

MIKE ELLEDGE: So Laura has also served as the vice-chairman on the Committee on Consumer, Pharmaceutical, and Medical Packaging for the past few years and was named as one of the 100 Most Notable People in the Medical Device Industry by Medical Devices and Diagnostics Industry Magazine. Our co-presenter - bless you - is Tamara Reid Bush, who is the director of the Biomechanical Design Research Laboratory and a visiting assistant professor in the Department of Mechanical Engineering here at State. She uses her expertise in human motion analysis and the measurement of complete force systems to study automotive, office, and medical seating, sports biomechanics, hand function, and musculoskeletal dysfunction of the cervical spine. I may be talking to you afterwards for a little assistance. Tamara recently received the Michigan Campus Compact Award for community service work, leading a group of students in the development of a rehabilitative tricycle for children in the Sparrow Hospital Pediatric Rehabilitation Facility. So please welcome Laura and Tamara.

DR. BIX: Thank you. Good afternoon. We're very pleased to be here. We're going to be probably a little bit different, but Tammy and I are actually quite used to be a little bit different. Most audiences, I think, even think we're unique and innovative or weird and strange. So I will let you be the judge of that.

We're here today to talk about some of the work that we're doing around usability and packaging. I learned from one of my graduate students that the best time to acknowledge people is, in theory, you have the attention of the audience in the beginning. So I want to make sure that I acknowledged that this work that's represented here is a vast team of individuals from different backgrounds, at different points in their career, that have all contributed in some way, either minor or major, to the presentation.

With regard to the agenda, I want to talk to you a little bit about the traditional approach to packaging. I'm guessing that most of you probably don't put a lot of thought into package design, but I do. I want to give you just sort of the typical approach that we see as changing, and some of the drivers of those changes, as well as some of the methodologies that are being developed here at Michigan State to try to encourage accessible design and also evaluate it.

In terms of package design, Dr. Hugh Lockhart proposed this matrix, and basically he says that three different functions - and that's protection, utility, and communication - have to be performed by packages of all types, and that it has to be performed in different environments, in the physical environment, in warehousing distribution, supply chain, things like bumps, shocks, bruises, vibrations. All kinds of things

occur to your products before they reach you. We also have to consider the atmospheric environment; water vapor transmission, temperature, light sometimes can degrade and affect products negatively. And we also have to consider the human environment. Almost every package has an interface with the user and handlers, as well, at some point in the process. The traditional approach has been very product-centered, and we have concentrated most of the science and methodologies that we have developed around making sure that it doesn't break before it reaches you. We do damage boundary curves. We do fragility testing. We do shock and vibration. We have all kinds of ASTM and ISO standards and technologies around making sure that we make the most cost effective package that can protect products in those environments. We've done this same sort of scientific and thoughtful approach in the atmospheric environment, where we understand moisture vapor transmission, oxygen permeation, interactions between the chemicals in the polymer materials and the product as well. And if you look at our own curriculum here at Michigan State you will see that very accurately reflected.

The thing that we've neglected, I believe, and maybe you can talk to the rest of the faculty and they would disagree with me, but I believe the thing that we've neglected through the years has been the human environment. Most of the work that we do in the human environment is either qualitative

in nature - can you hear me? Okay. Either qualitative in nature or has been done around motivating a purchase. The work that has been done around motivating a purchase is generally held very close to the vest because it's considered to provide a competitive advantage. So in terms of the science, methodologies, and technologies that we have to evaluate, this area of package design is very poor. This is slowly beginning to change, however, and I think a large part of the driver of that change is the aging of the population. Now, I'm sure you're all very familiar with the fact that the population is aging, but when you start to look at the figures it's really kind of staggering, and this is something that I try to convince the industry of when I go out and talk to them with regard to this. On the Y-Axis you'll see that this is millions of people in North America. And this is WHO data, WHO data, from 1950 to 2050 that are over the age of 75. Now, as I get older, my idea of what old is gets older as well. When I was six, I thought 36 was absolutely decrepit and ancient. I don't think that anymore. But I do still think that 75 is pretty old. So when you look at this, this isn't just happening here in North America, it's happening all over the world. These are U.S. Census statistics and the light gray indicates the percentage of each country's population that is over the age of 65. The darker gray is that same age group at the year 2025. So a lot

of countries, Japan in particular, is paying close attention to this, and a lot of the ISO developments that were being mentioned in the previous presentation, are being driven by conveners from Japan.

When you couple this type of statistic with the bar graph on the right, which indicates the percentage of each age group that is either disabled or severely disabled, if you look at those bottom two bars, the light bar of the 80+ population indicates that 71.5 percent of the 80+ population has some level of disability, and that over half, 53.5 percent, is severely disabled. When you couple that - to use the previous wording or terminology - with the pervasiveness of packaging, this is a demographic that we in packaging need to be paying close attention to. It's basically a tidal wave that's ready to hit us.

At the same time we're seeing changes in the retail environment, which are also incentivizing usability. We have an extremely competitive climate with an escalating number of products, as well as escalating consumer expectations. Changes in advertising are occurring because of ddr, satellite radio, tivo, remote controls, multiple channels where you can filter advertisements. When I was a small child, you had to watch commercials basically, either that or move yourself, change the channel. There were only three channels. So advertising

dollars went a lot farther then than they do now. What's happening is that in this climate, then, packaging takes on a more prominent role in both winning the mind of the shopper, which is what we call the first moment of truth, creating the purchase incentive, but also in retaining the consumer after they use the product. And so some astute companies are starting to recognize that this is changing packaging from an expense to be dealt with to a tool for adding value and services to their products. So we're starting to see them slowly begin to embrace usability. Unfortunately, my industry generally follows the almighty dollar, and the dollar is starting to go there, consumers are starting to vote with their bucks, if you will.

This is one example of packaging that has utilized ethnographic techniques to improve its design and increase its sales. This is Huggies Baby Wash by Kimberly Clark. Does anyone have a child that's under two? A few people. What Kimberly Clark did was they developed - they call it the CVS, or the Consumer Vision System, and they actually hold a patent on this system. Kimberly Clark includes products that are not all the time pleasant to deal with. They deal with feminine hygiene products. They deal with diapers. They deal with incontinence products. So a lot of times they found their consumers didn't want them in their bathrooms filming them with the use of their products. They found that if they changed the

point of view from looking at the consumer to the user's point of view or the consumer point of view, people weren't as afraid to let them into their homes. So this is a small camera that shows the consumer point of view when using the products. The insights that this garnered - this probably may mean nothing to you - but this is an extrusion blow-molded high-density polyethylene bottle with a continuous thread closure. Basically what that means, it's slippery when wet, and it requires multiple movements to get the closure off of the bottle. So, I don't know why this didn't occur to them, but when they put the vision system on young consumers, primarily mothers, what they found was they only had one hand free to use that bottle in that wet and slippery environment. So trying to manipulate that very slippery bottle with the closure was difficult. So based on the insights garnered from the consumer vision system, they changed to this bottle, which now has a flip-top closure, it has an embossed side, which theoretically makes it less slippery, and a wave design to add to the grip. And since then they've seen an increase or a rebound in their market share that they were previously losing. That's the patent on the CVS.

There have been similar sort of success stories with Domino Sugar. It was estimated that for six months when Domino Sugar went from this paper bag into, again, a plastic container which was resealable, that they were unable to keep sugar on the

shelves in the retailers that ordered this, despite the fact that consumers were getting less sugar for a higher price. And again, I'm about usability because I think it's the right thing to do, but I have to make the business case for it, unfortunately, in the world that I live in.

With regard to other thought leaders that are starting to increasingly embrace usability as a platform for selling products, Proctor and Gamble. Proctor and Gamble tests over four million consumers a year in over 60 countries, and between 2000 and 2007 it's reported that their spending on ethnographic and personal research increased five-fold. They conduct about 4,000 to 5,000 new studies each year with consumers and packaging. This is from Paul France, who is actually - they have a universal design team, and he is the leader of their universal design team and this represents some of the simulations that they try to do in their laundry products division as they design.

So seeing this need, what we're trying to do at Michigan State is develop some methodologies which can quantify the interface between people and packaging in order to inform design and set boundary conditions for designs. This is a collaborative effort between the School of Packaging and the College of Engineering, specifically the Mechanical Engineering Department. One of the tools that we're using is change

detection, and I think we're short on time so I won't show you that, but if you have an interest in perception and vision, I'd be happy to demonstrate it after the talk. We're also using four different eye trackers. We have actually three different eye trackers. We have a 501, a 504, and now a brand new mobile eye which we're trying to use to quantify how long people look at different elements on the package, what they look at first, second, third, so that we can inform the label design and prevent things like medication error, which are very common, unfortunately.

There's a very famous information processing model which indicates that for information to be effective it must be first noticed, it must be decoded, meaning in the case of visual information it must be basically focused and brought into the brain, then it must be comprehended or understood. If the information is in a language that is not familiar to the person or if it's a reading level that's beyond their comprehension, the message will fail there. And then finally, you're trying to move the consumer to some sort of behavior to comply. That might be taking a drug at the correct time and in the correct dose, or it might be motivating a purchase, depending on the type of information that you're using. We've used these systems to quantify two warnings, which are required to be prominent and conspicuous on labels, and we're trying to

say to the federal government that these warnings are not prominent or conspicuous and that we can prove it with quantified data.

So this is one of the eye tracks. Basically what happens is an EER infrared beam is directed into the eye of the user and then using an algorithm that employs both the corneal and pupil reflection, we can track the position of that beam in space. Researchers can then go into the data file and draw zones around the areas of interest on the package, and then using the software, we can pinpoint how long the crosshair spent in each of those zones, so we can tell how long did they spend reading the brand name versus the warning, and what order did they read it in. We've used this across five different products and with - on five different zones of interest. The first zone was a warning that was intended to be conspicuously displayed. That was a warning that says there is no child resistant feature and that the package shouldn't be brought into a household with children. The second zone is a tamper-evident warning which tells you what tamper-evident features should be in place on that package, and this is required by regulation to be conspicuous and has been since the 1982 Tylenol poisonings. The third zone was marketing information. This is things like extra strength, and aspirin-free. And the fourth zone is brand name. The fifth zone is drug facts. You might think that this is just

time, but each of these zones has a different amount of information in them. So what we do is we divide by the number of typographical characters in the zone, and we get time per letter, and then we can look at statistical differences in the amount of time that subjects spent per letter. So you can see that the brand information and the other marketing information, the claim statement, they exhibited significantly more time on those zones than they did any of the required information, such as the child resistant warning or the tamper-evident warning. Initially, we weren't looking for this, but women spent more time on the marketing information than the men did, but they spent the same amount of time on the required information. So I don't know what that says for the advertisers but I'm sure they could make something out of it.

Across all five packages, and this, to me, is maybe even - it is the most startling piece of the article that we wrote - this is the number and percentage of people that entered zero time in the zones. So if you look at the T.E. warning, again, this is required to be conspicuous by regulation, that for this package, 95.1 percent of subjects' eyes never crossed into that zone. For this package, 80.3 percent - and that's the one that did the best - 86.9 percent on package three, 88.5 percent on package four, and 96.7 percent on package five. So what, to me, that says is either it's not important and we

shouldn't have it be required to be on there, or if it is important it's not meeting the letter of the law. We also tried to quantify physical effort and movement as people use and interface with packages, and we have a unique issue with regard to child resistant, senior-friendly packaging, because we have to keep an increasingly adept population out while allowing an increasingly infirm population in. So this is some of the video insights that we've garnered in the course of testing. This first clip, watch the small child on the left very closely. I don't have sound.

(Video clip played)

DR. BIX: So she was in in ten seconds. That one you really didn't need to hear the sound. This one, the sound is more important. I don't know if there's anybody that knows what's wrong with it or here to help. There we go. Excellent, thank you.

(Video clip played - not audible)

So if you listen closely, at first he's playing. He just said, "You push down and turn." So one of the big problems that we have with child resistance is I think these children - when I was small you got turned out into your backyard and your mother called you in three times a day to eat. Now, they're going to day care and they're going into Computer Tots and they're learning to read, and their fine motor skills

are increasingly adept, while their gross motor is probably not. But it's an amazing design problem to try to defeat them and at the same time allow another population in. So, some of the work that we've done is coupled - we partner with Western Michigan, Deborah Lindstrom-Hazel. Dr. Deborah Lindstrom-Hazel is an occupational therapist at Western Michigan University's Occupational Therapy Program. And we're using some of the standardized tests that they use - and you guys are probably familiar with these - pinch gauges to look at key pinch, tip pinch, and palmer pinch. We look at bilateral palm-to-palm squeeze to look at the ability to press and turn. We use grip dynamometers and we recently figured out through Dr. Bush's lab that our wrist dynamometer is really kind of garbage, but she's built us one that works really, really nicely. With this work, what we did was we had a group of people with disabilities, a group of small children, and a group of seniors 70+, and we tried to use standardized methodologies to see if there's any clear place that we can find statistical differences so that we can then translate those into design and segregate so the little guys don't get in and the big guys do. We found the only clear place where we found statistical significance on almost all the tests - and I'm sorry this is so small, but the purple here is people with disabilities, the blue is older adults, and the green is small children. You can see the letters indicate

statistically significant differences in the data, if there is a different letter. We found almost on all the size measures statistically significant differences. On the strength measures, we found no significant difference with the exception of grip strength. That was the only place that we found one. And on the dexterity measures, we used a standardized test of dexterity, and we found no significant difference there. Most of the packages that we have for child resistant packaging, leverage are different in cognition or in dexterity, simultaneous dissimilar motion, push and turn, squeeze and turn. Very few, if any, leverage a difference in size. And so the sort of theme of this thesis that we produced together in the two departments was maybe we're leveraging the wrong paradigm and that's why people complain that they can't get into their packages and yet the children still can.

We also have just gotten in two new systems. This is a pair of gloves that is equipped with bend sensors which will measure flexion in most of the joints and flexion and extensions across the metacarpal phalangeal joints, which are the joints down at the bottom of your hand. We have not implemented this in a research study yet but it is a new system that we have. We're also using kinetics or force mapping or pressure mapping to understand the forces, the relative forces that occur as people open packages. So you can see that this represents the

thumb, the pointer finger, the middle finger, the ring finger, and the pinkie of the left hand, and this is the opposite, the right hand. So you can see, as the user opens, what's going on in terms of a series of sensors mapping pressure. We then - well, it doesn't want me to go on. We then use this to find the areas of the hand which are most affected in terms of the - receive the highest pressures, and using that information we are basically, because it sends back so much data to sort of filter the data, we draw around the joints that - or the portions of the hand that we want to track. So you can see this is the distal phalanx of the - what is that, the first digit, first digit, I think. So you can see in real time what's going on there from a pressure standpoint. So as the person starts to open what happens with that distal phalanx, what happens with the tip of the thumb, what happens with the intermediate joint on the thumb. We then take this and divide it into tasks to look at what's going on for tasks. And you may be going, well, what kind of design insights does this provide? We're trying to see if we know that certain joints are afflicted with arthritis, with pain more than others, can we shape-optimize off of those joints, can we shape-optimize onto the larger muscle bellies, onto the larger bones, onto the larger torque arms where people are using their bodies more effectively as opposed to just

changing the seal interface which will then create situations in distribution that manufacturers aren't going to like.

So with that, Tammy is going to talk about - did you fall asleep? You fell asleep on me?

DR. REID BUSH: Thank you. Let's see. All right, I'm on now. Okay, thanks, Laura.

I'm going to go ahead, and Laura said we were kind of an odd team, and yes, that's correct. And you're going to think, wow, they're really odd when I go to this next slide here.

So we were just talking about packaging and we're no longer talking about packaging. So over here you see I have a cyclist on the right, and then on the left side this is what the computer sees. This is a motion capture system and I use this to demonstrate how we gather motion data because it's a little easier to visualize than five or six targets on two different hands, which would just be a set of 12 targets in space. So at least up here you can see on the left that does look like someone riding a bike. If you look over here on the right, this is the actual individual, and the targets that look like they're glowing are actually lightweight wooden spheres coated with a reflective tape. That reflective tape can be seen - we have a six-camera system surrounding the individual and around each camera is an infrared light source that bounces back off of each

of these targets. So we note the location of the targets that gets transferred into the computer and then we can take the X, Y, Z coordinate data and gather some objective measures about - for the cyclist, what the leg angle is, what the arm angle is, what the torso position was.

So we took this same technology here and we've been utilizing it in the area of hand functionality or in package design and development. And this work is really in its infancy right now because we're just getting started with the methodology development. A motion capture system has been used for sports biomechanics for a long time. It's been used for gait analysis, walking, for quite some time. But studying the fine movements of the hand, people are just beginning to do that. So Laura and my relationship is actually very unique because I go to biomechanics conferences and I talk about package design on hand functionality, and she goes to the packaging conferences talking about biomechanics. And right now no one is doing this sort of combined research. And then we bring in the medical profession as well to this team science approach, and we become really unique.

So here's a hand targeted with the same retro-reflective targets, and we position these on the hand. This is a very basic targeting scheme. We were really looking at one feature, and that was movement of the hand with regard to the

jar. So we only have a few targets on this hand. But we could elaborate and study each of the fingers as we become a little more familiar with how to do this for the packaging side. One caveat that we found in the literature is that when people study how a device is being used, they don't study the device, or the package in this case, in a real scenario. For opening of jars there is some literature on how people go about opening a jar but they require that the jar remain fixed on a tabletop at a certain height, certain distance away from the individual, and they hold it down, and then they remove the lid. Well, of course, that's putting quite a few constraints on the individual and how they open it. And I understand why they did that, because when you ask someone to go ahead and pick up the jar and open it as they would in a normal scenario, we can get a varying response. So we have started with a young, healthy population, healthy in terms of no hand, arm, or shoulder injuries, and we found two different opening scenarios by this population. Over on your left, the individual grasps the bottom of the jar and grasps the top of the jar and then rotated the two in free space. And then over here on the right you can see the individual grasped the side of the jar and twisted both the top and the side of the jar together. So we came up with two different styles, and I'm sure there's more. As Laura has told me with her experience, particularly with the aging population,

they may take that jar and stick it under their arm and grasp it or in between their legs. So we're working towards how do we collect objective data in those scenarios as well. But we're starting with a little easier case right now, and our goal is to move down that path.

So to accommodate this with the targeting system, over here we placed targets on the jar, because not only do we want to know where the hand is in this space, we also have to know where the object is in the space that we're studying, and how the hand and object move relative to one another. So we have what we call the side rig over here, and then for the grasp, when they're grabbing the side of the jar, of course we cannot have targets on the side of the jar, that would change their grip style, so we placed a pole rig on the base of the jar. Then we had subjects pick up these jars and open them as they would in a normal fashion in front of the camera system. So here's an individual using the pole rig and then using the side rig in front of our camera system, and we collected data of this nature. Then we processed it. So we believe that the qualitative collection of information is equally as important as the quantitative collection of data, and it's the marriage of those two that we feel is really going to lead to success in understanding how to develop and design packages that are more usable. So this is one piece of the objective data, and over on

the left this was the left hand on the closure, and you can see as that ramps up that this individual was rotating the closure while keeping the jar or hand fairly stationary. They actually continued to rotate up to 50 degrees when it was actually only required for 25 degrees of rotation to open this jar. But this gives you a little bit of an idea of some of the data that we can garner from these techniques.

Now, motion from a biomechanics perspective, motion is only half of the information. The other half of the information is the force. And in the packaging world they have studied some of the forces associated with the packages and seal force and what it takes to break the seal force. What we're interested is what can the user do, what are the abilities of the user and how do the materials we select or the designs we have change the ability of the user to peel back that lid. So to test this we have - I have six different load cells. They are all three inches cubed, and they can measure the forces relative to the load cell. So, you can see they measure forces in three axes as well as the twisting movements around. So we can get not only that peel force that the user could apply, but the vertical pulling force as well, and depending on how we mount it to the rig, we can get basically get any type of force measurement that's possible for pulling, pushing, probing.

So how can we use this? Well, pull-tabs, right? An area that we're just starting to study are different types of pull-tabs, and we're using the load cells to evaluate material, so whether it's the slippery plastic that's used on the top of your cottage cheese and your yogurt that you pull back, as compared to a Mott's applesauce lid, which is a little thicker, more of a texture, and it's a foil-type, as compared to a completely different design which is a ring pull-tab. So what can the user do in terms of exerting their maximum force on these different types of pull-tabs? And that's just one area for force investigation, and as I said, we coupled the motion, so how they do the movement, along with the forces that they can generate.

So in conclusion, Laura and I have the same belief here, even though we may be an odd pair out in the research world. We are firm believers that you have to understand the ability of the user first before you can successfully design for the user. So our goal is to go along these lines and collect some data and some data bases that can be used to inform the design based on users, starting, of course, with those who are free of dysfunction, but with the idea that once we develop these methodologies, we will move toward someone with disability. Our next line of action is to target those with arthritis, and then moving down that scale. Because this was

said in an earlier talk, this is this huge variability in disabilities, and so we're gradually going to move down that road with these techniques. And again, we aren't silos. We work together and we also work with folks in the medical area as well so we can understand the complete system in a team science approach.

So I think that's all I have, and I'll call Laura back up here and if you have any questions, or what's the procedure?