference, it'll just take a little bit longer.

Jaclynn McKay [00:21:13] So that's really exciting to hear that a steam iron is a suitable option for processing fabrics with ninhydrin. So for those footwear units out there, they have that as an option. But I know sometimes the footwear units are combined with the latent print unit. So what they still be able to use a traditional heating chamber if they wanted to.

Brian McVicker [00:21:38] They could and they're actually probably more experienced with that anyway. So I think if I had access to a heating chamber, I might use that. The only difference is if you have something large that may not fit nicely in there, or if you had different areas along the shirt or a sweatshirt that you might want to process, the iron may just lend itself to be more useful in some of those situations.

Jaclynn McKay [00:21:59] Good to know. Are there any areas that you would like to see expanded in possible future studies?

Brian McVicker [00:22:06] Yeah. As we're just talking about the iron vs the heating chamber, it would be interesting to have a more controlled study where you really isolated those two variables to see if there was any performance difference between the two ways to catalyze the reaction. It might also be interesting to see how ninhydrin, DFO and Indian dione perform on dark colored substrates. So with Indian dione and DFO, it requires alternate light source to produce a luminescence reaction. So a light color reaction in the background is dark. And so it's a little more tricky to photograph than it is if you were to use ninhydrin in using a system like we had used, it's very easy. So I wouldn't mind seeing how those three chemicals compared on dark colored substrates.

Jaclynn McKay [00:22:52] Speaking of future studies and new research, as the research and technology program manager, are there any other areas of footwear and tire research that you're involved in and would like to speak about?

Brian McVicker [00:23:06] Several years ago, we started a study on what they would call a black box study. So you're trying to evaluate the performance of footwear examiners when provided comparison sample sets. And so there's been a lot of criticism over the,

you know, the validity of a lot of these pattern based disciplines, including footwear. And so this is an opportunity for the FBI laboratory to step up and make a robust assessment of performance of examiners. It was open to both international and U.S. participants, and it took us several years to complete. Each person was provided 100 samples. And so we got a lot of good data. And overall, the study went well. So the performance was good and that was a lot of fun. I got to help with the design of that project and then also the execution and then helping out with the analysis. I worked with researchers and statisticians on that project and so I brought the sort of subject matter expertise when it came to footwear and tire. I wanted the results to be able to be understood and used by practitioners like myself. And so I sort of brought that to ensure that what we reported out in the conclusions we found to be useful to the audience. And within that study we came out with a sort of a mini research project where when developing the crime scene like samples that we prepared using known footwear and various substrates, tile, paper, things of that nature, we needed to see if there was a way to assess the quality of each of those crime scene like impressions, because we wanted to ensure that the samples we provided were representative of low quality stuff, high quality stuff. So, you know, if you have a high quality impression, it's going to be easier to see similarities and differences. But the confidence in the examiners or their ability to come to the correct conclusion may diminish as the quality decreases. And so we set up the samples based on quality. And so we were able to create a rubric, the subject matter experts, including myself on that project. We assess the quality and give a numerical score. And that numerical score, it helped to feed into the composition of the comparison sets. And then before that, I was the leader of the National Footwear Database study to assess the feasibility of a national footwear database here in the U.S. This would be using shoe prints at crime scenes or shoe prints collected from arrestees to develop links between scenes or to develop suspects. And so it's not being practiced widely here in the U.S. and there's no national system. And so we worked with international partners to make this assessment, and I reported on that. And there's ongoing research with the National Institute of Justice and the Forensic Technology Center of Excellence where where we have a working group set up to now look at the outcomes of the study and the report that I authored to now turn that into pilot studies and local law enforcement agencies.

Jaclynn McKay [00:26:05] That's really exciting. Brian We we actually have another podcast episode this season about what Wisconsin is doing with providing footwear investigative leads and building their internal footwear database. So that's really exciting. We'll be sure to link all your studies on the FTCOE landing page for this episode as well. Well, Brian, thank you so much for your time discussing this study. It's truly been a pleasure chatting with you today.

Brian McVicker [00:26:34] You too. You're a very professional group, it was nice to hang out with you guys.

Jaclynn McKay [00:26:37] If you enjoyed today's episode, be sure to like and follow just science on your platform of choice. For more information on today's topic and resources in the forensics field, visit forensics COE.org. I'm Jaclynn McKay, and this has been another episode of Just Science.

Introduction [00:26:55] This episode concludes our case study season. Tune in next season to learn about a multidisciplinary approach for improving fatal and non-fatal shooting case outcomes. Opinions or points of views expressed in this podcast represent a consensus of the authors and do not necessarily represent the official position or policies of its funding.