QUARTERLY OF THE INDUSTRIAL DESIGNERS SOCIETY OF AMERICA **SPRING 2015**

INNOVATION

The Hand

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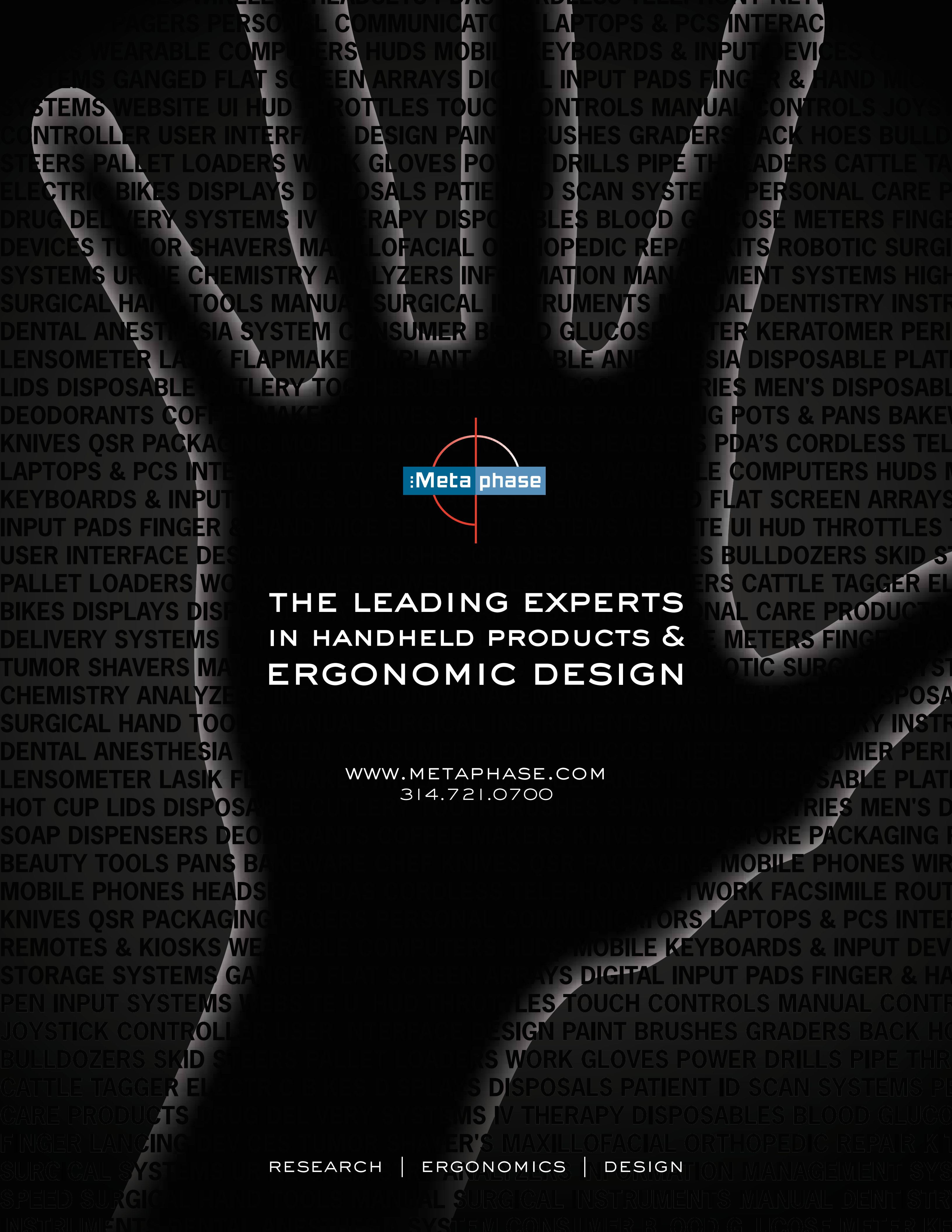

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INNOVATION®

THE HAND

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The quarterly publication of the Industrial Designers Society of America (IDSA), INNOVATION provides in-depth coverage of design issues and long-term trends while communicating the value of design to business and society at large.

IN EVERY ISSUE

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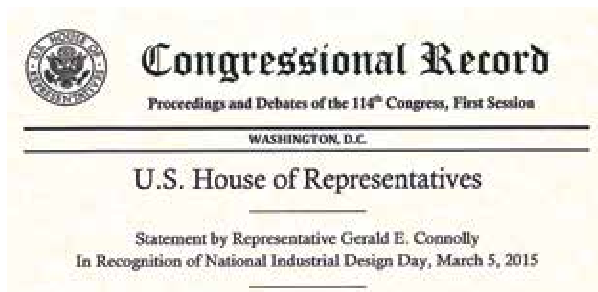
Increased Recognition Prompts New IDSA Initiatives

IDENTIFYING ID


Congressional Record
Proceedings and Debates of the 114th Congress, First Session
WASHINGTON, D.C.
U.S. House of Representatives
Statement by Representative Gerald E. Connolly
In Recognition of National Industrial Design Day, March 5, 2015

IDSA's 50th anniversary received a significant celebratory jolt recently with the official Congressional Declaration of March 5, 2015, as the first **National Industrial Design Day**. The declaration was recorded in the US Congressional Record, and Representative Gerald E. Connolly acknowledged that industrial design professionals "improve our lives in every way and are worthy of our recognition." It was on March 5, 1965, when several industrial design societies officially merged to become the Industrial Designers Society of America (IDSA). Since then IDSA has grown from 600 members to thousands of members in more than two dozen countries today. Connolly also commended IDSA "for being an instrumental force in the growth and expansion" of industrial design.

Recognizing industrial design as a critical contributor to our nation's economy follows an equally important milestone in August 2013 with the publication of the National Endowment for the Arts' (NEA) *Valuing the Art of Industrial Design.* In this landmark study, the NEA recognized industrial designers as "significant contributors" to the invention of new products and services. The NEA report cites a Bureau of Labor study that forecasts the number of employed industrial designers in the United States will reach 45,100 by 2020, a 10.5 percent increase over 2010 figures. A follow-up study released by the NEA's Office of Research & Analysis in January 2015 entitled *Value Added by Architectural and Design Services* found that specialized design service industries—interior, industrial, graphic and "other"—added $15 billion to the US economy.

Does this increased recognition and prominence for industrial design mark a new era for the profession? Undoubtedly yes, but it also ushers in increased responsibility for organizations such as IDSA whose mission is to promote and protect the profession of industrial design. To better meet these challenges, IDSA is forming a government and regulatory affairs task group to proactively monitor, interpret and contribute to policy discussions that impact industrial designers. At our international conference in Austin, TX, last August, we sponsored two open discussion forums—including one on the amicus briefs filed in the *Apple v. Samsung* patent lawsuit.

Currently, two bills on Capitol Hill (HR 1057 and S 560) are seeking to exempt automobile replacement parts from design patent protection. Backed by insurance lobbies, the intent is to allow automobile replacement parts that do not meet the same crashworthiness standards as the original equipment manufacturers replacement parts. Should these bills pass, American consumers will be at risk, and the precedent will lead other powerful industry lobbies to seek equally dangerous and risky exemptions. No other nation has a similar exemption for replacement automobile parts. This is an example of a situation that IDSA should seriously consider weighing in on.

IDSA's leadership is very interested in your opinions and suggestions on forming a government and regulatory affairs group. Send me your comments to me at danielm@idsa.org.

Thank you, and best wishes to your continued success.

—Daniel Martinage, CAE, IDSA Executive Director
danielm@idsa.org

FROM THE EDITOR

CECI N'EST PAS UNE...HAND

When is a hand not a hand? Dr. Bryce Rutter, founder of the design firm Metaphase, is an expert on hands. Metaphase specializes in ergonomics of all kinds, especially when it involves our hands. When Bryce and I first discussed the topic of this issue, I'll be honest, I was concerned that it might be too narrow, too focused, if you will. Would all of IDSA's diverse membership be interested in a complete issue of the journal focused on a human factors topic? Something told me that I was thinking too narrowly, so I greenlighted it despite my doubts. No risk, no reward, right?

It didn't take long to understand that my concern was completely unfounded. Bryce assembled an amazing array of writers around a wonderful range of topics. First consider that our hands are our interface to the world, that we use them to do almost everything. With them we grasp and hold and touch and type—we explore the entire world with them. The topic's range becomes instantly broader when we consider that people also communicate with their hands—they talk with their hands, invite with their hands, regret with their hands. When you consider the hand as a metaphorical idea, it turns out that this topic may be one of the broader and most interesting ones we have addressed recently. The hands are actually a beautiful idea made real, that make the world real and connect us to our emotions.

> ***This Living Hand*** *by John Keats*
> *This living hand, now warm and capable*
> *Of earnest grasping, would, if it were cold*
> *And in the icy silence of the tomb,*
> *So haunt thy days and chill thy dreaming nights*
> *That thou wouldst wish thine own heart dry of blood*
> *So in my veins red life might stream again,*
> *And thou be conscience-calm'd—see here it is—*
> *I hold it towards you.*

The idea that the hands do much more than twist and grasp was re-enforced by a great friend and colleague, Paul Earle, director of Leo Burnett's Farmhouse creative incubator, who points to the fact that the hand—as a metaphor and as, a word—comforts (as in You're in Good Hands with Allstate®") and inspires confidence (as in "Raise Your Hand If You're Sure"). Timeless reflections about the power and strength of the idea of touch and feel as double entendre.

So when is a hand not a hand? When is it a metaphor, an idea, an emotion?

Taking up the idea of the hand as metaphor, it occurred to me that this would be the perfect issue to give out a few hands—hands long-deserved to a number of people who are important to IDSA, to me and especially to INNOVATION.

First, an enthusiastic hand to Charles Austen Angell, IDSA's outgoing chair, who has led IDSA to new places in every way and strengthened the organization, its leadership and its outbound communications. Austen's visionary and charismatic hands have led IDSA and enabled INNOVATION to thrive according to a vision, a drive and a pursuit of excellence that is truly inspiring.

Next, a hand to Daniel Martinage, IDSA's executive director, now in his second year. Daniel is a consummate professional and brilliant association leader who has faced IDSA's many challenges with tact and optimism. With his soft hands he has gently guided IDSA back to solid footing as a membership organization and has created the sturdy platform we now enjoy.

Also a hand to all our guest editors over the years who have generously volunteered their time and effort to bring a fresh and unique perspective to each issue.

As executive editor I extend a special hand to Karen Berube, our managing editor and art director, and Jennifer Yankopolus, our brilliant copy editor. Karen and Jennifer are the hands on the backbone of this journal who worry over every square inch of INNOVATION in a never-ending dedication to making each issue the best it can be.

Last but certainly not least, a big hand to Bryce. It turns out that doing an issue about the hand is a great way to explore the depth of human understanding and human interactions. In his introduction Bryce asks the question, how do our hands age, and how does aging impact our ability to perform day-to-day tasks? This special issue of INNOVATION delves into all things related to designing products that are seamless extensions of our hands and our minds. A sincere thank you to Bryce and his talented group of writers who bring us this issue of INNOVATION about the human hand.

—Mark Dziersk, FIDSA, INNOVATION *Executive Editor*
mark@lunar.com

BOOK REVIEW

A CONFESSION ON THE SECRETS OF CONSULTING

I'll never forget the first time I opened this book. I'll confess, I actually let it sit on my desk for a couple months, in part because it is copyrighted in 1985. It just wasn't a priority compared to the sea of blog posts piled up in my inbox. Besides, on the Super-Information Autobahn of today, 2012 is ancient, let alone '85. I need actionable information now, not a long-winded book from the '80s. I'll never forget the first time I opened this book because my assumptions could not have been more wrong.

It was a Sunday afternoon when I started *The Secrets of Consulting: A Guide to Giving & Getting Advice Successfully* by Gerald M. Weinberg. I was outside on the patio of my next door coffee shop. No computer. I wasn't thrilled to be there. But I had put this book off for too long. It was time. When the waitress with the red hair and white teeth asked me what I was reading, I nodded to the cover. "*The Secrets of Consulting*. Oh, fun." Her eyes widened as she turned back around.

I shrugged. Her response mirrored my mood. The irony, I was about to learn, was that Weinberg's honest insight about the word "consultant" was about to address the very indifference that both the waitress and I had felt. In the first pages I was struck by his frankness: "Perhaps you thought that the consultant, of all people, must be logical, single-minded, and above all, serious. Nothing could be further from the truth."

I felt an eerie sensation in the back of my neck. Like Weinberg had been sitting behind me, read my mind and was now writing directly to me. But that's silly.

I read on: "First of all, consultants deal in change. Most people function quite logically most of the time. Most of the time they don't need consultants. The time they do need a consultant is when logic isn't working. They are, in a word, stuck." Interesting. I flipped though the first chapter to see the Three Laws of Consulting in bold:

1. "In spite of what your client may tell you, there's always a problem."
2. "No matter how it looks at first, it's always a people problem."
3. "Never forget they're paying you by the hour, not by the solution."

I was hooked. From cover to cover *The Secrets of Consulting* contains years of distilled wisdom in the form of paradox, dilemma and contradiction. In the click-bait age of "5 Weird Habits That Wildly Successful People Do Every Day," Weinberg's no-fluff, story-based writing style is refreshing, inspiring and memorable. The end of each story is boiled down to a sentence-long law or principle. Today, it's easy to expect content to be modeled to the constraints of their location. Blogs are long, tweets are short. In 1985, neither of those words existed. Had they, Weinberg's writing structure would have suited both. The best of both worlds. As a writer, his content structure is fascinating; as a human, his wisdom is unforgettable.

My favorite story comes from the last chapter, "Getting People to Follow Your Advice: Lessons from the Farm." Weinberg explains that for city folks, getting to know farmers is not the most thrilling endeavor. Time seems to move at a slower pace outside of city life. Less is said out loud. Yet, come natural disaster, blizzard, tornado or flood, your neighbors will appear with food, tools and help in every type of way. As Weinberg puts it, "Not a lot of words—just help."

On the other hand, if you don't desire their help, an understood "thanks" and a head nod is all that is needed and they disappear back into silence.

Because farmers don't tend to be the talkative type, city folk think of them as simple minded. This couldn't be further from the truth. Weinberg explains that every one of his neighbors is "involved in a multimillion-dollar business that is intricately interconnected with 20 other businesses." Consultants need to think of themselves in this way—partners who provide value when needed and step out of the way when they're not.

We need more stories today. Stories have plots, characters, disappointment and redemption. They're hard to forget. This is a must read for anyone who consults or who hires consultants. This is a must read for everyone because the moment someone asks your advice you've become a consultant. Now, if only the waitress with the red hair and white teeth knew that when I asked for her favorite drink on the menu, she had become my coffee consultant.

—Leigh Wasson, Senior Social Media Strategist, Supreme Optimization, @leighwasson

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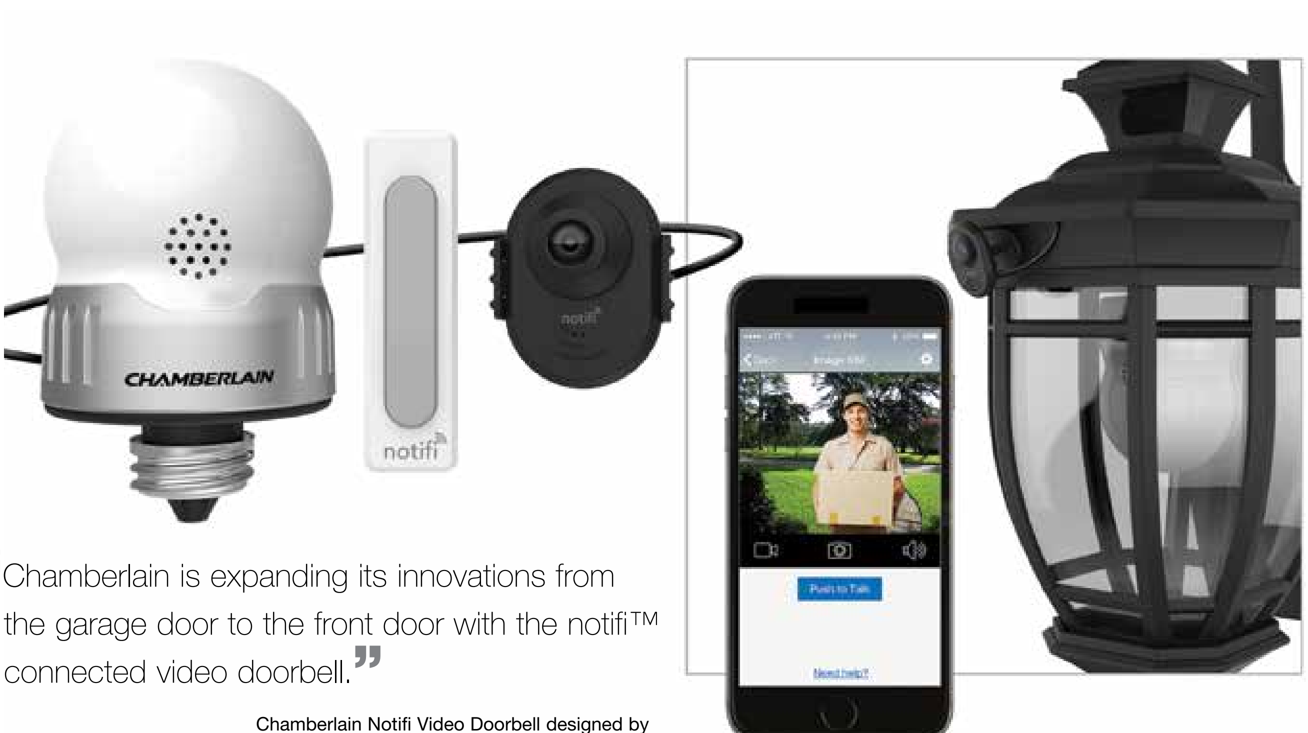


"Chamberlain is expanding its innovations from the garage door to the front door with the notifi™ connected video doorbell."

Chamberlain Notifi Video Doorbell designed by
The Chamberlain Group for Chamberlain; www.chamberlain.com

DESIGN = STORY

I'm a words person working in the visual world of design. As an avid reader and sometimes writer, I've always had an ease and comfort in the verbal, and marveled at how words, sentences, punctuation, even grammar taken together can spin narrative and have meaning, sometimes, beyond the words. That is, tell stories.

To take a tool from a writer's craft, there is irony in this words person working in the visual world of design—and loving it. The power I see in words telling stories can be even more potent in design.

For me, design is intended to tell a story that creates an intimate relationship with its "reader." Rather than words, design tells stories in the visual language of shapes and symbols, punctuating its language with hard corners and bold colors and whispering with smooth edges and soft hues.

As in our interpersonal communications, the more you find common links with someone, the more emotional the bond you have with that person. In the same way, design can speak to you—whether it's a chair you sit in or a package you buy—in a common language that demonstrates "I get you" in a way that creates relationship.

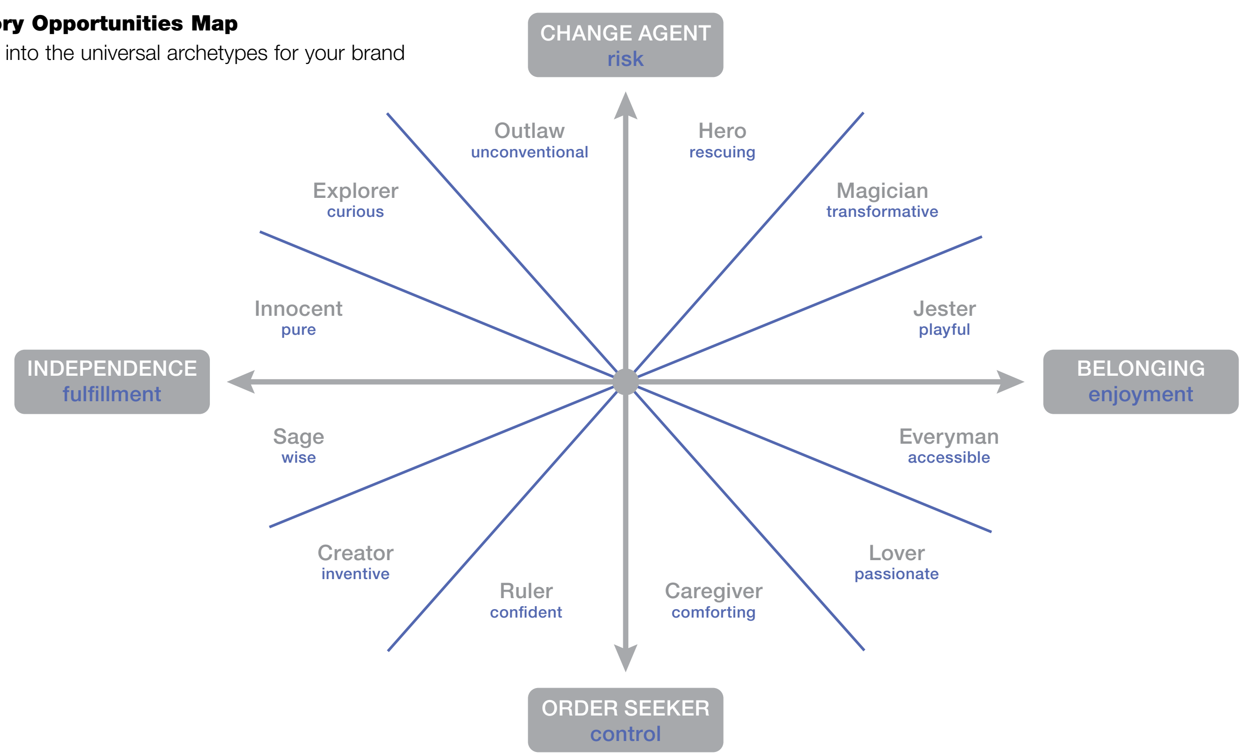
The idea of a common language was studied by Joseph Campbell, who studied tribes both exotic and urban around the world and recognized that the same stories were being told without any possibility of communication between them. He called this concept "monomyth" or "variations of a single great story." This phenomenon, I believe, demonstrated what Carl Jung called the "collective unconscious," a link that connects all of us, regardless of condition, to our common journey of humanity: "a collective, universal, impersonal nature which is identical in all individuals."

Tapping into this collective story is the pinnacle of what design can and should be. Because that is where relationships develop among people, products and brands.

Jung's work defined the common characters in this story as archetypes, which even without a lot of study we

Story Opportunities Map

Tap into the universal archetypes for your brand



intuitively understand because they are universal. All the fairy tales we grew up with include this cast of characters: a brave man (Hero) who despite the odds rescues the Princess (Innocent) usually with the help of a fairy godmother (Sage) or wizard (Magician) and her return is celebrated by her father the King (Ruler) by sharing a feast, complete with entertainment (Jester). And everyone lives "happily ever after."

Archetypes have become instrumental in design strategy for defining the essence of a brand that tells its story through design. A Jester is associated with imagery, symbols and patterns that we recognize intrinsically, without knowing why or how, appealing to our playful spirit. The Wizard's magic wand suggests a problem-solution story, while his crystal ball implies a story about the future. A Sage communicates wisdom, while a Hero is what Campbell called each of us to be in our own life journey in his mantra, "Follow your bliss."

All of these archetypal characters manifest in us in some way, and the shapes and symbols that mimic these icons start to carry that communication with them. Brands tap into these symbols for the emotions they conjure and to create a more intimate bond. It is this visual language of design that delivers a common experience.

These shared stories provide the currency of meaning to shape, form, color and any other tool of design. What intrigues and excites me about working in the domain of the visual is the power these shapes and symbols have for what they communicate in short order based on no other link between us beyond our shared stories and their characters.

I like to think of shapes as the words, form the grammar and color the punctuation in a designer's craft of articulating meaning to tell stories. In this way, design can tell stories more efficiently—one image has the power to tell a story beyond what any number of words could.

This is the real opportunity.

Design, when it wields its fluency of visual language, appeals to that "single great story" of being human we all share. In doing so, design taps into not only our emotions, but our being. To not only engage and delight, but to move people. Like any great story should.

—Gina Signorella, Client Services Director, Boxer Design
Gina.Signorella@boxerbranddesign.com

LETTER TO THE EDITOR

Dear Tucker,

I just could not resist writing to you after reading your piece in the Winter edition of INNOVATION. I know you don't know me, but I just have to let you know how your article brought back such memories of your mom, dad and Budd to me.

My name is Harry Giambrone, L/IDSA and I was a student of your dad's at the Dayton Art Institute. After graduating in 1951, I went to work for Jack Morgan in Chicago and worked with him until 1960 when I returned to Dayton to start my own consulting design business. Not incidentally, I became a member of the Society of Industrial Design (SID), for what that is worth, while in Chicago. I'm so glad that you wrote about the SID organization for I'm certain very few are aware of the origins of their present organization.

But what I really want to talk about is my relationship to your mom and dad and Budd. When I returned to Dayton, I of course got back in touch with them and enjoyed our camaraderie over the years. At times I worked for your dad and Budd in the more modern version of the Chicken Coop. We remained friends and had a lot of laughs together with Budd's great sense of humor. Unfortunately, I never got to know you as a young man, but I do remember when you were born. Your mom and dad were so proud of your accomplishments. I'm now 90 years old, have the shakes and can hardly hold a pencil but have lots of pleasant memories of our profession and its progress. Most of all, the memory of your mom, dad and Budd will never fade.

—Harry Giambrone, L/IDSA
hgiam@att.net

Above: Read Viemeister, FIDSA (left) and Budd Steinhilber, FIDSA in the Conference Room of their new VIE DESIGN STUDIOS office building (circa 1952)

Farm & Wilderness Foundation

ALL PLAY +

One of those huge, wicked problems lurking behind the stubborn economic mess we're in is jobs (not Steve). More than the changing labor needs of industry, the problem is what are people going to do as technology changes the very nature of work and the meaning of life. Luckily, polymath industrial designers will be able to keep ahead of that unemployment curve—but what about everyone else? What makes the outlook bleaker than imagining robots doing all the work is the prospect of everyone lazing around watching Kanye West, "Keeping Up with the Kardashians" or reruns of "StarTrek." What about our clients and our customers? How much artisanal beer can we drink?

The answer is important to industrial designers and educators because we create the future, both through the stuff we design and in how we train the kids. It seems like unemployment hits knowledge workers less than other fields—but eventually (if all goes well) we'll all be in the same boat.

In the last INNOVATION issue, I wrote about the 15 forefathers who founded one of our predecessor professional organizations back in the '30s, when "1984" was still in the future. I speculated on what they were thinking when they banded together to form the Society of Industrial Design (SID). What did they gain from joining forces? I thought that together they could be faster than a speeding bullet and more powerful than a locomotive! But Budd Steinhilber, FIDSA corrected me: "In deference to your vague speculation, there is a much simpler answer. Here's my understanding of the history: Seven of those initial founders had offices in the State of New York, which collected a flat business tax. However 'professionals' (e.g., doctors, architects, civil engineers, attorneys, et al) were exempt from the tax. When Walter Teague, FIDSA sought exemption, he was informed that creative services were not considered a profession, that all professionals have strict codes of conduct and ethical guidelines governed by their professional associations. Teague set out to change that by

NO WORK?

initiating a professional society of industrial designers (as in SID). He won his case. Thus, the original motivation tended to be about self-interest—more about money than moral obligations."

Industrial designers are at least as important as lawyers. Our personal rewards—physical gratification and intellectual pleasure, even more than intellectual property—fuel progress. Our profession is both good and fun. Machiavelli wasn't talking about us when he said "The ends justify the means" because our iterative process is both the ends and the means! It is a circular funfest of interdependencies. Our job depends on users and our users depend on our work. "User-centric" means we care about them and that we also need them to use the stuff we designed for them.

Malcolm Gladwell isn't worried about fixing climate change; he says it's a technical problem and that if things like Moore's Law continue, technology will be able to outpace the disasters with new solutions. We'll be saved by some version of the Internet of Things where all our stuff is so interconnected that it attains some kind of mass intelligence—people won't have to worry about losing their keys or the level of the oceans because our things will do the worrying and the fixing for us! OK, so that solves global warming, but survival isn't everything. The next problem will be what will be left for the people to do?

If the machines are taking all the responsibility and doing all the work, what's the meaning of life for us? Our personal identities are linked to our work. We measure our worth in the size of the home we earned, our frequent flying perks or the brand names of our clients. Work is the supreme signifier. Our jobs give our lives direction as well as sustenance.

What's work? Although it seems counterintuitive—all those spinners at SoulCycle are actually doing work, according to scientists. Physics has a formula for work: a constant force of magnitude F on a point that moves a displacement s in the direction of the force: W=Fs. For people (and Webster's) *work* is "a job or activity that you do in order to earn money."

Having a job is great: you win points (i.e., money), get a role in a team, get a schedule for your life and a future. A company is a support structure that gives people meaning (and a warm place to do emails). Employment reaches deep into our lives. It's hard for non-job-related activities to create such a strong bond. Many jobs may seem menial—everyone working at McDonald's may not be "lovin' it," but even it has perks.

I became an industrial designer because I saw how much fun and satisfaction my dad was having. (He obviously was not doing it for the money!) I noticed when I was building my loft that it seemed like the construction workers were a happy bunch, too. I realized that everyday they made something with their hands and left work satisfied that they had accomplished something tangible. When I was in high school I went to the Farm and Wilderness summer camp in the Green Mountains. They opened for their first summer in 1939 without any facilities because they spent all their money to acquire land in West Bridgewater, VT. They turned adversity into opportunity by putting the campers to work building their own cabins. By the end of the summer not only did they have a bunch of funky cabins, they had created a community with an unbreakable bond. It turned out that what is more meaningful than learning to water ski or even singing "Kumbaya" is contributing meaningful work to the community.

What makes work meaningful? Doing things that make you feel good and that feel good for your community. Doing things that are needed or useful, or are a means of self-expression. Personal meaning comes from personal satisfaction and also from the significance that other people or groups bestow on your work. (For example: this article. I'm feeling good writing it, but my compensation is when you, dear reader, enjoy it, too!) Hobbies and play are meaningful work.

Psychologist Jean Piaget declares, "Play is the work of children." (Meaning that play is important for kids—not that they must work in a sweatshop *playing* with weaving machines.) Although play usually is recreational, our job—solving problems and making things—could be considered play (at least that's why I do it).

Nowadays, values seem misplaced. For instance, the ConEd workers might be very satisfied after fixing the electrical line while passersby wonder why all those guys are wasting time hanging around the manhole—we should be thanking them for keeping our lights on. Tiger Woods was the first to earn $100 million in *Forbes*' annual list of the highest-paid athletes—meanwhile the cops are profiling the kid playing basketball in Brooklyn. What may be overlooked in the push for efficient and high-paying results is that the *process* is what is important, more satisfying and meaningful than a pot of gold. Menial labor, like spinning at SoulCycle or stirring the Brooklyn brew hops, has a different kind of value. Play is more important than pay.

As a species moving toward total control of our environment, we need to prepare ourselves by training everyone to value meaningful employment—both how to do it and how to appreciate it. Doing meaningful work will help humanity in two ways: make the growing population feel valued and encourage us all to work together on projects (critical or not). Meaningful is doing scientific research, developing more efficient transportation, growing better food, cleaning up the garbage, taking care of sick people and, of course, designing better things!

The good news is that all humans are designers—in fact *designing* is the constellation of attributes that distinguishes humans from other animals. We can recognize humanity's micro-design capabilities by crowdsourcing results (as well as picking up your kid's dirty socks). Everyone can feel fulfilled creating cool stuff (just like we designers do every day). It might not feel like utopia—but it is! Or at least it's on the road to some kind of Beautility where fun and function unite (you can't have *function* without *fun*).

—Tucker Viemeister, FIDSA
www.tuckerviemeister.com

A LOOK BACK

OVERLOOKED IDSA FELLOWS RESTORED

One of IDSA's most distinguished honors conferred publicly and annually on certain members is Fellowship, a unique group of members known as the Academy of Fellows who have "earned the special respect and affection of the membership through distinguished service to the society, and to the profession as a whole," as the honor is formally described. Such members can be identified by the "FIDSA" following their names for the rest of their lives.

Unfortunately, over many years, cumulative historical clerical practices and the merger of predecessor organizations in 1965 to form IDSA have denied a number of deceased members proper, permanent recognition in IDSA's honored Academy of Fellows. The number of "overlooked" Fellows has accumulated because of past organizational protocol going back far before the merger that originally created IDSA. During IDSA's 50th anniversary in 2015, we would be remiss if we did not correct as many of these errors as possible.

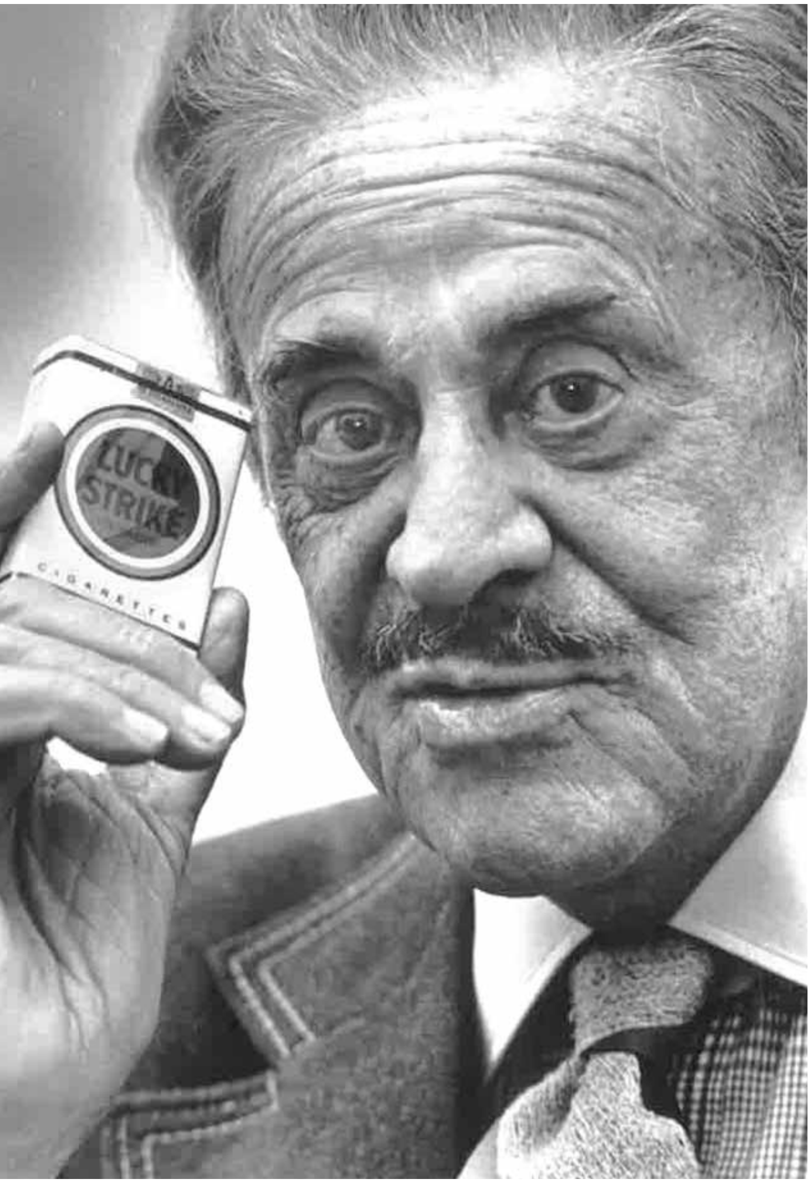
Long before their merger in 1965, IDSA's predecessors, the Industrial Designers Institute (IDI) and the American Society of Industrial Designers (ASID), honored their outstanding members with Fellowship, and identified them as such in their annual membership directories. However, as these Fellows became deceased or dropped their membership, their names (and their honor) were removed from the current directory. Accordingly, the directories of IDI and ASID in 1964 included only Fellows who were still living and were still members at the time the directories were published.

When the merger of these predecessor organizations occurred in 1965, IDSA automatically accepted and honored all living IDI and ASID Fellows, (FIDI and FASID, respectively), as Fellows in IDSA (FIDSA). But of course, at this time, IDSA was not aware of a number of deceased

Former IDI members John W. Hauser, John Vassos and Alfons Bach are all IDSA Fellows.

Fellows who had been dropped from previous membership directories. For a number of years after that, IDSA's annual directory included the member status (such as Full, Associate, Life, Fellow) after each person's name. However, between clerical errors such as Fellows being erroneously listed as full or life and the continuing practice of removing names of Fellows who became deceased or had dropped or been dropped from membership by IDSA, the number of living Fellows continued to decrease.

The IDSA list of Fellows as an honored independent group only began with the 1978 directory, which listed



One of the founders of ASID, Raymond Loewy, FIDSA has always been a member of the IDSA Academy of Fellows.

primarily the known, living Fellows on record at the time. Starting with the 1992–1993 directory, IDSA decided to include deceased Fellows in the list, even though some had dropped their membership or had been dropped when they stopped paying dues. At this time, some deceased Fellows' names were added, when known or remembered, but others were not because they were still unknown.

By 2001, this comprehensive list of Fellows in the annual directory was being called IDSA's Academy of Fellows. As chair of IDSA's Design History Section at that time, I became aware that many deceased Fellows were missing from the Academy, so I conducted a thorough analysis of all IDSA directories back to the first, published in 1966, and determined that about 30 IDSA deceased Fellows had been omitted from the Academy of Fellows. These were all immediately added to the 2002 Academy of Fellows list, and included prominent and well-known pioneer industrial designers such as Egmont Arens, FIDSA, a founder of the Society of Industrial Designers (SID), the predecessor to ASID, in 1944; Dave Chapman, FIDSA, founder of the Chicago Society of Industrial Designers in 1938; Donald Deskey, FIDSA, a founder of SID; Lurelle Guild, FIDSA, a founder of SID; and Russel Wright, FIDSA, a founder of SID.

In 2012, it was noticed that Walter Dorwin Teague was not listed in the IDSA Academy of Fellows. Teague, who entered the profession in 1927 after a successful career as a graphic artist, was called the "Doyen of the Profession" by 1934 and was one of the founders of SID. Because of Teague's outstanding fame and influence in the profession, this seemed to be a glaring and embarrassing omission. I realized that he had died five years before IDSA was formed, and therefore had been automatically removed from the membership list of living Fellows of ASID, the standard process described earlier. Accordingly, he had never been identified by IDSA as an ASID Fellow. This sad discovery triggered a renewal of my interest in searching for additional Fellows who had been overlooked earlier than the 1965 merger. However, this would be possible only by searching through pre-1965 directories of IDI and ASID, few of which, if any, were readily available in 2012, 47 or more years later.

It turned out that some of these directories were, in fact, buried in archival storage in the Special Collections Research Center at the Syracuse University Library in a collection of industrial designers' work and personal records initiated in the 1970s by Arthur Jon Pulos, FIDSA, a past head of the Syracuse Design Department, an industrial design historian and an IDSA past president. The collection contains the personal files of a number of early designers, such as John Vassos, founder of the American Designer's Institute (ADI), predecessor to IDI, in 1938, as well as large collections from IDSA. I requested and obtained authorized funds (about $300) shared by the IDSA Board of Directors and the IDSA Design History Section to hire a professional researcher to look through archival materials at the Syracuse Special Collections archives, specifically to look for pre-1965 IDI and ASID membership lists.

Over several months, nearly 30 file boxes were carefully searched at the library, but in only four of them were pre-1965 directories of IDI and ASID found. In July 2013, I submitted a report to IDSA of what was found and verified from the pre-1965 ASID documents, along with copies of the actual documents confirming the information. Of the 15 founders of ASID in 1944, all of whom became Fellows, eight had been overlooked and excluded from the permanent Academy of Fellows, including Walter Dorwin Teague, Norman Bel Geddes, Raymond E. Patten, Joseph B. Platt, John Gordon Rideout, George Sakier, Joseph Claude Sinel and Harold Van Doren. The remaining seven founders of ASID who had already been identified as Fellows are Egmont Arens, Donald Deskey, Henry Dreyfuss, Lurelle Guild, Raymond Loewy and Brooks Stevens. An additional ASID Fellow was found: Gilbert Rohde. All of these were prominent members of the profession in 1944.

Teague has already been publicly honored by IDSA as a posthumous Fellow on pages 11–12 of IDSA's Fall 2014 issue of INNOVATION, and his name has already been added to the Academy of Fellows. The others will soon follow. Bel Geddes was a highly successful New York theatrical set designer before he entered industrial design in 1927, and practically invented the interstate highway system with his Futurama exhibit at the 1939 New York World's Fair. In 1934, Patten established the first industrial design department for General Electric in Bridgeport, CT. He held this position until his death. Platt, who designed the classic 1951 Parker 51 fountain pen, was a friend and neighbor of Loewy. Van Doren and Rideout were partners in their 1931 office in Toledo, designing streamlined toy scooters and pedal cars. Van Doren later opened a Philadelphia office to design Philco major appliances. Sakier designed glassware for Fostoria Glass in West Virginia for 50 years, and in 1927 headed the Bureau of Design Development for the American Radiator and Standard Sanitary Corporation. Sinel, a New Zealander, was designing art deco products and package designs in the 1920s, and later taught industrial design at a number of schools. Rohde was appointed director of design for the Herman Miller Furniture Company in Zeeland, MI in 1932 and was a pioneer in modern furniture design.

In addition, the following seven Fellows from IDI who had been overlooked in the Academy of Fellows were found and documented in pre-1965 IDI documents. They are Ruth Gertz, Henry Hagert, Marie Kirkpatrick, Alexander Kostellow, Ben Nash, C.E. (Chauncey Eugene) "Chick" Waltman and Scott Wilson. While some of these names are not well known, Kostellow was on the faculty of the first degreed industrial design program initiated at Carnegie Institute of Technology in 1934, and went on to become the prominent and beloved head of the design department at Pratt Institute in Brooklyn in 1938 until his death. Waltman was already well known as a decorative lamp designer in Chicago as early as 1920, and probably established Chicago's first industrial design office in 1925, although the name of the new profession was at the time yet unknown.

It would be unacceptable to deny permanent recognition to deserving Fellows honored by predecessor organizations prior to 1965. Despite these late discoveries through continuing research, IDSA is proud to add these 16 overlooked Fellows to its Academy of Fellows, which can found on the IDSA website (www.idsa.org/academy-fellows) with, in most cases, photos of the honored individual.

—Carroll Gantz, FIDSA
carrgantz@bellsouth.net

Sea of hands leading to the Wat Rong Khun White Temple in Thailand.

WELCOME TO THE HAND

Over 95 percent of all the products we interface with daily involve the use of our hands in some way. We use this anatomic tool to pull, twist, grip, pinch, move, steer, hold, squeeze, turn, lift, scratch, slide, tighten, bend, tap and open, among other things. But how do we intuitively know when to use two, three, four or five fingers?

How do we sense and control our arms and hands to type an email or dissect heart tissue when the brain needs to control a multiplicity of joints and degrees of freedom? How do we sense textures, surfaces and materials? How do our hands age, and how does aging impact our ability to perform day-to-day tasks?

In this special issue of INNOVATION dedicated to the hand, we begin with how the hand is tied to our culture with an article by **Paul Earle**, who delightfully shares how we use gestures to communicate everything from happiness to hate and how the hand has played a significant role in corporate communication programs. **Dan Formosa** provides a foundation on the anatomic structure and design of the hand, including how the hand doesn't work. **Mary Carlton** and **Les Carlton** illuminate the ontogeny of hand's function, highlighting how we acquire coordination, control and skill throughout our early years. **David Cowan**'s article segues into how these skills and capabilities slowly deteriorate as we age and how his students at Georgia Tech envision products that facilitate the quality of life and aging in place with dignity. **Brad Fain**'s article extends this thinking by presenting a framework for empathetic design and design validation techniques to measure the efficacy of designs when used by challenged hands.

In today's digital age, the way in which we interface with products is changing dramatically. The pervasiveness of mobile devices and gaming controllers has created a whole new role for our thumb. **Keith Karn** provides us with a compelling argument to move beyond traditional static anthropometry laid out in the classic Henry Dreyfuss Humanscale series to research and design digital interfaces that are compatible with how our fingers and thumbs move dynamically in space. Staying in the digital space, **Laura Joss** highlights the importance of going beyond traditional research methods in the design of mobile devices by implementing longitudinal ethnographic techniques that allow designers (and to me, "designers" includes people like Laura who shape and inform the design outcome) to gain valuable insights into day-to-day use of prototypes to fine-tune and finesse each and every last detail in the product.

We then drill into the finer points on how to design handheld products. **Peter Clarke** shares his insight and experience in packaging design with design guidelines that eliminate wrap rage. **Eunji Park** and **Stephanie Morgan** highlight the importance of thinking beyond the product itself, taking into account the ecosystem within which the product lives, in their case designing hearing aids for aging hands and minds. We then dive in deeper, literally, with **Alan Mudd**'s experiences in the research and design of handheld laparoscopic surgical instrumentation for which he provides key insights into instrument grip design and control location to optimize a surgeon's dexterity and control.

Given the long, brutal winter we all have experienced, I asked **Stephen Wilcox, FIDSA** to share his thoughts on the ergonomics of shoveling snow, and as only Steve can do, he somehow segues from using our hands to shovel snow to highlighting key human factors that designer's must address when designing handheld surgical instruments. Lastly, **Michael Wiklund**, author and expert in human factors engineering, provides a terrific checklist of critical success factors that need to be considered when designing any type of handheld medical device.

I trust that this issue will touch each reader in its own way with hands-on information, giving you a better grip on how to design handheld products that exploit the potency of the human hand in defining a unique and ownable consumer brand experience.

On the other hand…

—Dr. Bryce G. Rutter, IDSA
INNOVATION Guest Editor, President, Metaphase

THE HUMAN HAND

I remember the first time I touched my wife's hand. It was truly electric, as it still is today. Her skin was warm and smooth. I don't know how I could sense it, but through her touch I could feel her radiance, warmth, confidence and sense of humor. That first touch instantaneously triggered every one of my brain cells and immediately created a unique haptic signature that still persists 31 years later. Similarly, I remember how my grandfather's hand felt 24 years ago, when he was 92, as I sat on the couch next to him holding his hand. He was tall with thick, calloused hands from the manual labor of a farmer pushing on the end of a shovel, picking apples or working on his Farmall A tractor. While his hands were large and strong, his touch was gentle. I also will never forget how my memory of his hands changed in an instant when I reached out and held them as he lay in his casket.

By Bryce G. Rutter, PhD, IDSA

bryce@metaphase.com

Bryce Rutter is a renowned specialist in ergonomic product design and the leading expert in the design of handheld products. He has been profiled by the *Wall Street Journal*, CNN, CTV, CITYTV, *Chicago Tribune*, *Ottawa Citizen*, *Toronto Globe & Mail, Lexus Magazine* and *Metropolis*. He has been awarded over 100 patents, and his company has received more than 75 international design awards.

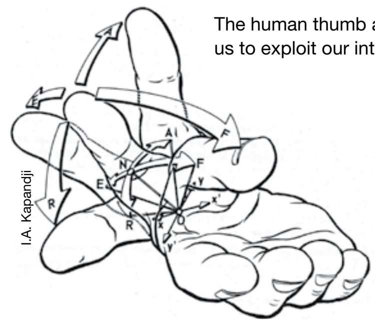
What is truly amazing to me is how indelibly etched these tactile experiences are in my heart and mind decades later. These are great examples that underlie the power of touch and the permanence of haptic memory. Both magnify the need and opportunity to sweat each and every detail in the design of everyday objects—because every detail matters.

What Is a Human Hand?

Next to the brain, the hand is the most fascinating and complex human organ we have. It is used for more natural actions that interface with our artificial world than any other anatomical unit, and as such its role in helping humans to effectively work and play is significant. Given the central role hands play in our existence, it is surprising just how little we understand about how we elicit such utility from these funny-looking, five-pronged, multihinged instruments of prehension dangling from our shoulders.

The oldest definition of the human hand is provided by Sir Charles Bell in his 1834 *Bridgewater Treaties, Volume IV: The Hand, Its Mechanism and Vital Endowments as Evincing Design*: "We ought to define the hand as being exclusively to man—corresponding in sensibility and motion in that ingenuity which converts the being who is the weakest in natural defense, to the ruler over animate and inanimate nature." Without a doubt this is the most fascinating book written to date on the evolution, phylogeny and ontogeny of the human hand. Bell's definition, by virtue of its generality, is specific and offers clearly defined boundaries for the word. Human is implicit in the word "hand."

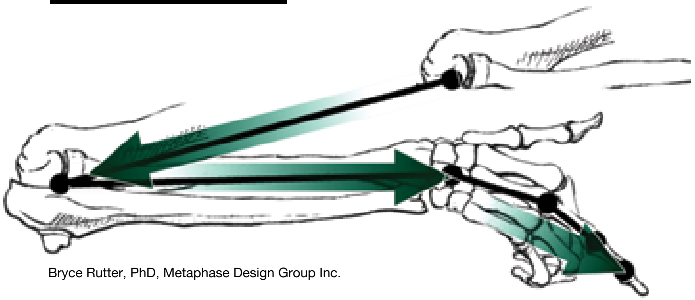
What is clear and defining about the human hand is that we possess an opposable thumb to the other four fingers. This hand function alone separates man from primates, who also possess five digits but without opposition do not have the advance functioning capability that we as humans possess as toolmakers. So next time you look at your hand, pay a little more respect to the role of your thumb!



The human thumb affords opposition and has allowed us to exploit our intellect to its fullest extent.

Think about how we use our hands throughout a typical day. You wake to your alarm using your fingers to turn it off, trudge off to the kitchen to load your coffee maker, grab and position your cup under the spout, grasp the fridge door handle with one hand and with the other reach in and grab the cream that you then pour into your coffee. Using a wide variety of grips and dexterous motions, you use knives, forks, spoons and other kitchen appliances to make a quick breakfast. Now off to work. You jump in your car, and using a wide variety of hand controls, you navigate the streets while selecting your source of entertainment and adjusting the climate. At work you sit in front of your workstation using your mobile device, keyboard and mouse to navigate another digital day. Two hours in and the amount of time and the number of different ways in which you have used your hands to navigate a typical life is nothing less than amazing and ubiquitous. There is no other organ we use as continuously and with as much variety as we do with our hands.

Our current understanding of the human hand is limited to physiological and anatomic characteristics and, to a lesser degree, by mechanical properties of what the hand is capable of doing. To date, there is no agreed to model on how the hand is controlled or coordinated by the brain—referred to as motor control. The prevailing majority opinion is that as we mature we build a library of motor programs that are stored in our brain that we draw on for each and every action. For example, this camp believes that when you reach for your cup of coffee in the morning that there is a homunculus in your mind that selects the "grasp my coffee cup" motor program off the shelf that drives your grasping behavior. Regardless of the prominence of this opinion, it's impossible for me and other leading experts to accept this



Bryce Rutter, PhD, Metaphase Design Group Inc.

As we grow and as adults when learning new and novel tasks we acquire coordination and control in the arm by first "locking" out the elbow, wrist and hand joints, then after mastering shoulder control we successively unlock and master the remaining joints—proximal to distal motor skill develop.

theory when you think of the trillions of motor programs that would need to be stored in your brain for even the simplest day—not to mention the need to marshal them in picoseconds or less to execute a successful outcome without any delays. This camp also has great difficulty explaining how we can successfully execute new and novel behaviors when there is no previous motor program to pull off the shelf.

In 1967, J.J. Gibson pioneered the field of ecological psychology, which prescribes that our movements and behavior are driven by what we see and that objects around us provide information meaningful to the control and coordination of action—*affordances*—and when integrated with intentionality cause us to react with the most effective action patterns. For example, when you look at the handle of your coffee cup, you immediately and automatically know what grip to use based on the relative size of your hand to the size of the handle and whether the cup is full or empty.

Understanding affordances and how they drive our grasping behavior is important because through the articulation of a product's shape, size, color, textures, mass, etc., designers are in fact constructing affordances that tell users how to most effectively interact with the product. For example, if design constraints dictate that a product requires a specific amount of force or range of motion, the designer can embed visual, tactile and auditory cues into its design that will afford and elicit the most effective user behavior, biomechanically, functionally and emotionally.

All of us at some point in time have tried to use a product only to be frustrated to learn that how we think is in fact incorrect. This lack of intuitiveness is directly linked to a product's affordances being wrong. Explicit and seamless communication of a product's functionality means that the content of its affordance provides all the necessary cues relative to action, size and form for the user to automatically determine the optimal behavioral interface. A final point: I do not want to confuse product semantics with affordances where the former speaks to a product's imagery, contrasted to the latter, which is the scientific and calculated articulation of a product's form, scale, texture, color and physical properties by the designer to communicate all necessary visual, physical, functional and sensory-based cues to drive the most efficient human response.

How Hands Get Smart

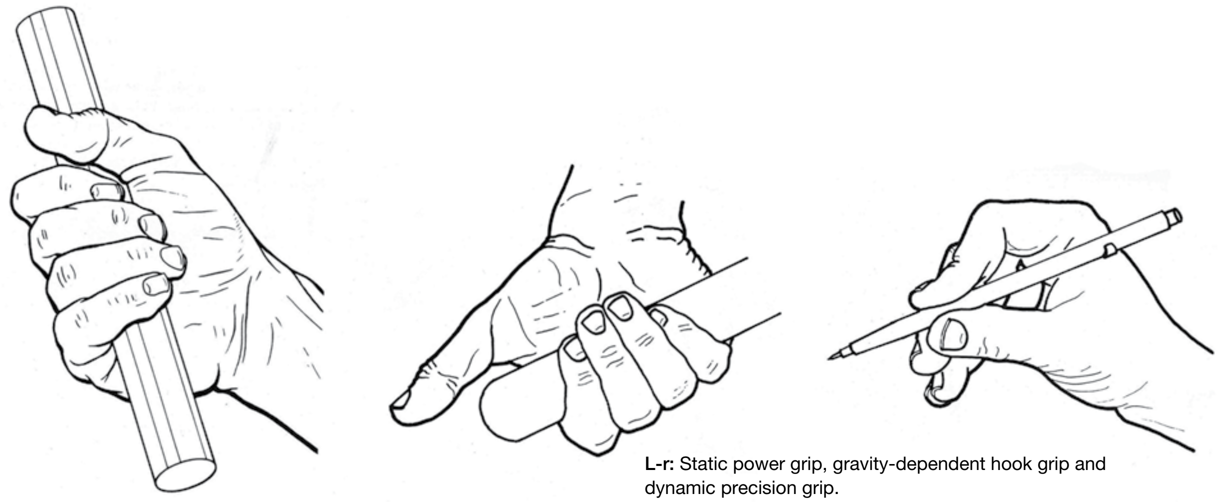
We've all witnessed infants taking their first Frankenstein-like steps, then over time learning to walk fluidly like an adult. Similarly, when you are learning how to play a racquet sport you have the same initial awkward robotic motion, and as you begin to master the skill, your finesse, coordination and control increase. In both cases, the same phenomena is in play. Mastery of coordination, control and skill in the hand develops proximally to distally. As we begin to learn a new task, our brain by necessity limits the degrees of freedom it needs to control the biokinematic chain. When learning any new, hand-related task, first we lock out the shoulder joint, then our elbow, wrist and fingers so that our brain has fewer things to control. Then as we develop mastery over our shoulder joint, our brain engages control of the elbow and subsequently the wrist and then the fingers.

This is important when designing handheld products that require any degree of novelty or learning. To the extent that you can design a product that leverages legacy motions that do not need to be learned, there will be a benefit. However, when not possible and you are designing products that require novel control characteristics, it is imperative to think about how novice users will migrate to expert users and how you can articulate the scale, form, textures, control interface and configuration of the product to mitigate control conflicts and to optimize the acquisition of dexterity. This is accomplished by designing in physical attributes that allow the novice user to be successful as they migrate through to mastery.

Grip Architectures & Grasping Strategies

While the variety of things we do with our hands on a daily basis are broad and diverse, common threads cut across the way in which we use our hands. Broadly speaking, we use three general categories of grip architectures: static grips, dynamic grips and gravity-dependent grips. The most common type of static grip we design for is a power grip when brute force is needed, for example, when swinging a hammer or holding a small bone saw steady when cutting the skullcap. The most common type of gravity-dependent grip we use daily when carrying things is the hook grip. Precision grips—which include bilateral, trilateral and multilateral grip architectures—are used when accuracy is needed, and typically are dynamic grips that we use to execute dexterous control over an object.

I.A. Kapandji



L-r: Static power grip, gravity-dependent hook grip and dynamic precision grip.

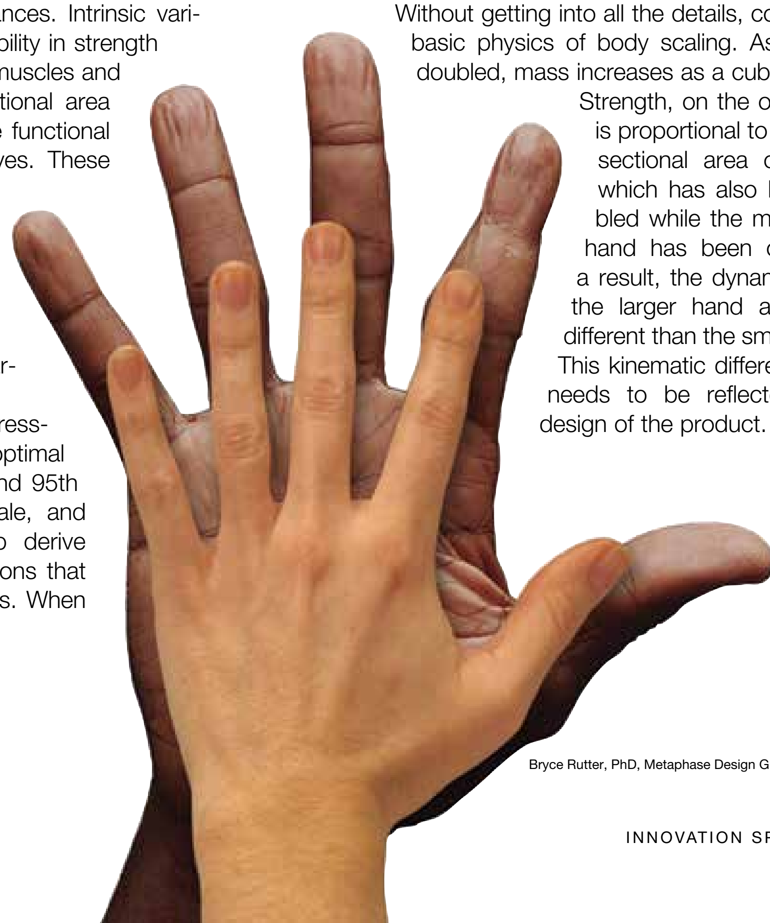
Static and gravity-dependent grips differ from precision grips in that the former relies primarily on the larger and more powerful extrinsic muscles of the hand in the forearm, whereas precision tasks utilize small muscles within the compass of the hand. Small muscles within our hands provide highly dexterous and accurate movement and control; however, they quickly become fatigued. Conversely, when using static and gravity-dependent grips that recruit larger muscles in the forearm and upper arm, these muscles have more endurance, but the trade-off is that they also provide less accuracy. The challenge in the design of hand-intensive products is determining the balance between endurance, strength, precision and dexterity, then developing a design strategy that elicits the most effective balance between these factors.

Scaling Products to Fit 5th to 95th Percentile Hands

One of the biggest challenges in designing handheld products is accommodating hand size variances. Intrinsic variability in hand size also equates to variability in strength (remember smaller fingers have smaller muscles and strength is correlated to the cross-sectional area of the muscle), and directly impacts the functional reach envelopes of the digits themselves. These factors directly impact the design and layout of controls for tools, instruments and, more generally, any hand-product interface. Variability between a small female hand and a large male hand can be up to 1.5 inches in length and 1 inch in breadth across the metacarpal ridge. (shown right)

An effective design strategy for addressing accommodation is to overlay the optimal hand-product interfaces for 5th, 50th and 95th percentile hands, both male and female, and use this compound mapping to help derive surface topology and switchology locations that will accommodate the full range of users. When working through this balance with small hands, be cautious about including too much fill in the palmer region, which effectively pushes the hand away from the product and directly impacts fingertip reach and the ability to exert fingertip control. With large hands, reach and force are typically not an issue. However, because of the scale of the digits themselves, spacing of switchology becomes much more critical in preventing accidental actuations. Also important with large hands is to ensure that there is sufficient bulk on the product to engage the ring and pinky fingers to ensure a good, secure grip, while the index, middle and thumb are busy performing highly dexterous control operations.

It's not uncommon for designers to be challenged with developing a sizing program to accommodate 5th to 95th percentile hands. We see examples of this every day with small-, medium- and large-size categorizations. The classic mistake when implementing a sizing program is the assumption that the product can be linearly scaled. Scaling products to accommodate for size variability is a nonlinear exercise. Without getting into all the details, consider the basic physics of body scaling. As length is doubled, mass increases as a cube function. Strength, on the other hand, is proportional to the cross-sectional area of muscle, which has also been doubled while the mass of the hand has been cubed. As a result, the dynamics within the larger hand are entirely different than the smaller hand. This kinematic difference alone needs to be reflected in the design of the product.



Bryce Rutter, PhD, Metaphase Design Group Inc.

Getty Images (US), Inc.

While we all share the same anatomic structure, all of us have a unique fingerprint.

Touch Sensitivity

Our ability to sense infinitesimal differences in dimensions, temperature, surface textures, surface topology and materials is nothing short of astonishing. Within our 10 fingertips alone we have no less than 20,000 specialized neuroreceptors that independently sense and report back to the brain heat, cold, proprioception, pressure, itch, chemical pain, thermal pain and joint stretch. Equally stunning is that all the more than 7 billion people on this planet have a unique fingerprint.

Our hands afford the ability to sense a bump on a sheet of glass as small as 3 microns high—to put that in perspective, hair ranges from 80 to 120 microns in diameter. I've conducted research on computer input devices in which 0.009 inches in the height of a mouse can be sensed by the palm of the hand, causing users to score the design as being a poor fit. I've seen in the design of a pen's input stylus that as little as 0.001 inches transforms it from feeling perfect to feeling like a fence rail in your fingertips.

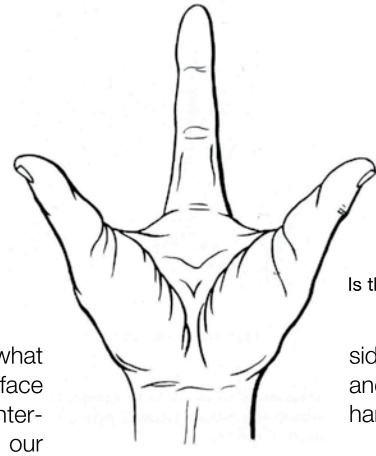
This potency of touch can easily be witnessed by placing laptops from different manufacturers in front of you, then closing your eyes and running your fingertips slowly across the surface of the lids. Some feel masculine, and some feel feminine. Some feel tough, and some feel durable. And some simply feel cheap and awful. Because our fingertips are populated with these highly specialized and unbelievably accurate sensors, minute changes in something as simple as texture define how consumers experience your product and how your brand imprints its signature in their mind.

The power of tactile sensitivity and the accuracy of our fingertips are showcased by those who have lost their sight. Those who are blind feel the world through surfaces, textures and temperature, and communicate through the subtle and sophisticated three-dimensional language of Braille. Through minute changes in dot reliefs, Braille readers sense patterns to discern individual characters, and with the stroke of their hand across a line of what appears to be random dots, they integrate and translate patterns into words and sentences. The sense of touch provides what the loss of vision has taken.

The Future of Handheld Product Design

Many argue that in the future, we will not hold products but rather will control functionality through nontactile holographic interfaces or interfaces that provide synthetic haptics. Once we cut the cord and migrate into synthetic interfaces, a myriad of design opportunities and challenges will be introduced.

Let's consider what is going on in the robotic surgical system space. Because everything is controlled by wire, as opposed to traditional mechanical connections, we can



I.A. Kapandji

Is there a better hand design?

design every system response to produce what we think is the optimal man–machine interface design. But how do we define this optimal interface? How closely should we be mimicking our human system? And do we now have the technical capability to amplify hand function?

We know through research that when you reach to grasp something, there are two distinct phases in this movement action. First is the transport phase where your hand form is frozen and transported close to the proximity of the object with which you want to interact. During this phase, your arm accelerates and then decelerates as you approach a point in travel when the hand unlocks and the manipulation phase begins; when the hand and fingers begin to form into the grip architecture needed to be successful. Similarly, during the manipulation phase, your hand accelerates, and then as it approaches the object of desire it decelerates until contact is made. There has been significant research conducted in the kinematics of this motion, and we understand it clearly. So a key question in the design of any robotic interface is whether or not you replicate the exact kinematics of the human system or amplify or alter certain kinematic features of this natural action to improve hand performance.

A related design factor is gain. For example, when a surgeon who is interfacing with the controller moves the hand's position by 2 inches, at what amplitude should the tool tip be? Research is inconclusive on this topic. Based on research and the few systems in place today, there seems to be gravitation toward a sweet spot somewhere in the order of a 2:1 to 5:1 gain. More generally when considering gain, the type of robotic system we are dealing with drives the significance of the gain parameter.

How we design in gain depends on the type of robotic system being developed. If it is a surgical robotic system operating within the heart where fractions of a millimeter matter, then what we may need to do is dial in gain that decreases the potential risk of crashing into sensitive anatomic structures, thereby actually enhancing surgical performance. Alternatively, when operating heavy equipment, such as controlling a bucket on a backhoe, we have a lot more latitude in terms of speed and accuracy, and as a result, the amount to gain we introduce into the system can be dramatically different. Furthermore, we need to look beyond fixed gain and evaluate the benefit of dynamic gain and consider how we apply it across both the transport and manipulation phase of grasping to enhance hand-function performance.

Another interesting factor in robotic interface design relates to who the user is. Younger millennial users who have grown up with virtual reality and have advanced dexterous control experiences from years of gaming present an entirely different set of legacy experiences and skills when compared to baby boomers. Robotic surgical systems are far less daunting to millennials than they are to baby boomers, who sometimes struggle to adopt new techniques with different degrees of freedom. What is fascinating is that research suggests that traditional laparoscopic surgeons need no more than five or six surgical procedures to be at parity when using a robotic surgical system. It's unclear as to whether or not this is entirely due to the elimination of reflected motion or is a combination of the kinematics and true motion. What is clear from the research is that regardless of age, the most difficult surgical skill, suturing, is improved when using a robotic surgical system as compared to using traditional laparoscopic hand instruments.

Synthetic haptics offer the ability to amplify feedback to the user. For example, surgeons routinely use the tip of their instrument to gently tease and push against the tissue in an effort to feel the tissue's compliance and characteristics. It's not at all unrealistic to think that we can amplify this feedback in a way that provides surgeons with a degree of touch they have never experienced before, thereby enhancing their surgical performance.

Another area of advanced research is in gestural and holographic interface design. We've now gone beyond a physical connection between the user and the system and are now driving control through dynamic gestural hand forms. This is the edge today. Thought leaders are exploring ways in which we can accelerate control, minimize the stress and fatigue on the human hand, and amplify the sense of touch.

For me, I find the concept of touch versus synthetic haptics to be a conundrum. While the latter may increase my ability to perform in virtual space, I wonder whether it disconnects me from the hand–mind emotional experience that I get every time I touch my wife's hand or when I grasp the perforated leather steering wheel of my sports car. Or maybe we need to consider surgical techniques to alter the hand's design in order to improve performance! ■

By Paul Earle
paul.earle@leoburnett.com

Paul Earle is executive director at Farmhouse, the innovation center of Leo Burnett. He would like to thank his colleagues, as well as the marketing and innovation teams at Allstate, for their assistance in this article.

A HAND IS WORTH A THOUSAND WORDS

We all want to populate the world with work that has enduring resonance with people and influences their behavior. Great product and service design can certainly achieve this goal of creating experiences that *matter*. So can communications design. And on our best day, those design elements all work in concert.

This issue of INNOVATION focusing on the human hand presents a great opportunity to study the appendage's power holistically, which includes the hand's role as a profoundly effective communications medium.

Consider these hand gestures; each is iconic and laden with meaning:

- The peace sign, which came of age during the 1960s
- The earlier use of the same gesture: "V" for victory, popular during WWII
- Thumbs up
- Okay
- We're number one
- Hang loose
- Rocker, a signal that initially gained popularity at heavy metal concerts in the 1980s
- The hand wave

Hands can also be used to signal defiance (the fist was used for more than just boxing in the 1968 Olympics) and to demonstrate anger (two words: the bird). Hands can be used to intimidate, even as a predecessor to violence (gang signs), and to demand stopping (in the name of love, as the Supremes sang, or otherwise).

Speaking of love, a relatively new gesture that is being seeded in pop culture today is the emotionally salient symbol of the heart produced using two hands. Hands connect people to others, not just figuratively, but literally. Consider the handshake and the high five.

Hands are so expressive. They are beautiful conduits of human emotion. This is the source of "talking with the hands," especially in cultures that are more overtly emotive, and is why hands in general can speak such volumes about how someone is feeling.

Good Hands

As product developers and marketers in the service of innovation, perhaps we can therefore learn from the potency of hands as communicators to help create future offerings that connect deeply with people. Isn't a huge part of innovation the quest to affect how people *feel*?

Let us take a close look at one marketer that has had a famous amount of success in leveraging the power of hands. It is a certain insurance company. "You're in Good Hands with _________." (I bet you were able to correctly fill in the blank with "Allstate" without reading ahead or clicking the Google app on your smart phone.)

A 2004 Bloomberg study found that "You're in Good Hands with Allstate®" was the best-known slogan in the United States, with an awareness level of an astonishing 87 percent. The line has been unwavering since then, so it's safe to assume that it retains its place near the pinnacle.

Like almost all great creations (of any kind), "You're in good hands" has a deeply human story behind it. The idea was conceived in 1950 by Allstate sales manager Davis W. Ellis. In the period during which he was thinking of new marketing approaches for Allstate, his daughter happened to be hospitalized. Ellis was moved when her doctor assured the family that she was "in good hands," and was struck by the warmth this phrase conveyed. It soon became Allstate's brand promise and slogan.

The rest is history. The Leo Burnett Company, engaged in 1957, soon thereafter helped bring the idea to life in print and over the airwaves. The slogan and cupped hands imagery have been used consistently over the years. From spokesman Ed Reimers in the 1960s to Dennis Haysbert today, the idea has remained relevant. As long as people are people, they will want to be in good hands.

From the perspective of design and innovation for the future, "You're in good hands" serves as a centering point for all that Allstate does; it's often the starting point for brainstorms, sets the bar high for quality and caring and gives employees a higher purpose.

As designers, where might a brief of "good hands" take you? There are many examples in this journal of literal solutions, but perhaps the figurative solutions might be just as provocative.

The Hand Abounds

Not surprisingly, other marketers have recognized the power of hands to connect emotionally with people. The highly recognizable logo for United Way comes to mind, as does the "Raise Your Hand If You're Sure" campaign for Sure deodorant. (Please accept my apologies if that wildly catchy jingle stays with you for some time; we can deconstruct it if the next edition of INNOVATION focuses on the head.) Of particular note is a little tech company that has had some success using the image of the hand in thumbs-up position (uh, Facebook).

An online, a la carte logo merchant called 99 Designs offers variants of at least 35 different logos with hands in them. If I take the company's name literally, more than one third of its total "inventory" features hands! Some might say it should diversify, but why would it? Hands work.

One of my favorite formats of communications design happens to be movie posters. In this medium, prominently featured hands are abundant, which makes sense given the hand's strong ability to tell stories, evoke emotion and drive behavior (in this case, buying a movie ticket). Of the 75 most iconic movie posters of all time (according to a study by Complex Media, Inc.), hands are a central element in at least 15 of them.

Buyenlarge/Buyenlarge/The LIFE Images Collection/Getty Images

Who could forget the poster for *Halloween* featuring an obviously powerful hand, strangely reddish orange in color with unnaturally bulging veins holding a knife? I'd argue that the image might even be scarier if the designer took the knife out of it and left the rest to the imagination.

The illustration of Fay Wray being held so obviously against her will in the massive, brutish, clutched hand of King Kong is another instantly recognizable image, although I suppose that referencing this is technically off-brief for this assignment given the request to focus on the human hand (gorilla-centered design, anyone?). But I think it's close enough. We're all family.

Then there is the art for the all-time classic poster befitting the all-time classic film *Breakfast at Tiffany's*. For sure, Audrey Hepburn's eyes tell a story, but so, too, do her gloved hands, namely the positioning of them. Their ballerina-type elongation signals her grace, femininity and sophistication, while the angle at which she holds them suggests playfulness and curiosity. To me the entire movie is distilled by her hands in that poster.

Not to be lost in the brilliance of the art is the all-important link back to the product itself. In the movie business, the "product" is the film. The hand images bring the products to life, help the products get adopted (box office sales), and become real assets that not only can serve as connective tissue to future development, but inspire it (in the case of *Halloween*, the sequels). This is an important lesson about the power of fusing product and story and can apply to any category.

The Hand as Design Inspiration

In a time of 3D printing and the ensuing frenzy of product proliferation, of Moore's Law taking effect in industry after industry, and of an ever-exploding array of communications media, the innovations that will have the most impact will be the ones that are fundamentally the simplest, the most human and the best storytellers. The hands are all three, which is why they have been and always will be excellent sources of design inspiration. ■

By Dan Formosa, PhD
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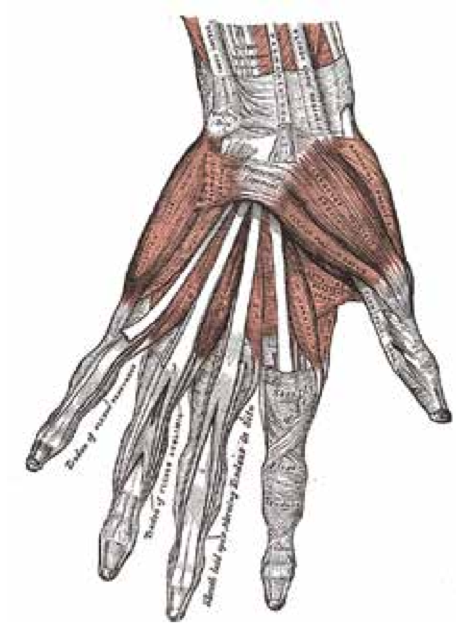
HOW YOUR HANDS DON'T WORK

My friend GG—that's how he signs his name—bought a new guitar. Playing it is causing some unexpected finger pain. The new guitar is not very different from his other one. He's blaming the new guitar's neck shape and how his hand fits around it. But that difference is subtle at best. Or maybe it's the string gauge and scale length of the neck—both affect how tightly the strings need to be tightened to be in tune. But again, I don't think so—the differences between the guitars may be noticeable but would not be that significant.

My advice was that he should look at not just his fingers, but also at his entire body posture—study the possible effects of the new guitar's larger size, its balance and the angle it's being held on his shoulder, elbow and wrist angles—the entire arm. In understanding the hand you need to understand what's happening at least up to the shoulder.

Hand problems, including tendonitis and carpal tunnel syndrome, are common among musicians. They can devastatingly impair their ability to perform. A combination of rapid finger movements, excessive hours of practice and sometimes-awkward hand positions can cause mechanical havoc. Musicians aren't alone. People in the meat-packing industry, construction workers, hair stylists, people who type a lot and sewing machine operators can have similar problems. Women are more at risk than men. Obesity can be a contributing factor. Cold weather doesn't help.

THE HAND



A hand's mechanical issues can be many. Each one contains 27 bones, 123 ligaments and 30 arteries. Movements are controlled by 17 small muscles within the hand itself, and 18 in the forearm. As a mechanism, it's versatile. We use our hands to sense things—fingertips are sensitive to touch, able to distinguish minute qualities of an object, such as subtle differences in shape and texture. Hands can sense cold and heat, airflow, dryness and moisture. Hands can accomplish tasks that require brute force, and others that require speed and precision. They can capably wield a heavy hand tool or help push a broken-down vehicle to the side of the road—but they can also thread a needle or play a violin. The hand is a stunning example of mechanical engineering. Kind of.

It's also complex. And like any complex mechanism, it's easily susceptible to damage. With each hand's 27 bones comes 27 major joints—actually more when you count every intersection of the wrist bones. Among its 27 bones are some of the smallest in the body. You've got smaller bones in the ear, but those are protected by your head. Your little toe is tiny and at risk of being stubbed, but shoes prevent that from occurring too often. Hands are generally exposed, often overworked and frequently at risk of some type of accident or mechanical failure.

The muscles that enable your fingers to do most of the work—grabbing, pinching or squeezing—are not in your hand. Fingers are controlled by large muscles located in your forearm, one body part away. A well-orchestrated array of muscles, tendons and ligaments allows that to happen. Tendons are the string-like tissue that connect muscle to bone. Ligaments are similar in composition, but they connect one bone to another. Both are made of collagen and are surprisingly strong—lots of tensile strength. If you've ever had a strain or sprain somewhere on your body, you are probably well aware of their function and their limitations.

Cuts, scrapes and burns can put your hand out of commission. An accident, some sort of physical trauma, can do damage also. The causes of these scenarios are obvious. Let's focus on the more hidden risks, the problems caused by tasks a person is deliberately performing using a man-made object—problems that can be prevented by design. This understanding can also improve performance because the same principles that reduce risk will optimize the ability of the hand to accomplish tasks that are quick or complex or that require strength and endurance.

All that lifting, pushing, pulling, pressing, pinching, hanging, turning, luggage carrying, writing, typing, track-balling, texting, scissoring, hammering, piano playing, rock climbing and fall-preventing, among other activities, can take a toll. Improper wrist angles can exacerbate the detrimental effects of these behaviors. So can factors like weather or vibrations or rapid repetitions of movement. The hand works like any other mechanical object, subject to the same laws of physics. When designing, it helps to consider the hand as a mechanism, too. Here's a quick overview of how your hand works, and how it doesn't.

Basics in Physiology

Muscles contract. That's all they know how to do. Have your brain send your muscle a signal to fire and that muscle will get shorter. To expand a muscle you need to send a signal to an opposing muscle, stretching the first muscle back into place. That, or you need to rely on gravity or some other external force.

Consider your wrist. Grabbing something requires contraction of flexor muscles located in the underside of your forearm. Releasing your grip relies on the contraction of the extensor muscles located on the upper side of your forearm. Muscles are therefore either pulling from one side of the wrist or the other. The tendons that connect to those muscles run

Illustrations from *Anatomy of the Human Body*, Henry Gray (1918)

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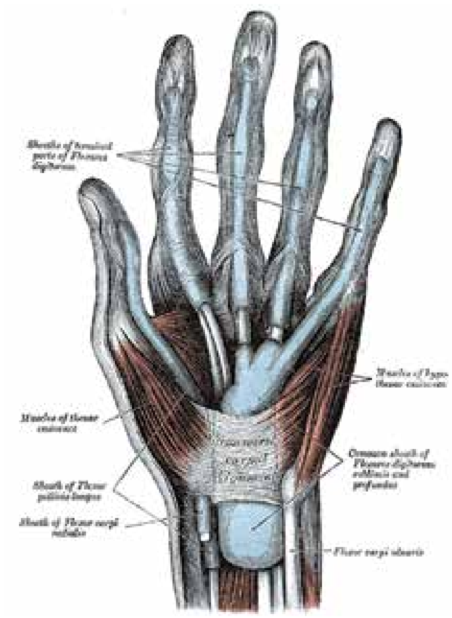

from the middle of your forearm to the very tips of your fingers. Finger movement is complicated by the fact that those tendons need to pass through your wrist—and your wrist can bend.

Your wrist contains a series of eight, small, interlaced carpal bones. They allow your hand to rotate side to side—the movement we use to wave down a New York City taxi. It can also flex forward and extend back, an approximately 160-degree range of motion, although actual range will vary depending on the person. The carpal bones form a concave shape as you look at your wrist with your palm facing you. Stretching across the edges of the curve is the ribbon-like, transverse carpal ligament. That combination of bones and ligament form the carpal tunnel through which the tendons must pass. Flexing a finger and then extending it causes the tendon to move through the tunnel.

With the wrist unbent, the tendons can pass through the tunnel easily. When the wrist is bent, the tendons pull against the transverse ligament (your grip will also be much weaker). Parts start to rub against each other. The rapid movement or the excessive force of that rubbing will cause tendons to become inflamed. The median nerve, sharing space within the carpal tunnel, can get squeezed, cutting off the blood supply. Repeated movements just make things worse. Common terms for the resulting problems, which occur often, include repetitive stress injury, cumulative trauma disorder and carpal tunnel syndrome.

Then there are your fingers. Your index, middle, ring and little fingers each have three bones: distal (farthest from the wrist), middle and proximal. And each finger has three joints. The location of the farthest two joints can easily be seen by looking at the creases in the skin with your hand palm-side up. However, contrary to popular belief, the third joint is not located at the third crease in your finger—it's in the center of your palm.

Like the transverse ligament in the wrist, the fingers also have sheaths that keep the tendons in place. The three joints give each finger three places where things can go wrong. Repeated, rapid and excessive movements of the fingers too often or under too much stress will cause the tendons to inflame. A scroll wheel on a computer mouse, for example, can be one such cause. A small nodule can appear on the tendon, making it even less willing to pass through the sheath. A snapping, referred to as trigger finger, will be felt. The remedy calls for not bending that finger for a few weeks—usually achieved by using a splint.

Your thumb has just two segments, distal and proximal. A few muscles in the palm at the base of the thumb help it to close, open and flex. Through overuse—like excessive gaming or texting—its parts are similarly susceptible to breakdown.

Your middle finger is the strongest, and your index finger and ring finger are the next strongest, just about equal to each other. The little finger, aka the pinkie, has less strength. Don't write it off, however. For many tasks, such as squeezing a pair of pliers, the pinkie will also have the most leverage since it's furthest from the hinge. It therefore contributes significantly.

Smaller Hands and the Triple Whammy

A final thought: Females can be at more risk for hand problems due to three challenges they face using products that don't consider females' generally smaller hand sizes—a triple whammy:

- Smaller hands means smaller muscles and mechanical components within the hand and forearm.
- A smaller grip span may necessitate operating the device with fingertips, not the stronger middle segments of the fingers.
- The pinkie may not be able to reach at all and, therefore, can't contribute.

Of course there's lots more information out there on this topic. Consider this a primer. ■

By Mary J. Carlton, PhD and Les G. Carlton, PhD

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THE DEVELOPMENT OF HAND GRASPING BEHAVIOR

From the moment we are born, movement becomes an essential aspect of how we interact with our world. The mastery of movement is essential to our survival, but it is also a source of our career success and our entertainment. How these skills are acquired and mastered has been a topic of discussion among generations of developmental psychologists.

How we interact with objects in our environment is often viewed from two perspectives: The first of these is prehension, or the act of reaching for and grasping objects. The organization of the grasp is important for how the object will be controlled and manipulated. The second perspective focuses on the manipulation of the object for the functional goal of accomplishing a task. The term "manual dexterity" is often used to describe the ability to both grasp and manipulate objects. In any case, the ultimate goal of these acts is to accomplish tasks by interacting with our environment using our hands and a variety of tools and equipment.

The Early Development Process

From a traditional motor development perspective, the fine motor control of the hand is described as being driven by maturation. Early hand use is mostly reflexive, and further changes and levels of control, accuracy and complexity come as we age. These changes occur in a relatively distinct pattern starting with undifferentiated, whole upper arm action and proceeding to intrinsic finger or digital manipulation.

Similarly, the act of grasping objects starts with a palm grasp and evolves to a pincer grasp. This distinction is characterized as proceeding from a grasp using the whole hand, with the fingers acting in unison much like a movement that would occur if you were wearing a mitten, to a grasp using the thumb and fingers in opposition to perform tasks such as grasping a pencil.

This description of the development of fine motor control of the hand was originally grounded in a series of early developmental studies by Lolas Halverson based on the observation of children between the ages of four and 13 months attempting to pick up a 1-inch cube. It was concluded that in early stages, infants can not change their grasp to accommodate different objects. It was further suggested that the ability to perform this task is mastered by the time infants are 12 months old.

This view of the development of fine motor hand control remained the standard description until researchers began to take a look at children's hand behaviors in a slightly different way. The first observation came from watching adult behaviors. Adults approach the task of picking up an object in a very distinct way. The shape and style of their hand grasp is closely tied to the size and shape of the object that is being manipulated. Large items are interacted with using the whole hand with all fingers participating, whereas small-item manipulation is accomplished using only the number of fingers required to control the object. This effect further evolves to the level where very large items eventually require the use of both hands to effectively manipulate them.

Now consider that children have very small hands and the objects they interact with are large relative to hand size. This observation led to a series of experiments and a new description of how the development of fine hand motor control is viewed. When body scale is considered, it was observed that the type of grasp used by very young children varies with the size of the object. This includes both the number of hands and the number of fingers involved in the grasp to accomplish the task. This effect begins to be exhibited with children as young as four months who tend to vary their grasp after making contact with an object, suggesting they are using both haptic and visual information to adjust their grasp. By the time children are eight months old, they begin to adjust their grasp prior to contact with an object, indicating the beginning of the use of visual information to guide and control their grasp.

As we know, hands do not always function independently. Bimanual control of objects is an essential aspect of the fine motor control of hands. Although most early spontaneous hand and arm movements of infants are unilateral (asymmetric), bimanual reaches begin to emerge as early as two months of age. During the next year of life, children exhibit a range of behaviors, including both the refinement of unilateral grasping and the emergence of bilateral behaviors. By the time children reach their second birthday, they have begun to display a host of more complex control behaviors. Hands begin to draw, use scissors and complement each other while performing tasks that require each hand to use different movements while still working together in a coordinated pattern to accomplish a task, such as buttoning and unbuttoning items.

The take-home message suggested by these studies indicates that when an object is scaled to hand size, more sophisticated grasps emerge and that the grasp style and number of fingers used to accomplish a task across people's life span is driven by the characteristics of the object and the requirements of the task. In more recent generations, this concept has led design and marketing companies to produce equipment scaled for individual use, such as smaller eating utensils, cups and toothbrushes. Don't forget, the highly skilled child who, for example, plays golf and tennis, skis and even rides a bike, does so at an age much younger than previous generations all due to the opportunity to interact with tools and equipment that have been scaled to their body size.

Lifelong Learning

The development of manual dexterity is a lifelong process. While the acts of grasping and manipulating objects emerge at a young age and early in the developmental process, practice is required to develop skill in any task. Each attempt to interact with an object is equivalent to a single trial in the learning process. With more trials, or more practice, tasks are completed faster and more accurately and performance becomes more automatic.

Recreational activities from video gaming to tennis show large improvements in performance with practice, which, in turn, leads to yet more engagement. Individuals become highly skilled at the tasks they enjoy and the tasks required by their jobs because they spend a great deal of time engaging in the activity. It is said that true expertise in an activity takes 10 years or 10,000 hours of practice. This appears to be true in musical training, chess and sports.

Hand Development Milestones

Prenatal	Conception	0.0 weeks
	Hand buds with finlike finger buds appear	5.0 weeks
	Hands with digits appear	7.5 weeks
	Thumb differentiates axially rotating toward the palm	8.0 weeks
	Thumb specialization is morphologically complete	10.0 weeks
	Unilateral and bilateral activity of the arms, hands, and fingers begins	11.0 - 12.0 weeks
	Hands frequently open and close spontaneously	13.5-16.0 weeks
	Momentary extensions of fingers, and at long intervals	16 weeks to term
	Fingers touch palm forming a fist	20 weeks to term
	Effective opposition observed	24 weeks to term
	Hands rest and folded across chest in a semi-flexed posture	28 weeks to term
	birth	
Postnatal	"Power grip" where fingers form a clamp with the palm, thumb is only flexed	0 - 6 months
	Asymmetrical bimanual reach	2 months
	Refined unilateral grasping and beginning bilateral behavior	2-14 months
	Object contact begins and develops radially and distally	3 months
	Begin to vary grasp based on visual-haptic feedback	4-8 months
	Mid-palmar object contact predominantly	6 months
	Opposition appears	7 months
	Palmar power grip is highly prevalent and preferred	7-9 months
	Adjust grasp prior to contacting an object based on visual feedback	8 months
	Index finger - thumb object contact predominantly	9 months
	Complex, complimentary bilateral tasks	24 months

Many studies demonstrate that manual performance declines with age starting in the late 50s and early 60s. **Declining manual performance appears to be associated with loss of strength, loss of dexterity and joint impairment resulting from musculoskeletal disease.** Loss of speed with aging is a common finding for fine motor movements, and it appears that in some cases movements might not be as finely coordinated with advancing age. It is common for individuals to curtail manipulative activity as they age, leading to decreases in performance. This effect is compounded for older adults as it is often associated with loss of strength and changes in health.

As individuals age the necessity to continue to engage in manual tasks remains an important issue. How can performance be maintained as one ages? Can performance be maintained in the face of physiological changes due to aging? The answer appears to be yes and no. Engagement in manipulation activities throughout people's lifespan does not seem to eliminate losses observed on general manipulation tests. However, there is strong evidence to suggest that performers are able to sustain high levels of performance in the face of overall deterioration in general capacities. Experts in activities such as piano, typing and golf putting, for example, are able to maintain performance.

Instead of focusing on the declining performance-age curve, perhaps we should extrapolate from P.M.A. Rabbitt's observation for cognition and aging: "In view of the deterioration of memory and perceptual-motor performance with advancing age, the right kind of question may well be not 'Why are old people so bad at cognitive tasks?' but rather, 'How, in spite of growing disabilities, do old people preserve such relatively good performance?'" ■

THE AGING HAND NEEDS A HAND

Mary is 70 years old and is married to Ralph. Both are retired and living in the home where the children grew up. But with aging, they have succumbed to the illnesses of the elderly. He is overweight and has diabetes; she has a heart condition and arthritis. When we went to visit them, we found them a joy to be with—full of stories and hopes for the future, of grandchildren and travel. But their advancing chronic diseases will hold them back and eventually will force them from their home and independence. How can we help them meet these challenges and give them more years of independence?

Of great concern is the aging hand. Our hands are vital to the process of disease management. Ralph must check his blood sugar several times a day and then inject himself with insulin. But Ralph's fingers are big and not very precise, so each action in caring for his diabetes is a challenge. Mary's doctor would like to monitor her heart activity more frequently. But Mary struggles with her medications; the packages are hard to open and the labels are hard to read. She has had several episodes that sent her to the emergency room mainly because her medications were imbalanced.

Our graduate studio at Georgia Tech's School of Industrial Design is committed to helping Mary and Ralph. After weeks of secondary research and gaining an understanding of the diseases and the challenges faced by the elderly we were able to conduct primary research with interviews and observations in the homes of elderly people, like Ralph and Mary, who have multiple chronic diseases. With the help of Georgia Tech's HomeLab, we identified 60 potential subjects. Initial phone interviews led us to select 10 subjects, and teams of two visited each home. Using a structured interview, and inviting the subjects to show and tell their key activities, sharpened our findings. The design team returned to the studio to explore and develop their design innovations.

Acknowledgement: *The MID 4012 Graduate Studio: Co-instructor Herb Velazquez, IDSA and graduate students Chris Bartlet, Bradley Bergeron, Matthew Gregory, Chandan Hebbale, Achyuthkumar Sanath, Allison Miller and Shuyi Wang.*

By David Cowan, IDSA

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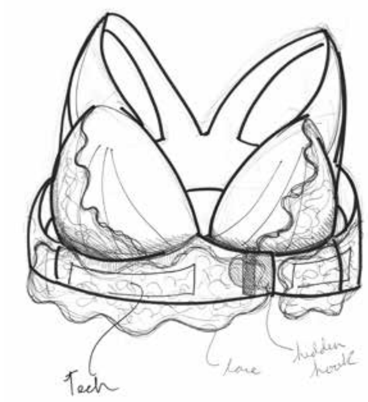

The Elderly and the Red Line

As people age, they follow a line of health—the blue line—or are affected by health challenges—the red line. The 2000 World Health Organization report "A Life Course Approach to Life" shows that as we age, the red line will cause us to eventually seek an assistive care setting. This represents a loss of independence and increasing cost of care. Those living with multiple chronic diseases are doubly challenged—often one disease, like arthritis, makes caring for a second disease, like diabetes, more difficult. These are the people we are designing for—helping them with universal design approaches to improve their lives and prolong their independence.

The elderly currently number 40 million, but will grow to 72 million by 2030; 85 percent of this population will have a chronic disease, and 61 percent will have two or more chronic diseases. The most common diseases include heart disease, diabetes, arthritis, COPD and kidney disease. These diseases all have significant medication, exercise and dietary requirements.

Hand Strength and Dexterity

The dexterity and strength of our hands are often needed to effectively deliver the care needed to treat and manage these diseases. Too often these challenges lead to missed medications, poor nutrition and little exercise. The resulting exacerbation of the diseases will frequently send people to the emergency room or hospital for care.

The diseases most affecting the hands are arthritis and neuropathy—22.7 million adults have arthritis that noticeably limits activity, and 20 million adults have peripheral neuropathy. Arthritis is an inflammation of the joints, including the little joints of the hands as well as the big joints of the wrists, elbows and knees. In the hands, arthritis results in stiffness, pain and deformity. Peripheral neuropathy is a disease that attacks the nerves resulting in a lack of feeling in the fingers as well as pain and weakness. Obesity, also common to this elderly population because of their general inactivity, is a major factor in hand dexterity; big fingers are often weak and clumsy.

Without good hand dexterity, it becomes difficult for diabetics to check their glucose levels and inject insulin. Those with hearing aids struggle with battery replacement and volume adjustments. All who suffer with arthritis, neuropathy and obesity struggle with food preparation and exercise. There is an important and large need to support the elderly with devices that lessen the challenges to their disease-impacted hands.

Universal Design

Many universal design techniques will help those who experience challenges with their hands. Large handles and Velcro fasteners are the most common solutions, but they are not always a part of the products developed to assist the elderly, particularly in medical devices. Our design team considered the concepts of universal design for each of the common chronic diagnoses that affect the elderly and explored the treatment and management strategies the elderly use to care for their chronic diseases. The designs ideas that are being considered include:

Heart Monitor Bra. Heart disease is especially common in women. Allison Miller is designing cardiac sensors (ECG) into a fashionable Velcro-fastened bra that will communicate to separate devices using Bluetooth or wired connections. Because self-image is important to people's mental health, this design will address three important factors in a woman's health: heart health, arthritis and mental health.

Diabetes Management System. The traditional insulin syringe/pen depends on considerable finger action, including pinching and grasping. Shuyi Wang is designing a new insulin pen with a larger form that allows an easier grip and use and a glucose monitor that will have a larger and clearer readout.

Hearing Aid for Thick Fingers. The small size of a hearing aid requires equally small batteries and controls. Chandan Hebbale is using new technologies to solve this problem: batteries with a significantly longer life and a voice-control volume adjustment.

A New Twist in Meal Preparation. Good nutrition is required of almost all who suffer from health conditions. But preparing fresh foods is often beyond the capability of the elderly. Most love to cook and have a legacy of preparing great food. But arthritic hands and poor eyesight cause them to avoid the kitchen and instead depend on prepared foods or restaurants. Matt Gregory is designing a new line of kitchen utensils that incorporates sensor technology. Also using more stable cutting surfaces and lever-action knives make food preparation easier.

The elderly need devices designed to support an independent lifestyle in spite of their physical limitations. New approaches to universal design are being explored at Georgia Tech to support the care of medical conditions common to elders, particularly those with multiple chronic diseases. ■

By Brad Fain, PhD
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Brad Fain is a principal research scientist at the Georgia Tech Research Institute (GTRI), with more than 23 years of experience in human performance research. He established the Accessibility Evaluation Facility at Georgia Tech and has pioneered evaluation techniques designed to measure accessibility and usability of products and services for people with disabilities. Fain also directs Georgia Tech's HomeLab research initiative.

Human Performance Based-Consumer Product Evaluations to Support Accessible Design

ATTACKING ARTHRITIS

Many individuals with functional limitations in their hands experience significant difficulty completing a variety of everyday tasks. Design issues in products and packaging solutions may be an annoyance to the general population, but for people with functional limitations in their hands they may be an absolute barrier to use. Universal design is a process that ensures consumer product design is inclusive, accessible and usable by as many people as possible in as many situations as possible.

Based on current trends, it is estimated that 35 percent of the US population will be over the age of 55 by the middle of the 21st century. In addition, the prevalence of arthritis is expected to continue to increase, such that 67 million American adults, up from 46 million currently, are projected to have doctor-diagnosed arthritis in the year 2030. Our abilities change as we age, and consumers are demanding products that are designed to their abilities.

An important part of the universal design process is being able to effectively measure accessibility and ease of use at the appropriate level of granularity. Resource constraints and schedule pressures associated with new product development often limit the amount of effort available to support the measurement of accessibility and ease of use. Designers should have a variety of useful techniques in their arsenal that will enable the appropriate application of resources to a given design challenge. The techniques should vary in terms of outcomes and the level of detail produced. The techniques I have used range from activities designed to raise awareness about a given issue or class of issues to detailed methodologies designed to produce actionable design guidance. There are four primary categories of evaluation techniques that we regularly use in our practice of developing products for hand use: empathy and awareness, screening, design validation and design research. Each technique varies in terms of the amount of effort required, the granularity of the outcome and the utility of the information presented.

Empathy and Awareness

In many cases, it is sufficient to just raise people's awareness about an issue or a general category of issues without presenting detailed scientific evidence. For example, sometimes it is necessary to communicate the existence of a potential design issue in order to secure necessary resources to address the issue through additional data collection. The Georgia Tech Research Institute developed the Arthritis Simulation Gloves as an educational tool to raise empathy and awareness around design issues faced by individuals with functional limitations in their hands.

The Arthritis Simulation Gloves reproduce the reduction in functional capacity experienced by persons with moderate to severe rheumatoid arthritis (RA). The gloves help those responsible for consumer products to better understand how RA affects a person's ability to grasp, pinch, turn, lift and twist objects. Product managers or designers can put these gloves on and attempt to open their company's products or packaging. If they are unable to do so, then chances are high that people with symptoms of moderate to severe RA will also have difficulty opening the same product or package.

A 1999 study published in *Rheumatology*, "Predicting 'Normal' Grip Strength for Rheumatoid Arthritis Patients" (http://www.ncbi.nlm.nih.gov/pubmed/10402072), showed that the mean reduction from normal grip strength in RA patients was -66 percent for males using their dominant hand and -53 percent for females using their dominant hand, resulting in a cross-sex mean of -59 percent. These data were based on a maximum pinch grip metric, which most closely resembles the strength model for RA. The gloves are calibrated to produce a similar reduction in functional capacity. The gloves are also designed to raise awareness and educate those seeking to understand the functional limitations associated with hand RA—but they are not designed to be a substitute for user testing.

Screening

Screening for accessibility is useful when the evaluator needs to either produce a quick assessment of a large number of products or give a simple pass/fail assessment of a product. Screening assessment methods are not designed to produce an exhaustive assessment of design issues, but rather to quickly identify the likelihood that the product or packaging solution meets some minimum level of accessibility or ease of use. We use a combination of laboratory assessments and user-in-the-loop testing to screen products. The laboratory assessment consists of identification of all the cognitive, sensory and physical tasks associated with interacting with a product or packaging solution and then determining if the functional abilities required to perform those tasks are likely to fall outside established guidelines or normative data. For example, in order to open a water bottle the consumer must be able to rotate the cap with sufficient torque to break the factory seal. If the torque required to break the seal, as measured by laboratory testing, exceeds published standards for the target demographic, then we may document performance of the task as a potential design issue.

To complement laboratory testing, we conduct user-in-the-loop testing with a limited number of research participants. As the official consumer product test lab for the Arthritis Foundation, the Arthritis Society of Canada, Arthritis Australia and Arthritis New Zealand, we routinely conduct studies in which eight participants with moderate to severe arthritis in their hands are asked to perform a series of tasks associated with procurement, usage and disposal of the product or packaging solution being tested. Data from user testing is combined with laboratory data to produce an assessment of whether the product meets the criteria established for the test. Such simple methods are suitable for a rapid pass/fail assessment but should not be used to drive design decisions.

Design Validation

Design validation techniques are used to determine if a product or packaging solution meets the initial requirements for the design. Design validation can also be used to help solve specific design issues. For example, we assisted a pharmaceutical company to design a new packaging solution that would be suitable for a medication for arthritis. The solution had to meet all of the child resistant requirements, but also needed to be senior friendly since people with arthritis would likely only need to access the medication when their symptoms of arthritis were particularly problematic. The same basic techniques are used in design validation as described in screening with two important differences. First, design validation is about quantifying human performance in such a way as to determine if the human-performance-related requirements have been met. To quantify human performance we may instrument the product or packaging solution so that pain thresholds can be directly measured.

By asking research participants to interact with instrumented test samples, you can measure how much force they can apply prior to experiencing pain or discomfort. If a significant number of the research participants reach their pain threshold for a given task prior to successful completion of the task, then a design issue can be clearly documented. Second, design validation requires a level of evidence that is typically much more stringent than what would be required for a screening evaluation. Design validation typically requires the use of 15 to 20 participants per target demographic population segment as compared to the eight to 10 total participants typical of a screening evaluation.

Design Research

Design research is an extension of design validation. The same techniques described in design validation are often used again with two important differences. First, the purpose of design research is often not the evaluation of a given product or packaging solution but to obtain generalizable research to enable the formulation of design requirements or to build a model of human performance. As such, the focus of design research may be on an entire category of products or packaging solutions systematically varied by some important set of design elements. A preliminary study of jars and bottles conducted at the Georgia Tech Research Institute indicated that consumers with arthritis experience significant difficulty purchasing, using and storing container-based products. While the required application of rotational force to the cap is the greatest predictor of the ability of people with arthritis to open a container, the study indicated that other factors interact with removal torque. Bottle size, bottle shape, bottle coefficient of friction, cap diameter, cap height, cap texture, cap material and cap coefficient of friction all interacted with removal torque when predicating the ability of a consumer to open a particular closure. The purpose of design research on this topic was to document the way that removal torque interacts with the various other design considerations in order to produce a container that is truly easy to use.

Second, design research is typically conducted on a statistically valid sample of participants representing specific populations of interest. A typical design research study may involve a hundred or more research participants in a given population segment in order to produce data that is representative of the general population. Such data can be used to build human performance models that would predict ease of use of new product designs or create specific guidelines that can be used to establish requirements for new product design. ■

By Keith S. Karn, PhD
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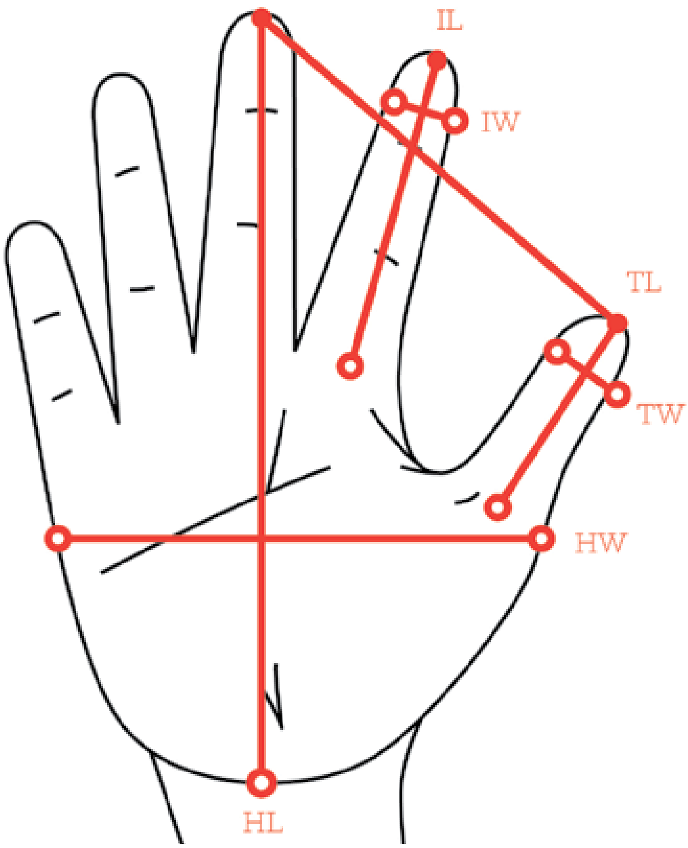
Bridging the Gap Between Researchers and Practitioners

WHAT SEPARATES US

Other species can't hold a toothbrush, turn a doorknob, grasp a hammer, hitch a ride, reach an octave or hit a space bar like we can. Our ability to form a good grip using our thumbs and opposing fingers differentiates us, and as our tools have evolved from hammers to smartphones, we increasingly wield our evolutionary advantage by swiping, scrolling and texting. (When's the last time you saw an orangutan play a video game?)



Imagine trying to design a handheld device with intended thumb actuation using this information, which is typical of the type found in anthropometry books.

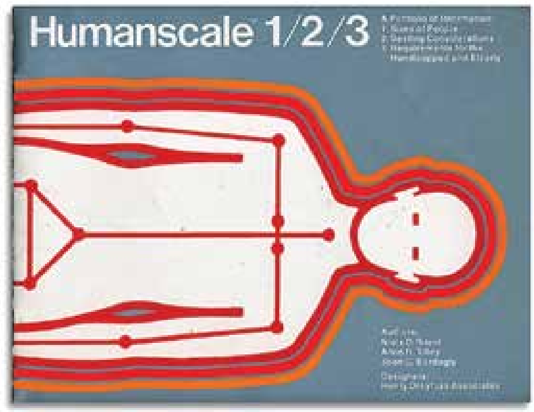
In the past 20 years, the thumb has become an even more valuable player in our everyday lives. The dramatic increase in cell-enabled, GPS-enabled and other compact electronic devices has resulted in more handheld products that are designed to be thumb activated. Not only do these cameras, cellphones, game controllers and keypads cater to our thumbs, but they appear to be changing the way we use them. British writer Sadie Plant first mentioned this phenomenon in "On the Mobile," her 2002 ethnographic research study on cellphone use. In it, she quotes a participant who observes that teenagers even "point at things and ring doorbells with their thumbs."

Obviously We're Not Getting It Right

Unfortunately, the thumb is not wearing its popularity well. As the frequency of cellphone texting rises, the muscles in people's thumbs get larger and subjective reports of pain associated with the activity increases. Ten years ago, carpal tunnel syndrome, a wrist ailment, was common due to overuse of computer keyboards and mice. Today the diagnoses du jour are thumb conditions such as "Nintendinitis" (coined in Dr. Richard Brasington's 1990 letter to the editor in the *New England Journal of Medicine)*, texting thumb and gamer's thumb. Excessive texting has also been linked to other pathologies of the thumb, specifically joint arthritis and tendonitis. Obviously we're not getting it right. What can we, as designers, do to provide safer products?

As product designers, we frequently hit a wall when designing for the hand. Anthropometric data is typically all we have at our disposal. Unfortunately, it does not help

Dimension	Mean	Standard Deviation	5th Percentile	95th Percentile
Digit 5 Height: Perpendicular to Wrist Crease	5.75 5.12	0.32 0.35	5.24 4.53	6.26 5.68
Digit 1 Length: Fingertip to Crotch Level	2.31 2.12	0.18 0.17	1.99 1.84	2.59 2.41
Digit 2 Length: Fingertip to Crotch Level	2.96 2.72	0.18 0.20	2.69 2.40	3.23 3.07
Digit 3 Length: Fingertip to Crotch Level	3.37 3.07	0.20 0.20	3.08 2.76	3.73 3.42
Digit 4 Length: Fingertip to Crotch Level	3.17 2.88	0.19 0.20	2.93 2.57	3.52 3.24
Digit 5 Length: Fingertip to Crotch Level	2.42 2.15	0.18 0.17	2.14 1.89	2.75 2.46



Humanscale 1/2/3's two-dimensional plots characterize the available anthropometric data, especially for the hand. Three-dimensional range of motion is not yet well represented.

answer simple, vital questions, such as what can you reach with your thumb or fingers, or what can you grip comfortably? Here is where anthropometric data of the hand, and more specifically the thumb, is letting us down:

- For the past 75 years, anthropometric data has come largely from military populations with much less data on civilians. The most comprehensive data relating to hand and finger anthropometry was based on US Air Force Flight personnel.
- Anthropometric measurements in general are limited to individual body segments in isolation. This measurement technique does not capture the coordinated multisegment/multijoint nature of more functional dimensions. As with other body parts, this is true of the hand where individual fingers (digits) are measured, but little functional data related to hand grip and finger reach is available.
- The postures in which anthropometric dimensions are measured are typically unnatural and therefore not useful to designers. Joints are typically fully extended during measurement, not in natural, functional postures.
- The collection and presentation of anthropometric data has focused on static poses and does not capture the dynamics of movement.
- Anthropometric data, especially for the hand, is still most often presented in two-dimensional plots, numeric tables, calculators or templates. Three-dimensional range of motion is typically not well represented.

Anthropometry's generic offerings are less than useful when addressing specific design challenges with unique constraints. This tension between basic and applied sciences is common in other disciplines as well. In order for data to generalize to the largest possible audience (and be publishable), it has to feature the most nonspecific, unconstrained data. Hence the "basic" in "basic science." Data collected for application to a specific set of design constraints is often seen as useless to anyone outside the immediate design team.

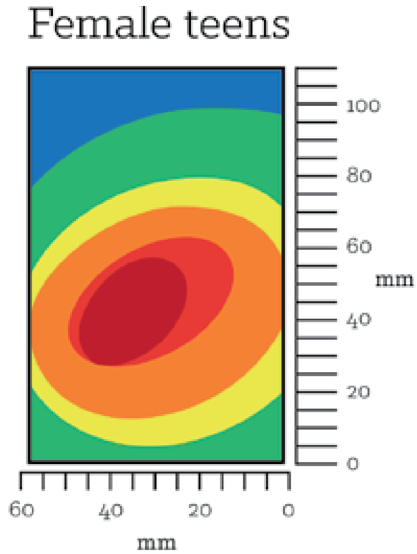
It's possible anthropometry may catch up to our expanding need for data around hand grip and thumb reach. In the meantime, in order for us to ensure a good fit between thumb-actuated devices and their human users, we need different tools and methods.

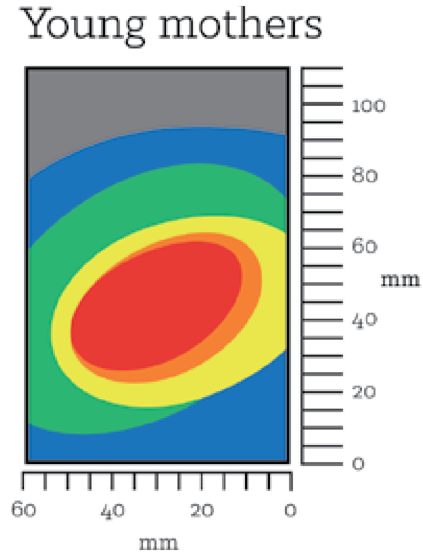
Computer Modeling to the Rescue—Almost

In its 2003 book *Kodak's Ergonomic Design for People at Work*, the company pioneered the notion that reach envelopes should be represented in three-dimensional space. Since then, computer models of three-dimensional anthropometric data have become available. These models have come a long way in making anthropometric data more useful and usable by allowing designers to envision the human body in relationship to product concepts while in the conceptual design phase—prior to building physical prototypes and while the design is still extremely malleable in CAD modeling software. That said, many anthropometric models still fail to adequately address the intricacies of the human hand and functional grip—specifically concerning thumb reach envelopes.

We need something to hold us over while we hope and wait for better anthropometric models of the human hand that will integrate well with our CAD systems. Reviewing the existing anthropometric data is always the best first step, but once you are convinced that the data you need is not available, I recommend moving on to collect your own product-specific data. This does not have to be super expensive or time consuming. While large sample sizes are always nice in anthropometric studies, a question that is tightly constrained, such as thumb reach on a specific product with a specific grip style by a specific user population, may be answered with data from as few as 30 to 50 people who fit the user profile.

Get creative when planning your study. Keep in mind that nobody has tackled the exact same design challenge and most likely nobody has collected the same data you seek.





A thumb "painting" the iPod screen (above) and reach envelope data for the female teens and young mothers in our study.

A Real-World Example

A few years ago while working at Kodak, we designed a pocket video camera with a candy bar form factor. The marketing team defined two target user groups: teenage girls and mothers of young children. Our industrial designers asked a seemingly simple question about where to place buttons intended to be actuated by the user's thumb on the back of the camera. We scoured the anthropometric literature and investigated the available computer models of the hand. None seemed adequate, so we decided to collect our own data. We had another study planned at that time on a related topic with the same two user groups. So we tacked on the collection of some simple anthropometric data.

Rather than simply measuring the length, breadth and depth of the thumb, we needed data that was directly applicable to our question about where to place controls. We needed to know what teenage girls and moms could reach on the surface of the camera. In order to describe this thumb reach envelope, we used an iPod Touch with a simple drawing program. To replicate people's grips—a big impact on thumb reach—we built a small cradle for the iPod that extended its shape to the planned dimensions of the camera.

We instructed participants to hold the iPod as if they were going to use it to capture a video. Then we asked them to swipe their thumbs across its surface. The drawing program running on the iPod captured their individual thumb reach envelopes as they "painted" the parts of the screen they could reach. Eventually, we combined the data from all participants in a group to determine the thumb reach envelope for that group—for example, specifying which parts of the screen 90 percent of participants could reach with their thumbs. We published this 2013 study, "Defining Thumb Reach Envelopes for Handheld Devices," in *Human Factors*—not so much to suggest reuse of the data, but more to suggest that this method may be useful to others.

Bridge to the Future

While it is always fun, and often useful, to collect your own data, I hope the need for do-it-yourself thumb reach data does not last long. Surely, the companies working on three-dimensional models of thumb reach will grab others' data and integrate it into their models. There has already been some progress toward using three-dimensional scanning of human hands, and researchers at Hokkaido University in Japan have proposed a system for the virtual ergonomic assessment of products by integrating a digital hand model with a product model. The resulting anthropometric data will no doubt be merged with in-depth motion analysis of various styles of grip and typical hand motions.

All of this should culminate, eventually, in useful models of the hand that can be brought into standard desktop CAD applications to help designers determine how best to design products to avoid injury. And we will fondly recall this blip of time when the lack of readily accessible relevant data stuck out like a sore thumb. ■

Best Practices Checklist

- Think beyond *Humanscale 1/2/3*. A table of numbers or a template cannot do justice to the complex postures and movements of the multiple articulated joints of the thumb and fingers. See if current computer models provide the anthropometric data you need in a format compatible with your CAD system.
- Review existing anthropometric data, but once you are convinced that the data you need is not available, move on and collect your own data.
- Get creative when planning your study. Keep in mind that nobody has tackled the exact same design challenge you face and most likely nobody has faced the challenge of collecting the data you need.
- Consider sharing your results and techniques with others in a publication or conference talk.
- Keep the pressure on your CAD system vendors for better plug-in modules for hand anthropometric data.

By Laura Joss, PhD

Laura Joss is a senior design researcher at Motorola Mobility, where she currently leads industrial design research on mobile devices. She previously completed her PhD in experimental psychology and cognitive neuroscience at DePaul University.

Putting the User First

TALK, LISTEN, TEST, REPEAT

During the design of the Moto X smartphone, one of our guiding principles was to create a device that would bring comfort and approachability to technology. We based this principle on user needs that had been elicited through generative research and direct engagement with our target consumers. We knew that people were looking for a more comfortable, more user-centered mobile phone that would give them something different than the standard flat rectangular phone. Most mobile phones are difficult to manipulate and can be cumbersome to use.

A group of designers, researchers and Moto X owners discuss hardware options during a research session to inform the design of the second-generation Moto X.

We came up with a prototype that had a uniquely different form factor from current market offerings: a tapered edge combined with a curved back and tight borders that maximizes screen space and keeps the device easy to handle. We believed this design, which eventually led to the first-generation Moto X, would address the needs we had been hearing about.

Navigating the Journey

However, creating a phone with an innovative form factor also created unique technical challenges. From an engineering perspective, a curved form factor meant that internal components wouldn't fit as neatly as if the device was flat. It was a cultural challenge to push ourselves beyond the standard, and the time, effort and cost required to create the device was high. Knowing we faced these challenges, we turned to a cycle of rapid prototyping and research, to better answer the question, are we truly meeting users needs?

Feedback from early concept evaluations—in which we showed people our unbranded prototypes next to other brands' phones and talked through their thoughts and impressions—told us we were on the right track in terms of meeting comfort needs. Our Moto X prototypes felt more natural to hold and less awkward to maneuver compared to phones that were currently on the market at the time. The improved grip allowed for smoother, more optimal interaction. People also reinforced how important it was that a phone be comfortable to hold. When discussing their phone preferences, many of our interviewees considered comfort in the hand a primary deciding factor. However, we also learned that early prototypes were unstable on hard surfaces, causing issues for tabletop use.

By collaborating with our prototyping lab, we were able to quickly produce different prototypes. This allowed for a rapid cycle of prototype-test-repeat, and we were able to refine the form factor to adequately meet our engineering needs as well as create a device that is comfortable in the hand and alleviates concerns about device instability.

Diving Deeper

After we launched the first-generation Moto X, we wondered how use over time would affect perceptions of the phone. Internally we had used the phone, but we wanted to know what regular, nonexpert people were feeling and thinking and what lessons we could apply to the next iteration of the phone. Often this type of data comes from analyzing sales figures or through surveying consumers to get higher-level quantitative data. However, we wanted to delve deeper into what people were doing with their phone and how they felt about it so we could understand what was working and where user needs had evolved.

To get this deeper understanding, we created panels of Moto X owners that we could follow and engage with face to face. We gave these owners several tools for communicating with us as often as we wanted to communicate with them, including online forums, informal texts, in-person research sessions and panel discussions. This way people were directly connected to us and could communicate their thoughts and reactions about the device in real time, creating a continuous feed of data that allowed us to build on their feedback.

One of our first efforts was to hold group discussions where we brought together Moto X owners, designers, researchers and other team members to discuss hardware perceptions. Talking with people who had been using the Moto X for several weeks unearthed an insight we hadn't anticipated during the design process: User reaction to the dimple on the back of the device was strong. The dimple elicited an emotional connection to the phone we hadn't anticipated. In fact, several owners noted that they didn't want to use a case because they didn't want to block the dimple. The tactility of that design element was that important. We also learned that the dimple heavily influenced how people held and manipulated their phone; most people thought the dimple was meant to be an indicator of how to hold the device. These insights around a simple design element would have been completely missed had we not interacted with real-life users.

We were also able to dive deeper into understanding how our users' needs had evolved. Numerous different data sources told us that people wanted larger screens. However, we had to be careful with how we approached creating a larger Moto X. One of the things we had learned from our Moto X owners panel was that the shape of the device really resonated with them; it was extremely comfortable to hold. Thus, we had to find the balance between bigger screens and maintaining comfort in hand. Through additional cycles of prototype-test-repeat, we were able to strike that balance with the second-generation Moto X, and create a phone that has a larger screen but still offers the curved form factor that had resonated so well with users of the first-generation device.

"It just fits. We think your phone should actually fit your hand, not the other way around. So we went ahead and made one that does just that."

—Motorola

When creating a product that is uniquely different and that challenges design standards, a data-driven approach can help push the concept forward. In the case of the Moto X, we felt we had created a phone that answered a clear user need: people were looking for a more approachable, comfortable mobile phone. By following a cadence of prototype-test-repeat and iteratively testing our design, we were able to incorporate user feedback into our design process and determine if we truly were solving a problem. Importantly, by delving deeply into people's understanding of their device through our Moto X owners' panels, we were able to glean insights that otherwise are difficult to uncover in more traditional research methods. This approach to design allowed us to create a truly innovative product in a human-centric way and established a process that we can use to continue to understand our users' needs for future designs. ■

Take-Aways

- When considering a mobile phone, people aren't just looking for high tech with the best specs. Comfort in hand is equally important.
- To create a comfortable device, you sometimes have to break convention and push the boundaries of what is technically possible.
- Prototype early and test often to refine the design to best fit users' needs. Don't wait until the industrial design is complete to research your concept.
- Longitudinal research with the people who own your product can uncover insights that otherwise might never have surfaced. We found that people developed a deep emotional attachment to a design element over time.

By Peter Clarke
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Peter Clarke, the CEO and founder of Product Ventures, is dedicated to creating valued products and packaging to improve the lives of the consumer with breakthrough design. As an industrial designer, termed “the packaging design guru” by *Brandweek*, Clarke is a sought-after packaging expert who has been featured in *Fast Company,* the *New York Times* and Fox Business News.

DESIGN PRINCIPLES FOR HANDHELD PACKAGING

Have you ever considered why a pickle jar is the way that it is? Ergonomic considerations would most likely dictate a different format and configuration than the large, difficult-to-handle glass jar. It’s heavy, breakable and often impossible to open by hand. The overly large low-profile metal lid is difficult to grip and is held tightly under vacuum pressure from the hot filling of pickles during packing. It’s an ergonomic nightmare resulting in all sorts of compensating gadgets to overcome the difficulty of first-time opening.

All images are courtesy of Product Ventures

Unfortunately, pickles don’t care about ergonomics. Their size and shape dictate the size of the container they will be packed in, and the packaging itself must serve multiple purposes beyond fitting into the hand or providing ease of access to the product inside. You see, human factors is only one of the many factors to consider when designing handheld packaging, and the demands and limitations of packaging inherently dictate that not all factors influencing the design will be treated equally. It may not be feasible for all the factors to achieve perfection in the eyes of the consumer or the realities of their wallet. Instead, the more likely solution may be a practical compromise that results from factoring in what is most important for the product.

Considering Human Factors in Package Design

Design principles for handheld packaging should always include human factors considerations. Within the realm of feasibility, we need to ensure that packaging is intuitive—that it clearly communicates to the user how to interact with it and access the product inside. We, as designers, need to consider the grip of the package: How will the user lift or hold the package? How will it be accessed on the shelf and transported to the point of use? Is it a suitable size and shape to fit the human hand? Have we properly contoured surfaces to be comfortable to touch and hold? We also need to consider the force that is associated with interacting with the package: Is the opening force required appropriate for the target audience? How heavy is the pack to lift and to hold? Is the package meant for interaction in close proximity to the body or further away? And we need to consider what range of motion interacting with the package requires: Are we putting limbs or digits in uncomfortable positions or creating an overly taxing static load? Does the overall size and configuration of the pack allow for comfortable interaction?

Factors Beyond Human Factors

Human factors considerations aside, handheld packaging also needs to serve a higher purpose. Packaging's primary role is to contain, preserve and protect the product. This is especially true when we consider foods and other sensitive goods.

Most products must be contained before they can be effectively and efficiently moved from one place to another. The containment function of packaging makes a huge contribution to protecting the environment and reducing product waste. Defective packaging (or insufficient packaging) can lead to significant issues with both environmental and economic consequences. Packaging plays a vital role in protecting products as they go through the distribution system, traveling from the point of manufacturing to the consumer. Effective packaging is designed to ensure that the product reaches the consumer in good and safe condition. Packaging also serves as a brand ambassador, effectively aiding in the merchandising and advertising for the product. It communicates to the consumer the product's function and purpose while providing additional details, including price, prescribed use and ingredients, among other things. A package must protect what it markets and market what it protects.

The ongoing light-weighting efforts associated with water bottles can often go too far and compromise the consumer experience, making them precarious to open.

Packaging must also consider the environment and be designed with the understanding that its use is transient. Only a minimal amount of material must be utilized for packaging to serve its primary functions of containment, protection and delivery. The amount of material used must be balanced against the limited life of packaging, and considerations must also be given to the materials utilized for the packaging itself: where they come from; the environmental consequences of their extraction, creation and/or fabrication; and what happens to them on disposal. Unlike durable goods, packaging's life is relatively short-lived, but the value it provides is significant.

We also need to be careful about taking environmental concerns too far, reaching the point where the consumer experience is compromised. Consider the light-weighted water bottle with its diminutive closure and its flimsy feel. The amount of material in the bottle has been reduced to the point where holding the bottle securely is difficult because of the minimal wall thickness. Grasping and opening the closure is challenging because of its reduced diameter and ultra-low profile. Not to mention that when you finally do hold the bottle, grip the closure and proceed to open it, the bottle collapses in your hand and inadvertently spills.

Package materials also play a role in the ability of packaging to be ergonomic. Packages that are fabricated from sheet goods (cartons, thermoforms, blisters, steel cans) tend to be somewhat more challenging to make ergonomic.

Embossed tabs direct users how to open the package.

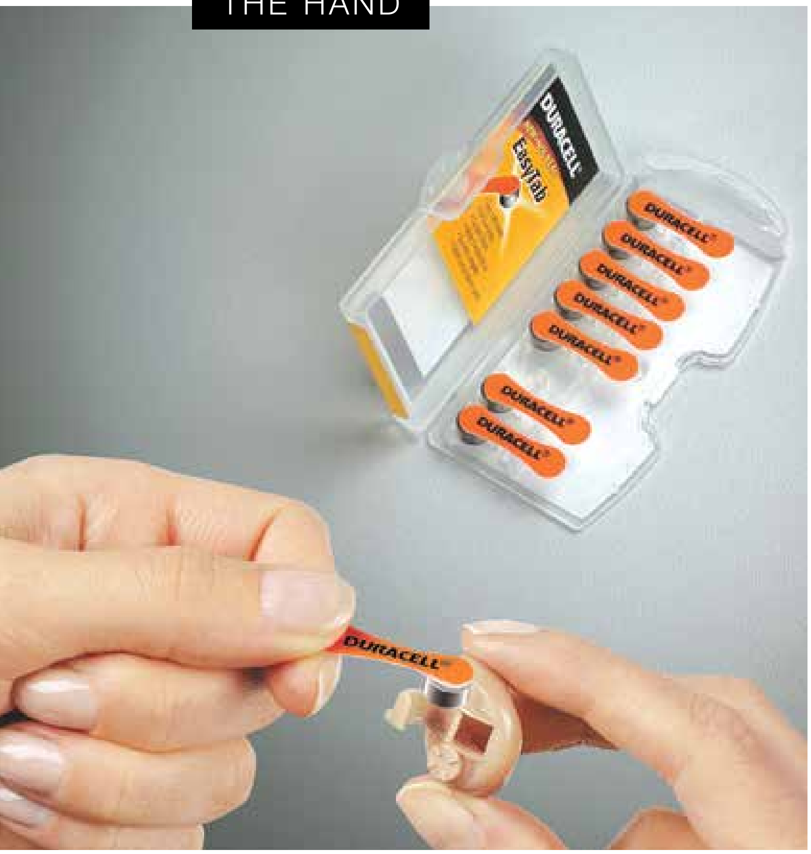
Bending or forming sheets of material creates structures with acceptable, but not great, ergonomics. On the other hand, packages that can be formed from materials that are reduced to their molten state prior to forming have the ability to take on more ergonomic shapes. Items such as bottles, jars, closures and other blow-molded or injection-molded parts have the benefit of being able to be transformed into shapes that are essentially independent of the original form of the material.

Fundamentally, packaging must do all that it does but do it in an economic manner. It must strike a balance between what the company can afford to produce for a reasonable and sustainable profit and what the consumer can afford to pay for the benefits that the package delivers. Packaging's true role is the containment and delivery of a product. In the absence of a product, packaging would not exist, so it must not impose an unacceptable economic burden on the product to be consumed. It is in the sweet spot between these two opposing forces of profitability and affordability that packaging must effectively operate.

Design Guidelines for Handheld Packaging

So then how does this all translate to specific guidelines and design principles for handheld packaging? Some of the considerations are as follows:

- Use clear, overt clues in the packaging to indicate the method of handling, opening, removing and/or dispensing. Understand that the packaging itself must clearly communicate how the consumer should interact with it, and strive to provide the necessary visual and tactile clues to facilitate an intuitive engagement.
- For items with tabs or features that require lift or tear-to-open access (such as thermoformed clamshells, trays with film seals or pouches with tear away tops) provide a sufficiently large area for the fingers to grasp. Consider using a tab size of at least 0.5 inches to facilitate ease of opening. If possible, consider adding texture through the use of embossing or surface finishes to aid in the ease of opening by identifying the direction of pull (emboss to lift, deboss to pull down).



The air activation label of the Duracell "Easy Tab" pack serves as a handle to aid less dexterous consumers in inserting the batteries into their hearing aid.

- For items such as bottles, jars or cans that are inherently round in nature, consider adding a noncylindrical grip feature to aid in stabilizing the container while holding or opening. Consider the target audience for the product, and tailor the diameter of the grip portion of the container to meet their needs. In many cases, if you solve for the case with the most constraints or the most demanding requirements, or the users who have the most restrictive needs, you create a universal solution that all can use.
- For items such as dispensing systems (pumps, trigger sprayers, etc.) where the consumer is required to actuate the system multiple times over the course of a usage session, minimize the force required to dispense the product from the system by providing sufficient leverage and finger purchase. Design the system to fit comfortably in a single hand, ensuring that contact surfaces are properly contoured, are free of any sharp edges and have no pinch points.
- When designing packages with rotationally applied closure systems, ensure that the contact surfaces of the closures offer sufficient grip. Strive to refine the diameter of the opening to allow for appropriate dispensing of the product, and be consistent with the ergonomic requirements of the target consumer. When feasible, design closure systems to incorporate rapid-rise threads to minimize the action required to open the package and to resist overtightening on reclosing.
- For large containers that are meant to be used over time, consider adding multiple grip points to facilitate lifting and transport in various orientations. There is often a different ergonomic requirement for different packaging actions. For example, a bottle may require a different handle location and configuration for carrying versus pouring.
- When possible, consider having the package serve multiple functions beyond containment, such as becoming an implement or aiding in the delivery of the product. When Product Ventures developed the Duracell "Easy Tab" pack, we turned the air activation label on the battery into a handle to aid less dexterous consumers when inserting the batteries into their hearing aid.

In addition to all of the factors that go into the design of handheld packaging, we should also be aware that certain industries have other overarching considerations that impact packaging above and beyond its typical purpose and that override other factors such as ergonomics. In the beauty and personal care industry, image plays a key role in the design of handheld packaging. In the pharmaceutical industry, the overlying principle behind package design is safety. In laundry and home care, utility and ergonomics play more important roles. In the food and beverage industry, product protection and shelf life are important factors, and in consumer electronics, shrinkage, or theft prevention, is a factor that drives the design consideration hierarchy for handheld packaging.

In the end, design principles for handheld packaging must strive to appropriately factor in the myriad of packaging requirements. Product preservation and delivery, manufacturing realities, brand communication objectives, merchandising, user experience and environmental sustainability all need to be addressed. It's a tall order for the package designer to effectively orchestrate. If we were to develop the pickle jar today, we might consider the human factors more thoughtfully and leverage a different package configuration that can provide a better consumer experience. Maybe it's a pouch so that you can grip the pickle more easily and avoid the comical chase-the-pickle experience of today. There can always be a better solution if all factors are carefully considered. ■

By Eunji Park and Stephanie Morgan

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Designing Hearing Aids

AGING HANDS & MINDS

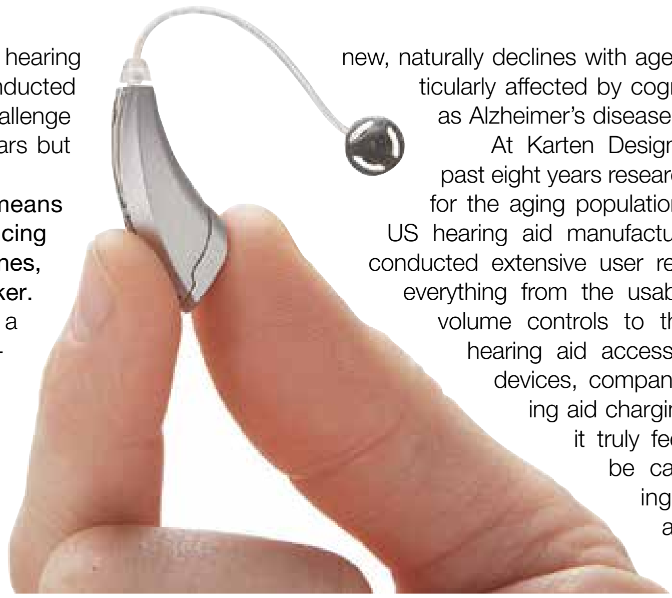
Don, a 73-year-old hearing aid user, has removed his hearing aid from his ear and is holding it in his hand; he needs to change the battery. He removes the dead battery from its compartment and, with seemingly methodical precision, takes a fresh battery between his index finger and thumb and attempts to insert it into his hearing aid. There is a sudden lapse in his dexterity, and he loses hold of the battery, allowing it to slip between his fingers and out of his hand. That the battery is too small for his aging eyes to easily detect is not the only problem. Because Don was not wearing his hearing aid, he has absolutely no idea in which direction the battery rolled away because he could not hear it hit the ground.

Don is perhaps one of the most impactful hearing aid users with whom our team has conducted research. He opened our eyes to the challenge of creating hearing aids not solely for ears but also for aging hands and minds.

Designing for aging hands means designing for people who are experiencing an overall physical decline—whose bones, muscles and joints are becoming weaker. The hands, in particular, experience a reduction in nerve endings, making it difficult to sense pressure, temperature or pain as precisely.

Designing for aging minds means designing for people whose brains process information more slowly, making the task of learning something new exponentially more difficult. The ability to retain information, be it familiar or new, naturally declines with age as well, but is particularly affected by cognitive ailments such as Alzheimer's disease.

At Karten Design, we've spent the past eight years researching and designing for the aging population as a partner with US hearing aid manufacturer Starkey. We've conducted extensive user research to examine everything from the usability of hearing aid volume controls to the development of hearing aid accessories—such as TV devices, companion mics and hearing aid charging devices—to how it truly feels for someone to be categorized as hearing impaired. We've also spoken with the stakeholders involved in the



Starkey Zon Hearing Aid

Starkey S Series Hearing Aid

hearing aid ecosystem, including patients, caregivers, audiologists, industry experts and dispensers.

And what we've come to understand is that while designing for aging hands and minds is not easy, it's not impossible. We'd like to share some of the insights and strategies we've developed during our partnership with Starkey to show how a deeper understanding of the complexity of the needs of seniors can lead to more meaningful products that holistically improve the hearing experience.

Functional and Cognitive Considerations

The following are physical design attributes that we have identified as being the baseline requirements for a successful hearing aid and related devices that specifically address the needs of declining dexterity and cognitive function.

Instinctive Accessibility of Controls. The majority of elderly users with declining dexterity and loss of sensitivity in their hands and fingers experience difficulties locating the control on their hearing aid. Various age-related physical and mental conditions also aggravate usability challenges. Therefore, controls with an obvious protrusion and distinctive edges become the baseline in quality design to enable easier and instinctive usability. However, when optimizing the protrusion and tactility of a control, the discreetness of the overall design should also be considered to satisfy both the user's functional and aesthetic preferences.

One-Handed Operation. A misplaced control often leads to misuse. If a control is positioned too low on the device, users will unintentionally push the hearing aid off their ear when trying to operate it. Elderly users also have difficulties stabilizing their fingers on the hearing aid and applying the right amount of force on the control while wearing the device, necessitating frequent removal to adjust settings. To alleviate this frustration and facilitate efficient operation, the control should be easily manipulated by one hand without needing to take the device off or ask others for help.

Clear and Effective Feedback. Once a control is triggered, users have difficulty identifying their current and desirable setting because of unclear feedback. Furthermore, individual health limitations among users drive and often complicate the type and the amount of feedback that is effective for them. For example, users with limited dexterity in their fingers often have difficulty with hearing aids that solely rely on vibrations or other tactile feedback. To alleviate frustrations and enable seamless interaction, selective sensory feedback that responds to the user's action should be integrated into the controls.

Minimal Training and Everyday Assistance. Elderly hearing aid users with declining memory abilities have difficulty remembering multiple steps and operating controls with their hands. A successful hearing aid control embraces commonly established gestures and ranges of motion that align with each function. At the same time, it should require that users undergo minimal initial training and need little to no assistance to operate the product. Reducing the amount of mental processing power needed is one of the key considerations for enabling intuitive usability of hearing aids and related accessories.

Eunji Park, a senior design researcher and industrial designer at Karten Design, identifies the macro context of people and the world they live in through technology and social and cultural lenses and translates that into strategic product development opportunities. Her recent research focuses on the digital health space where consumer technology and medicine intersect. ■ A design researcher at Karten Design, **Stephanie Morgan** thinks about how people think. She uses her background in cognitive science to explore the role cognitive activities, such as learning, memory, attention and decision-making, play in how people perceive, interact with and experience products in real-life contexts.

Social, Psychological & Emotional Considerations

Functionally optimizing a product for aging hands and minds is not enough to fully resolve the design challenge that creating a successful hearing aid presents. To elevate the user experience, researchers and designers must go beyond focusing on pure tangible interactions with the product and understand the social, psychological and emotional contexts in which the device is experienced. The following key insights reflect this notion and are integral to the meaningful design and ultimate adoption of hearing aids and related products.

The Social Stigma of Hearing Loss and Hearing Aid Use. We discovered that there is an overwhelming amount of stigma attached to hearing loss and aging. Most hearing aid users acknowledge that they do not want to publicly exhibit their use of hearing aids. For example, when in a social setting, some users visit the restroom to adjust the volume to avoid being identified as wearing a hearing aid or feeling embarrassed for having impaired hearing. As such, hearing aid users, their caregivers and hearing professionals are drawn to the idea of using a smartphone to discreetly control and adjust a hearing aid or related devices. Similarly, prospective hearing aid users with limited dexterity like the idea of a voice-controlled hearing aid, similar to Siri, as an option.

Conflicting Level of Adoption and Attitudes Toward Newer Technology. While new innovations promise overall improvement of hearing aid functions, adapting to new features can be a roadblock. We identified that seasoned hearing aid users are often reluctant to switch to a new hearing aid, even if it provides better usability. They are often dependent on—and emotionally attached to—their current hearing aid and fear they would need someone else to help them learn how to use a new device. Because of this emotional barrier, some audiologists reported that hearing aids without traditional features (such as rotary volume control) can negatively affect the sales of hearing aids, especially with senior groups (typically 75 and older). However, younger baby boomers (early 50s to late 60s) are likely to be up to date with technology and much more comfortable with using newer devices. This division between senior users and younger users should be kept in mind when designing hearing aids as it could even necessitate the development of two different devices.

Caregivers and Spouses Are Undiscovered Users. Although caregivers are not currently targeted as primary hearing aid users, they are often directly involved in the product's acquisition and use, and are directly impacted by the overall hearing aid experience. A caregiver is the one who typically makes an effort to bring the hearing impaired person to the audiology office and convinces them to purchase a hearing aid when hearing loss develops. The caregiver assists with the everyday use of hearing aids, such as identifying functional errors that the hearing aid user might not notice. Frequently, a hearing aid user's spouse appreciates hearing accessories like a companion microphone more than the hearing aid users themselves because these devices can improve their everyday communication and relationship. However, we learned that caregivers who are actively engaged in navigating, manipulating and troubleshooting hearing devices experience as much frustration and stress as the hearing aid user. When designing for diverse hearing aid users, designers should also consider caregivers as extended users—who can provide rich insights for improving the design, even if they are not the primary user.

When we first started working on hearing aids, it made sense to assume that our primary area of focus was going to be the human ear. However, it wasn't until we investigated the complexity of the user experience that we realized that designing hearing aids is really about designing for aging hands and minds. It takes a lot of effort to develop a contextualized understanding of a user's experience with a product. It involves examining social, psychological and emotional components and being able to interpret that information into action through design. Once you've developed a holistic understanding of the design problem, the potential to create meaningful products for the end user is ever so much greater. ■

By Alan Mudd
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Surgical Tool Design

DRIVEN BY USER COMFORT

Designing a product to be operated by the human hand represents a significant challenge for the industrial designer—not only because of the hand's complex geometry, variations in size and intricate range of mechanical motion, but also because it's the part of the body that expresses our unique abilities, whether that's a talent for playing the piano, building a ship model or performing life-saving surgery. When tasked with designing any handheld tool or product, designers understand that personal differences in physical user interaction may be very subtle (how many different ways have we seen people hold a pen?). Yet by acknowledging and accommodating these differences, the designer can make huge improvements in how the user experiences the product.

Farm Design collaborated with ConMed, a global manufacturer of surgical devices, to develop an improved version of its DetachaTip laparoscopy ("lap" for short) tool handle. Our team was challenged to design *and* engineer a new reposable (extended-use disposable) handle that would be more comfortable and offer greater control and precision than ConMed's previous product.

Specifically, the handle needed to address the differences in hand ergonomics and the personal working preferences of different surgeons. At the same time, the controls on the handle had to be accessible for right- or left-handed use, and we had to design the handle ergonomics for the increasing number of females in the surgical profession without compromising the fit of a large male hand. Finally, despite being a limited-use instrument, we needed to engineer the product with high-quality durable materials and provide the precise feel of a long-term reusable device.

The Challenges of Laparascopic Surgery

Lap tools are used in minimally invasive surgery. They typically consist of a scissor-like handle to which is attached a long, slender shaft that is inserted into the patient through a device called a trocar, which acts as a portal through the outer layers of tissue and into the surgical cavity. Operating the handle drives the action at the tip, allowing the surgeon

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to manipulate or cut tissue inside the patient while being guided by the fiber optic video taken from inside the cavity. Surgical device companies typically offer an entire lap tool system that consists of the proprietary handle and a family of interchangeable tool shafts with various functions at the tip, such as grasping, cutting or cauterizing.

Laparoscopic surgery is effectively surgery by remote control, and is particularly challenging because of the unique interaction among the surgeon, the tools and the patient. In a typical open-cavity surgery, the physician is looking directly at the targeted areas using conventional surgical tools that put the surgeon's fingertips in direct contact with the patient. When using a lap tool, the doctor is standing next to the patient table viewing a screen showing the image of what's happening inside the patient and manipulating a tool whose cutting or grasping action is being done about 18 inches from the surgeon's hands. In addition to being somewhat disconnected visually from what's going on at the end of the tool, the doctor is missing the direct tactile feedback of a blade or a probe touching tissue. The challenge for Farm was to design a lap tool handle that would offer many subtle but significant improvements over existing products, adding up to a more comfortable, precise and satisfying user experience.

Addressing Hand Ergonomics and Varied Working Styles

To capture the uniquely complex and detailed interaction between laparoscopic surgeons and their tools, during a four-year period our client had conducted comprehensive research into surgeons' experience with handles made by both ConMed and its competitors. The detailed results of that research drove the interaction design of the new product. For example, the research introduced us to a phenomenon called "laparoscopic surgeon's thumb" where surgeons develop parasthesia (numbness or tingling) from pressure put on the lateral digital nerve of the thumb by the thumb loop on the handle. This led us to pay specific attention to both the shape of the finger loops and the sculpting of all surfaces that the fingers would touch.

We also learned from watching laparoscopic procedures that surgeons typically hold the tools in a wide variety of orientations relative to the patient, so we had to consider and optimize the angle between the finger loops and the tool shaft in order to mitigate stress on the surgeons' wrists. And we had to define just the right amount of rotational travel for the thumb loop, providing enough mechanical advantage to properly activate the tool end without creating so much travel that it would be difficult for a smaller hand to operate.

Finally, our team understood that we could create a truly differentiated product if we designed it for the varied approaches that surgeons use for gripping the handle. Surgeons usually hold the handle like a pair of scissors, but in order to rest their hands during a long procedure, they often shift to a technique called palming, where they cradle the handle with the thumb loop resting in the palm of the hand, a slightly more relaxed approach that uses different muscles and reduces stress. And yet another common grip approach is used when the tool must be held almost vertically with the surgeon's hands held relatively high. In this case, the surgeon interacts with different areas of the handle and might even push against the bottom of the thumb loop.

Building on this extensive user and market research, Farm began a process that involved designing the form of the handle—including the tactile and mechanical interaction points—and engineering the internal mechanisms and snap-on tool shaft interface. As our team progressed along the development path, we validated our ideas by sharing sketch models and machined prototype concepts with surgeons. Their feedback guided the refinement of the handle features, form and touchpoints.

As the overall form and interaction was evolving, Farm's engineers developed the part design and internal mechanisms that would fulfill another critical aspect of the product performance sought by ConMed and our team: a high level of precision in the operation of the product. All moving parts had to interact smoothly and with no discernible play. And we had to engineer into the handle operation the pronounced auditory clicks requested by surgeons to indicate how far they had closed the tool tip or rotated the tool shaft.

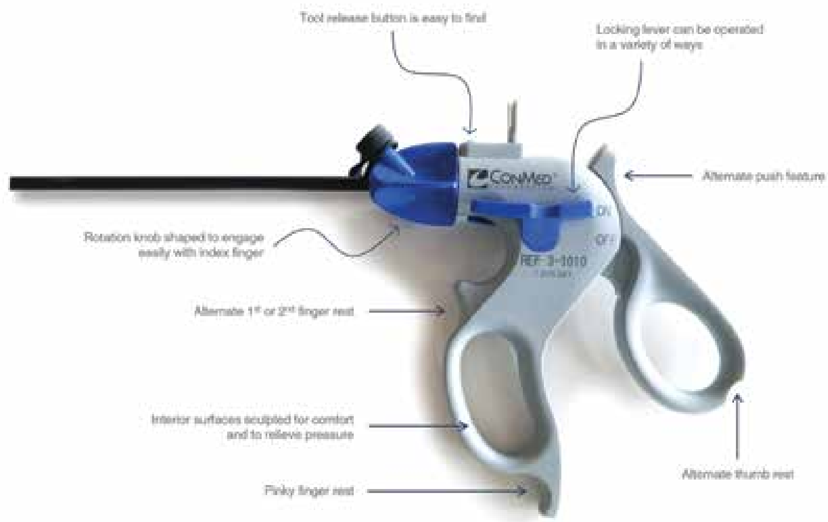
A Better Product for the Users and for ConMed

With the new DetachaTip handle design, Farm and ConMed have created a form that perfectly fits the hand:

- The handle accommodates all five fingers comfortably when held traditionally or palmed.
- The handle size and range of motion fit a wide range of hands, from small female to large male.
- Handle surfaces have been carefully sculptured to significantly reduce pressure points.
- The generous finger contact surface areas are designed for comfort while maintaining a compact overall handle size.
- The finger rest at the base of the handle is narrower and farther forward to accommodate the smaller pinky finger.
- The interaction area on the bottom of the thumb loop gives the user another grip option when operating the handle at a higher angle.
- The places where a glove might get caught when operating the thumb loop were minimized.
- The primary handle parts are injection molded with a light texture that's easier to grip.

The team also devised controls that are fully ambidextrous:

- The pivoting seesaw handle lock lever means it can be activated from a variety of positions.
- The tapered shape of the lock lever keeps it out of the way during use.
- The tool shaft rotation knob is easy to reach and carefully shaped for precise control by the index finger.
- The tool release button is placed on top where it's easy to see and where there's less chance of accidental activation.
- There are no triggers or buttons on the front of the handle so as not to interfere with the surgeon's natural squeezing motions.
- The handle lock, rotation knob and release button are molded in contrasting colors so they're easy to see.



To further enhance the user experience, the new DetachaTip handle weighs less than many competitors' products, yet balances well when a tool shaft is attached. The handle is constructed to communicate premium quality. Rotational parts turn with satisfying precision, and when comparing the ConMed handle to any other lap tool on the market, there is a noticeable lack of play where parts interact and a much better feel in the hand. When held, the user's fingers naturally fall into a comfortable position, no matter which grip approach is used, and it's easy to access all controls. Ed Connell, from ConMed's marketing team, had this to say: "When we put the new DetachaTip handle into a surgeon's hand for the first time, they initially think it feels weird. But then they start to operate it, and I watch their expression shift as they suddenly realize that every handle they've ever used has been far less comfortable than this. Every surgeon who tries this tool loves it."

By focusing the design effort on the unmet needs of the end user, Farm and ConMed have created the most comfortable and easy-to-use tool handle on the market, a compelling addition to the laparoscopic devices currently available to surgeons and a product that is boosting ConMed's bottom line. ■

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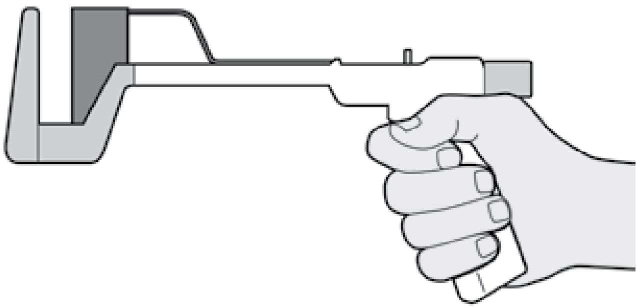
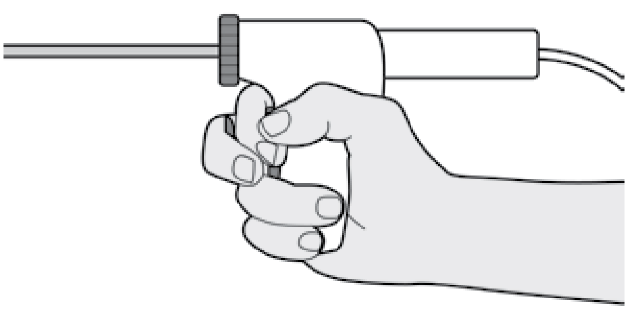
DO YOU ACTUALLY USE YOUR HANDS TO SHOVEL SNOW?

Bryce Rutter, PhD, IDSA asked me for a few words about the use of hands for what many of us have done a lot of this winter—shoveling snow. The fact is, however, that we really don't use our hands for shoveling snow. What we do, I think, is replace our hands with an alternative tool. The hands are just used to hold the tool—the snow shovel—in place. Such tools, it seems to me, are assistive devices, like glasses or hearing aids. Our original equipment is inadequate for the task, so we beef up that original equipment (our hands) with something that's a lot stiffer and that holds a lot more snow.

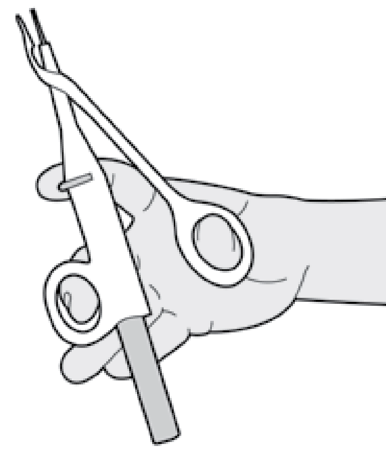


At this point, I'm going to blatantly segue from snow shovels into a discussion of surgical instruments, something I work on all the time. Some surgical instruments—for example, surgical staplers (shown above)—are conceptually like snow shovels in that they replace the hand rather than require actual use of the hand. Other such tools include scrapers, coffee cups, staplers and blow torches. Another type of surgical instrument, on the other hand, requires actual use of the hand—such as needle drivers for tying sutures (shown below). Other tools that entail use of the hand include pianos, keyboards, styluses, pens and pencils.



The key difference is that the former only involves use of the hand to grasp the tool and move it; the latter involves use of the fingers to manipulate things—the former is good for applying force but poor for precision; the latter is good for precision but poor for applying high forces.

What I've seen over the years working on surgical instruments is that sometimes there is confusion about what type of instrument is required; sometimes the momentum of certain traditional form factors puts surgeons in the position of having to, for example, achieve precise positioning by moving the whole hand (below). In such cases, the surgeon is forced to move the tip of the instrument into a very precise location using muscles in the back, chest and upper arms—not a very easy way to, say, use the jaws of a grasper to grab a tiny blood vessel, something surgeons have to do all the time. For such tasks, it's much better to use the muscles of the hand and forearm—in other words, to use the fingers rather than the arm to move the instrument's tip into position.



One other complication is that some instruments require both the application of great force and fine precision. Historically, this has led to some instruments that cause fatigue and overuse injuries by forcing precision from the wrong muscles (as above) and other instruments that cause fatigue and overuse injuries by opting for precision and, thus, requiring great force from the fingers and thumb. The way out of this dilemma is to provide electric or pneumatic power to instruments that have traditionally been unpowered. This is, in fact, a major trend right now in surgical instruments.

The general principle, then, is that with surgical instruments, in particular, and with hand tools, in general, a good initial question to ask is, "What muscles should ideally be used for this type of task?" and to design the tool accordingly. In some cases, this will involve rejecting what might be a traditional form factor and replacing it with something else. In other cases, the need for external power will become obvious. ■

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Human Factors Considerations When Designing Handheld Medical Devices

GET A [COMFORTABLE] GRIP!

Eventually, this article comes around to the topic of human factors considerations when designing handheld medical devices, such as surgical instruments, nebulizers and pen injectors. But first, I wish to share a story with an arguably feminist perspective.

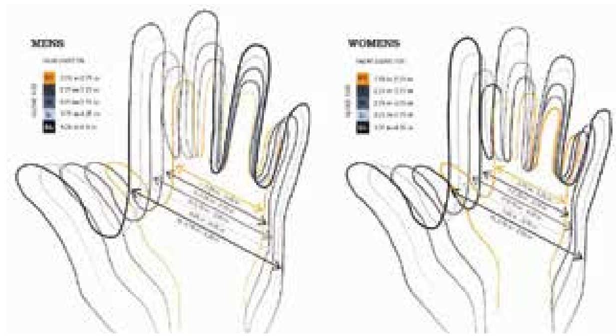
Several years ago, I delivered a talk about human factors engineering to a group of female gynecologists. The audience members' gender distribution was not a statistical aberration. Rather, they had been invited to a special event to express their opinions about the past, present and future of surgical hand-tool design. It was nice to meet such an interesting group of people who could reflect on the topic of gender bias in medical device design.

During my talk, I made the not particularly profound statement that handheld devices—and surgical instruments in particular—should accommodate a user population that includes people with very small hands as well as those with very large hands. I suggested that manufacturers should even go so far as to accommodate the 1st percentile female through the 99th percentile male, rather than the usual 5th to 95th percentile range that still neglects the needs of many users. Often, wider accommodation is quite practical.

My distinguished audience members would have been justified to collectively roll their eyes in response to my platitude about considering women's needs in addition to men's needs. After all, anthropometric data on the size of adult male and female hands has been available for decades. And yet, many devices intended for use by healthcare professionals have reflected a strong bias toward accommodating men's hands. Women have been burdened and disadvantaged by male-oriented medical devices, surgical instruments in particular.

Indeed, surgical instruments, as well as other handheld devices, have largely been designed by men, for men. We can acknowledge this on faith in the absence of a multiyear scholastic study to prove it, right? During the aforementioned event, some of the female gynecologists with small and comparatively weaker hands said that surgical instrument design had disadvantaged them for years. They reported that women often struggle to use devices made for larger and stronger hands; that ill-sized handheld devices compromise women's ability to perform certain procedures; and that women routinely experience greater physical strain than male colleagues who have larger, stronger hands.

Despite being the only male present during my talk, I was not the object of disdain regarding the historical design bias against women. The professional audience assumed that I had not designed some of the most offending devices, such as those with large finger and thumb holes that are difficult to stabilize when gripped by individuals with small digits. Moreover, they recognized that I and many others in the human factors engineering and industrial design field are their product development allies, at least looking forward. They already anticipated the introduction of new products in the near future that will be better suited for use by women, particularly individuals with smaller and weaker hands, and they credit enlightened designers and market changes (more female physicians) for making the difference. Notably, in the gynecology field, 83 percent of the new residents were women in 2012, (www.thedailybeast.com/witw/articles/2013/12/09/are-male-gynecologists-creepy.html) and the percentage is likely to increase in the coming years. After all, almost 50 percent of the students graduating from medical schools in the US these days are women (http://crgp.ucsd.edu/documents/GenderinMedicalProfessionsCaseStudy.pdf).



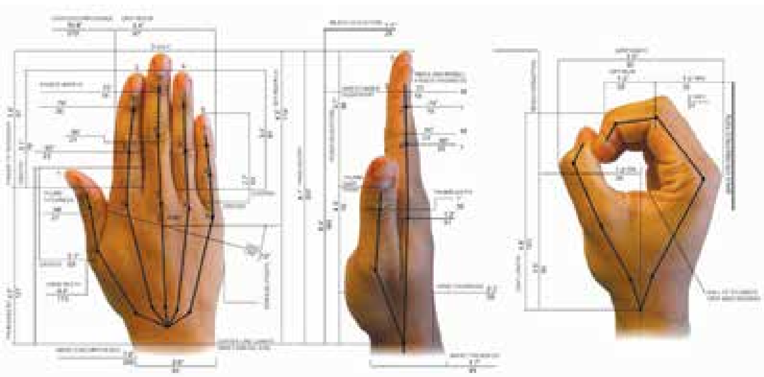
Accommodate the User

So what should handheld device designers be thinking during the early stages of product development? The user-centered designer's mantra is that devices should accommodate the user and not the other way around. As such, user interface requirements based on users' needs should drive the design process. It's the modern way.

Sometimes, you can optimize a single handheld device to suit both women and men. To ensure that people with small hands can maintain a secure power grip (with fingertips opposing the thumb) on a handle that also suits someone with a larger hand, it's a matter of setting lower limits for the forces required to operate the device and making sure that lever movements do not exceed a particular user's reach.

When a single-size device (even an adjustable one) cannot fit all, accommodating users with particularly small hands and others with particularly large hands requires device variants. This approach parallels the need to produce different size protective gloves rather than just one size.

Keep in mind that designing a device that accommodates women might result in a device that is also preferred by men. It is the gender-based version of the argument put forward by universal design advocates. Universal design philosophy posits that making devices accessible to people with disabilities can also serve the needs of people without disabilities, which explains why kitchen tools designed for people with arthritic hands also work well for people with healthy wrists and fingers.



Handheld device design considerations extend beyond hand size, even though hand size is an important one. Other considerations include hand strength, range of motion, dexterity and sensation. Here's one that might not jump to mind: Plenty of women have long fingernails, which can certainly influence how they manipulate devices. For example, women with long fingernails are prone to use their knuckles instead of their fingertips to press a handheld device's buttons.

Circling back, I've suggested that women's needs have been discounted by medical device developers who have concentrated on the needs of their historical core customers: men. But this is not to say that hand tools have always been optimized for men. There are plenty of hand tools, and handheld devices for that matter, that pose physical challenges to both male and female users. Some, such as retractors, require the user to apply substantial force for a sustained period of time, which can cause cumulative stress. Some, such as cutting, cauterizing and stapling devices, require precise control that may be compromised by an improperly sized grip. Indeed, devices designed for traditionally female nurses with small hands (women still represent more than 90 percent of all licensed nurses in the US) have made professional life more difficult for male nurses with large hands.

And yes, I have yet to address the needs of laypeople, that particularly diverse population of folks who may operate prescribed and over-the-counter medical devices in nonmedical settings (such as homes, offices, restaurants, sports venues and automobiles). Meeting their needs will be critical to companies producing devices that historically have been used by clinicians but now are being used by patients and their caregivers (for example, family members and friends). Many of the following design considerations apply to handheld devices used by both healthcare professionals and laypersons.

Design Considerations

Here are some design considerations for handheld medical device developers who seek to meet users' needs. The list includes ergonomic factors and others that pertain to use safety and task effectiveness.

Hand size. Hand size does matter. A man with particularly large hands can stretch them 9.2 inches wide, while a woman with particularly small hands can stretch them only 6.5 inches (see ANSI/AAMI HE75:2009). So ensure that you perform the anthropometric analyses necessary to size your handheld device. You might want to go so far as to use a computer-based hand model to test your design concepts for fit.

Hand strength. There are all kinds of hand strength measures, including pinches, power grips, button presses and trigger pulls. As you would expect, the maximum forces people can exert vary widely. So does the force that an individual can comfortably sustain. These data should drive design characteristics, such as the required mechanical advantage of hand-operated cutting tools, a trigger's spring resistance or the force required to connect or disconnect two components.

Sensation. Hand sensation might not be a major consideration when designing a surgical instrument. It's the rare surgeon who has diminished fingertip sensation. But by comparison, loss of sensation is common among people with diabetes who have fingertip neuropathies. These people might experience tingling in their fingertips or more profound numbness that affects their ability to hold objects and perceive important tactile cues (such as a button click). Their impairment might call for handheld devices that do not require pinch grips, that incorporate buttons with more travel, or that produce both audible and tactile feedback in response to control actuations.

Dexterity. Similar to hand sensation, hand dexterity might not be a major consideration in surgical instrument design. But it is likely to be an important consideration when designing a device that people with Parkinson's disease or essential tremor would use to self-administer medication, perhaps via an inhaler or injector. Severe dexterity limitations among a device's intended user population might lead you to design a device that anticipates and affords a two-handed grip, forgives imprecise inputs and can tolerate dropping. Note that even people with normal dexterity will be well served by devices that limit the need for precise hand movements. There is no reason for a battery-powered device to require fine movements to open a battery compartment door and replace the depleted batteries. Device features requiring finesse are a hindrance to all.

Range of motion. Range of motion does not vary greatly among individuals. But pay close attention to typical ranges for the various fingers, hand and arm, and to positions that can cause strain or are simply impossible. To get a sense for the hand's movement constraints, place your hand flat on a tabletop. Now lift only your fifth finger (the pinky). Flatten your hand once more. Now lift only your fourth finger (the ring finger). Feel the difference? The fourth finger moves quite differently, straining to extend upward. So consider all the motions required by your device and make sure they are reasonable. Reasonable motions are those that do not approach users' physiological limits. Moreover, hand comfort and protection against injury calls for people to maintain neutral (i.e., relaxed) finger, hand and arm positions to the extent possible, which are generally the same positions at which humans can exert the greatest forces.

Handedness. Right-handed individuals outnumber left-handed individuals approximately 9-to-1. Still, the ideal device accommodates both right- and left-handed individuals. Otherwise, you will disadvantage a significant proportion of users or you will have to produce two variants. Notably, a hand-neutral device gives all users the option to use one hand or the other, depending on the task requirements.

One-handed use. At certain times, healthcare professionals might wish they had three or four hands to complete tasks. That is when they need to ask a colleague for help. So give them a break—and design your device to enable one-handed use when possible.

Repetitive motion. We've all heard about repetitive motion disorders, such as carpal tunnel syndrome (CTS). CTS is linked to repeated wrist movements that aggravate the carpal tunnel, which runs through the wrist and can press on and degrade the median nerve pathway (i.e., damage the myelin sheath surrounding the nerve fibers). The consequence is pain, tingling or loss of fingertip sensation; limited range of motion; and weakness. Not good. To prevent CTS and similar disorders, handheld devices should not require users to perform the same maneuver too many times in a row without a break; to apply forces nearing the user's maximum capacity; or even to apply a moderate, constant force for an extended duration. On a related note, handheld devices should not place extreme pressure on a body part

Fiskars

(such as the palm) for a short duration or even moderate pressure for an extended duration. Extreme pressure can damage soft tissue and strain muscles. Moderate pressure over time can deprive tissues of oxygen due to reduced blood flow and cause tissue damage.

Comfort. Don't underestimate the importance of perceived comfort. Sure, a device might function effectively without causing strain or pain, but users will appreciate one that feels good in the hand. Consider the difference between a simple pair of scissors that lacks ergonomic handles versus the contoured handles found on the classic Fiskars model, noting that the latter must be produced in right- and left-handed versions. Consider the hand tool that has just the right diameter to enable a closed (power) grip versus one so spindly that it requires an uncomfortably closed grip and perhaps a higher squeezing force to maintain the grip. And consider hand tools that have hard plastic handles versus those with overmolded soft plastic touchpoints that feel almost like suede. The bottom line: Make sure your handheld devices offer a measure of comfort going beyond simple utility.

Aesthetics. I have to mention aesthetics even though it ranges far from this article's core topic. Do healthcare professionals or laypersons care about the appearance of a handheld medical device? Sometimes they say sincerely that they couldn't care less about a device's look and feel. But years of user research tell me that most of these folks are fooling themselves. I recall a respiratory therapist asserting that he did not care at all about device aesthetics. Then my fellow researcher and I presented him with design sketches of the same device in various colors, including white, black, blue, yellow and green. He immediately scoffed at the yellow and green ones, stating that he hated their appearance and would not tolerate them in his workplace. So much for not caring! Accordingly, you should style handheld devices to match the intended use environment. Positive impressions arising from pleasing aesthetics are good for business and might even empower the user. As the contemporary saying goes, "What is beautiful is usable," but also consider that "what is usable is beautiful," as have the authors of a recent article, "The Interplay Between Usability and Aesthetics (http://dx.doi.org/10.1155/2014/946239)."

Sharps protection. Assume that devices with unprotected needles will cause needlestick injuries. So find ways to keep needles covered most of the time and ideally inaccessible after their use. While you are at it, try eliminating other sharp points and edges that can puncture and lacerate, or simply feel uncomfortable on contact and appear threatening.

Device exchanges. Consider how a device might be handed off between two or more people and optimize the device's design for such tasks. For example, study how a circulating nurse might hand a device in an opened package to a scrub nurse so as to facilitate picking up the device, avoid drops and maintain device sterility. Similarly, study how a scrub nurse might hand the device to a surgeon in a secure and ready-to-use manner.

Labels and instructions. The value of good labels and instructions is self-evident. Do not believe folks who suggest that nobody reads instructions. Both labels and instructions are part of a medical device's user interface, subject to validation in the FDA's design controls schema. Regulatory oversight recognizes that user interface elements can profoundly affect people's ability to interact with medical devices, including those that are handheld. Therefore, developers should take care to apply well-established label and document design principles pertaining to typography, graphics, color, nomenclature, syntax and so forth. Key takeaways derived from observing hundreds of people interacting with handheld medical devices include the following: put critical labels in view rather than where they might normally face away from the user, complement graphics (symbols and icons) with simple text, ensure that printed material contrasts sharply against its background and emphasize important information. In particular, printed instructions should not be overly dense with text and should use graphics to improve at-a-glance communication and enhance a document's overall readability.

Cleanability. Cleanability is now recognized as a critical design characteristic. Consider the recently increased concern about minimally invasive reusable instruments (such as duodenoscopes) causing superbug infections due to inadequate cleaning. (FDA recommendations for effective cleaning of duodenoscopes are available at http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm434871.htm). Clearly, reusable handheld medical devices should facilitate cleaning using reasonable care. Part of the solution is to limit the number of parts, seams, intrusions and other features that complicate cleaning. Another part is to provide clear and simple cleaning directions, which brings into play instructional material design guidelines that are outside the scope of this article but should be consulted.

Packaging. The quality of a handheld device's package could make all the difference between the device's success and failure. For example, a package might facilitate simple one-handed access to a coiled catheter used to perform heart tissue ablation, making it easy to remove from the package and subsequently place over a guide wire. Alternatively, a poorly designed package might require the use of two hands and increase the chances of a user dropping the device, allowing it to contact nonsterile portions of the package or to suddenly uncoil and strike the user in the face.

Conclusion

Designing a handheld medical device that satisfies the intended users should be straightforward. There is an abundance of user interface design guidance to keep you on track, such as AAMI HE75:2009. Equipping a nebulizer with a sturdy, comfortable handle is a no-brainer. So is producing a minimally invasive surgical instrument with a comfortable scissor-type grip that suits both women and men. Therefore, given that advanced human factors engineering and industrial design know-how is common in the medical device industry, device handling shortcomings seem mostly due to a lack of commitment to device accessibility and usability, including iterative user testing.

Now, let's turn our attention back to this article's initial focus. Let's enter a new era in which the next generation of medical devices fit women's hands as well as men's hands. After all, current trends suggest that in the near future women will be the majority in many healthcare delivery domains, if that is not already the case. The user interface design guidance is out there ready to be applied with a gender-neutral spirit. ■

MICHAEL WESTCOTT, IDSA

(1958–2014)

President, Design Management Institute

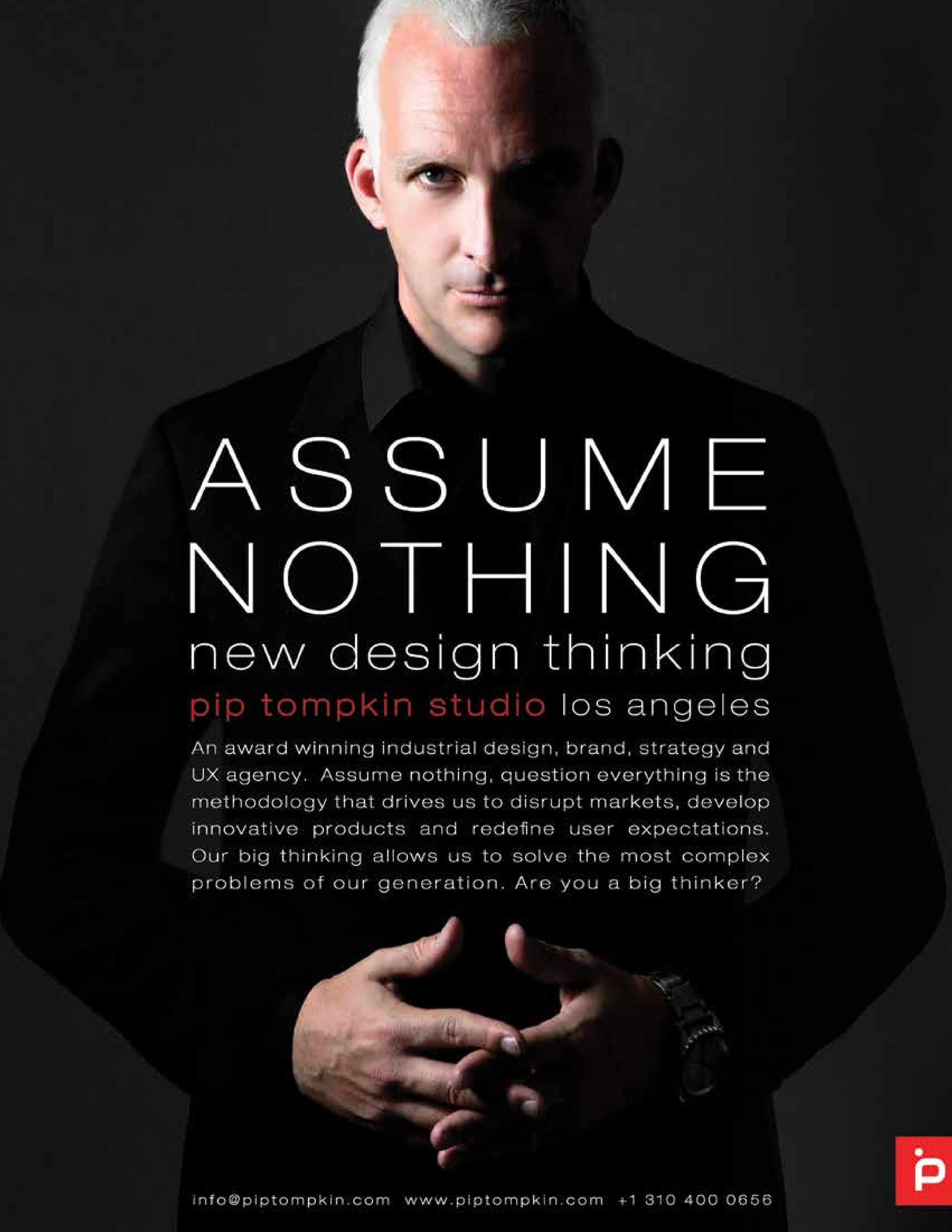
It seems to me like only yesterday that Michael Westcott was the IDSA Student Merit winner from Syracuse. We met as young design students on the north campus of the University of Michigan, my school, where the IDSA Central District conference was being held. From that moment until, well, even now, I was forever impressed by him and his talent.

When he left us this past fall, the world of design lost an inspired leader and a passionate champion of design. Michael passed away on October 4, 2014, after being diagnosed with ALS (amyotrophic lateral sclerosis).

Michael had great vision and was an excellent designer and thinker. He was also a wonderful friend. Although he had many priorities, education was of great importance to him. He started the DMI futurEd program and was dedicated to bringing education leaders to DMI professional conferences. His wish was to continue this further with the Michael Westcott Education Fund: www.dmi.org/MWestcottDesignEducationFund.

IDSA remembers Michael Westcott.

—*Mark Dziersk, FIDSA*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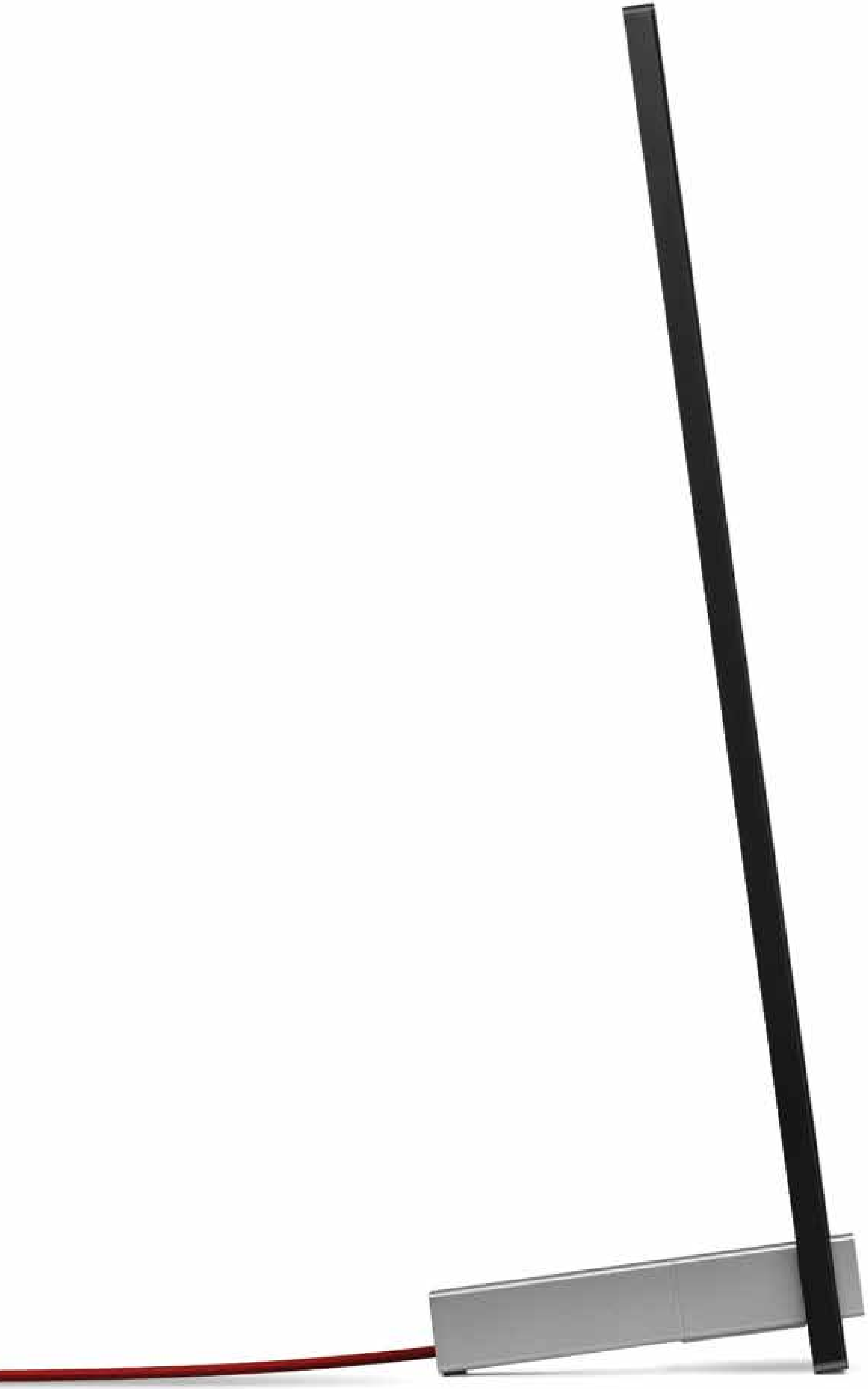

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