Motivation and Assumptions

- The automotive market is heavily weighted with older drivers, and becoming more so.
  - The leading edge of the ‘baby-boom’ generation is now part of the older driver market
    - People 55 to 74 will almost double by 2030, from 40 to 74 million in U.S. alone
- Customer satisfaction among older drivers is critical to the success of any vehicle manufacturer.
- New telematics products and services coming into the marketplace can offer particular benefits to older drivers.
- The ability of drivers to use these products and services easily is critical to customer satisfaction and to marketplace success.
**Scope of Today’s Talk**

- How well do older and younger drivers use embedded communication and navigation devices in a vehicle?
- Are the performance differences between older and younger drivers large enough that we need to design separate devices for specific age groups?
- Or, do the performance data show that a ‘universal’ design strategy is optimal for telematics devices?

**Telematics Design Challenge**

Telematics tasks “on top of” primary driving task:
- Not enough to ensure easy to do alone
  - Must be easy to do WHILE DRIVING

The challenge of telematics user interface design:
- Meet the needs of customers for communication and navigation
- At the same time, make sure that needs/requirements in the primary driving tasks are met.
How Define the Older Driver?

What age separates ‘younger’ and ‘older’ drivers?

- Age effects progressive, no threshold:
  - Large individual differences
  - Different rates in different individuals
- Reduced Vision Examples:
  - Presbyopia - Reduced focus on near objects: $45 \pm 5$
  - Reduced sensitivity to contrast: $50 \pm ?$

Reduced Vision Examples

Presbyopia

Reduced Contrast Sensitivity
Other Age-Related Vision Reductions

- Sensitivity to detail in moving objects: ~45
- Ability to ignore glare: late 40's to early 50's.
- Ability to resolve details in stationary objects
- Sensitivity to light
- Range of color vision
- Visual field
  - ‘Useful’ field of view
- Temporal sensitivity
  - Longer visual persistence
- Adaptation speed to dark and light
- Depth perception
- Separating figure from ground
  - Sensitivity to visual distractions

Other Age-Related Reductions

- Balance and Spatial Orientation
- Audition
- Tactile Sense
- Cognition
  - Speed of Information Processing
  - Attention
  - Problem Solving, Decision Making, and Intelligence
  - Learning and Memory
- Motor Responses
Age-Related Changes: Effects on Driving?

- In general, previous research shows low correlations of visual changes, with driving performance, of older drivers.
  - Exception: Cataracts - Older drivers with cataract were 2x more likely to report reductions in days driven and number of destinations per week, driving slower, and preferring someone else to drive. [Owsley et al. (1999), J. of Gerontology: MEDICAL SCIENCES, 1999. Vol. 54A, No. 4, pp. 203-211].

- Effects of some age changes may be compensated through skills/knowledge which grow rather than decline:
  - Slower reaction times may be offset by increased caution and vigilance or slower driving speeds

- In short, variations in vision and other physical and mental changes are highly variable with individuals as they age

Optimizing for the Older Driver

Even so, what design criteria optimize the older driver’s performance with such systems?

- Good control and display location
- High legibility of controls and displays
- Comprehensible controls and displays
- Easy reach and adjustment of controls and displays
- Easy distinguishable auditory stimuli
- Low vehicle noise for improved communication

But Also Benefits Younger Driver!

Communication Interface, Vision and the Older Driver
R. Young, Eyes on Design, June 2001
Universal Design Hypothesis

- Making things work well for the older driver should also make them work well for the younger driver
- Undertook study of telematics devices, using age as a variable

Communication Interface, Vision and the Older Driver
R. Young, Eyes on Design, June 2001
Picked Four of These Systems for Study:

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<td>Acura Navigation System</td>
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<td>Alpine Mobile Mayday</td>
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<td>ATX On-Guard Tracker</td>
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Portable:
- Palm Pilot
- Portico
- Wildfire
- PC Based Systems

Future Concepts:
- Evoq
- Other Internal GM
- Mercedes-Benz SLR
- Opel Concept A
- Lear Trans-G

Subject Sample

94 research participants:
- Randomly selected from mid-size vehicle owners in Detroit area
- Age: 1/2 under 50 years, 1/2 over 50
- Gender: 1/2 Male, 1/2 Female
**Methods**

- Stationary vehicle tests
  - Later research shows association with on-road tests
- Performed communication and navigation tasks under simulated driving conditions intended to mimic driving workload
- All devices tested by all participants, with full counterbalancing
- Ordinary in-vehicle tasks performed as controls

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**Procedure**

- Give prior instruction (storyboards & in-vehicle practice)
- Sit in vehicle, adjust seating position
- Watch and steer to roadway scene on video monitor in front of car
- Watch for small red light, step on brake
- Perform tasks in random order:
  - ‘Control’ tasks: Adjust mirror, vents, set cruise control
  - Navigate to school
  - Call your daughter
Data Collection Methods

- Three tiny video cameras recorded data:
  1. Face (to record eyes-on-road time)
  2. Hands (to record hands-on-wheel time and on-device behavior)
  3. Forward scene (to record brake light illumination).
- A microphone picked up vocalizations of participants (which were recorded on same videotape as above).

Driving and Device Performance

1. Communication and Navigation Measures
   • Task completion time (secs)
2. Simulated ‘Crash Avoidance’ Related Measures
   • Response time (secs) to simulated brake light
   • Mean subjective rating of situation awareness
     • “How aware were you of surrounding traffic when you were performing the secondary task.” (1 = Low, 100 = High)
3. Workload Measures
   • Mean subjective workload rating (3 averaged ratings)
     • Example: “How much mental and perceptual activity was required.” (1 = Easy, 100 = Hard)
Video Examples

Experimental set-up

Task: Find school using touch screen navigation system
  ● Successful (younger woman)
  ● Unsuccessful (older woman)

Task: Find school using toggle control navigation system
  ● Successful (older woman)
  ● Unsuccessful (younger woman)

Task: Call daughter using phone voice recognition system
  ● Successful (younger man)
  ● Unsuccessful (older woman)
**Results - Older Drivers Slight Worse Overall**

1. Older drivers took slightly longer (4.5 secs., 12%) to *complete* the communication and navigation tasks than did the younger drivers.

2. Older drivers took slightly longer (0.1 sec., 6%) to *respond* to a simulated forward event than did younger drivers during communication and navigation tasks.

3. Older drivers had a slightly *higher* subjective workload (3 points on a 100 point scale, 7%) than did younger drivers during the communication and navigation tasks tested.

4. Older drivers had a slightly *lower* subjective outside vehicle situation awareness (2 points on a 100 point scale, -7%) than did the younger drivers during the tasks tested.

5. Older drivers had more unsuccessful trials than younger drivers.

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**But Differences between Interfaces Far Larger than Age Differences**

The differences between user interfaces (compare T vs. S or R) were far larger than the differences between younger and older drivers (compare white vs. dark bars). Example: Unsuccessful completion.
Summary of Results

- Although older drivers showed some deficits relative to younger drivers, the size of these effects was small.
- The same relative deficits between younger and older drivers are found for the control tasks.
- The most critical factor overall is the degree of usability of the telematics interface.

Conclusions

- A poor user interface design will cause both younger and older drivers to perform poorly, and a good user interface device will cause both age groups to perform well.
- These results confirm the hypothesis that making devices that work well for the older driver should also make them work well for the younger driver.
- Therefore, Design and Human Factors resources should be placed into developing easier-to-use telematics user interfaces, rather than developing them for one age group or another.
Thank you very much, Dr. Trick.

I’m going to take one minute of my time to respond—out of all the very stimulating talks yesterday, Michael Sivak’s particularly intrigued me. He asked the question yesterday, “The information the drivers use. Is it indeed 90% visual?” And he presents a very nice scholarly presentation for those of you who weren’t here yesterday; tracing back in the human factors literature, where did this originate, and it ended up nowhere, basically. It ended up in a black hole. There is a corresponding set in the physiology literature, and this is from a very obscure 1991 paper [R. A. Young, "Oh say, can you see? The physiology of vision," Proceedings SPIE, 1453, 92-123 (1991)]. And usually in the vision physiology literature, a figure of about 70% is typically quoted, but then I have not traced that back. That may end up being nowhere also. But in this same 1991 paper, you can take the human cortex, which goes around like this. Your visual cortex is here in the back, and you can unfold it into a two-dimensional map like this, and no, your brain is not labeled with these little things here (chuckle), but V1 is your main visual area in the back. If you just lay a piece of graph paper over this—this is from an actual brain—and count the little squares, and estimate that area, it’s about 15% devoted to vision. However, it’s actually a volume. So you have to do an estimate of the full volume, and the total number of cells. Cells in the visual cortex are very small and compact. And if you do that, you get this about 70% figure here. But then if you start adding up all the other visual areas, and actually count the number of estimated cells, in V2 and V3, these are all primarily devoted to vision. You also have area MT, and it starts growing and growing. There are a few areas devoted exclusively to motor or auditory. A large part of the rest of the cortex is association cortex, where not only vision, but also other things can influence neural activity. So, basically, this author ended up saying, for a totally different perspective, 90% of the brain is used for vision. However, no one has ever quoted this paper. So, have no fear. This will not be cited, I don’t think. Okay.

I’m going to breeze through this early part because the people yesterday covered all of this. The leading edge of the automotive market is baby boomers. It’s important therefore to be able to sell to older drivers, as they will be “old” soon, or at least older. I’m going to talk about how well younger can and older drivers use the newer devices coming into the vehicle in this country. In Japan and Europe there’s a much higher usage of navigation and communication devices. But this is going to be a major, major change over the next four to five years in the United States, as well. Asking the question, “Are the differences between older and younger such that we need to design separate devices, or can we have a universal design strategy for these telematics devices?” We need to be reminded that telematics tasks are on top of the primary driving test. Driving is always primary. Eyes on the road, hands on the wheel, and mind on the driving. That is General Motors’ policy, and that is primary. These other things, therefore, always are secondary interfaces. This is not widely realized by those on the West Coast, Silicon Valley and also up north in the Microsoft world. No, the computer is not the primary thing that people do in the vehicle. The primary thing they do is drive, and there is a whole set of new user-interface design requirements that come when the task that you’re performing is the secondary task, and
not the primary task. It’s hard enough to use these darn computers here when they’re primary. So, you better make sure that when they’re secondary, they’re a lot easier to use than they are now. So, that’s our challenge.

What age separates younger and older drivers? We heard many examples yesterday of the individual differences. I’ll give a couple of examples here that affect universally every human being in the world, on the planet, of presbyopia and reduced sensitivity to contrast. This is a 70-year-old woman who’s saying, “Gee, I can’t read this instrument panel without my reading glasses, and if I put my reading glasses on I can’t see the road.” So, you’ve got a double problem there. Also, over here, if you have sunlight glare on your instrument panel, you can cause operators or drivers who have reduced contrast sensitivity, that could become obscure for them, whereas it might not be for someone else.

So, a large number of these things were age-related vision reductions, I will not go through all those again today. And other age-related changes as well.

Now, almost all the talks yesterday, with a very few exceptions, showed, however, that there are low correlations of these visual changes with actual driving performance—particularly for acuity. I don’t think there was one piece of data yesterday actually shown, except for some anecdotal comments, that acuity was shown to have any relationship to driving. Now, to obviously if you go to 20/2000 or whatever, and you’re actually blind and have no acuity, you’ve got a driving problem. But, in general, there’s very little evidence to show the effect of acuity of actual driving behavior. Now one of the exceptions is the paper by Cynthia Owsley who’s here, and was one of our speakers yesterday, which showed that with very severe cataracts, you can have effects on driving performance.

There was a considerable discussion why there’s so little correlation between visual tests and driving performance. I will submit to you, and I won’t go into it now, that the vision system is extremely powerful—evolution has insured enormous redundancy in there. Even if you lose whole parts of your visual system due to stroke, disease or injury—I saw a paper at last year’s conference at Ann Arbor on gerontology—of patients with 50% scotomas [T. Schulte et al., Automobile Driving Performance of Brain-Injured Patients with Visual Field Defects, Am. J. Phys. Med. Rehabil., Vol. 78, No. 2, Mar/Apr. 1999, pp. 136-142]. Investigators could find no measurable effects on their driving, or on standard tests and measures used for evaluating driving performance. So, vision is an enormously powerful system, and that could be another reason why we don’t easily see these reductions. Also, the vision system and human behavior itself is very adaptable and plastic, and people can make accommodations for many of the “deficits” that they might have.

My point is these age changes are very variable. You can have one person 55, who looks like they’re ready to topple over any minute. Another person 55, who is out playing tennis with 18-year-olds, or something. So, all kinds of variations occur. In general, though, how can we optimize for an older driver? Good control in the display location,
high legibility, comprehensible controls in displays, easy reach, easy distinguishable auditory stimuli, low vehicle noise.

But guess what? If you do all these things for older drivers, you also benefit the younger driver. That’s just logic. Now, let me show you some data that will prove that. Here’s the hypothesis. Maybe things work well for the older driver; it should also make them work well for the younger driver. This is what’s called a worst case design scenario of standard human factors practices. Vivek will, I’m sure, attest to that from Ford. If you design, as he showed also—like he showed with the eye ellipsis, you pick the position for the eye ellipse for obscuration of the A-pillar in the closest spot to the front of the vehicle, that’s the worst case, say for a fifth percentile person in stature. You design for the worst case. Now, the better case (a 95th percentile person sitting further back) will do even better. For instrument legibility, we choose the back of the eye ellipse instead of the front. So, the worse possible case, the furthest distance away, design for that; then the driver who sits closer, benefits. So, what I’m going to do is apply this same principle to telematics devices.

The data on this slide is from the U.S. census. I picked fifty as the number for defining older versus younger. This is the baby boom generation here—move with that big hump moving out, and if 50 is basically going to be a good dividing line between—if you integrate all this area, and this area, pretty soon 50 and over is going to be about half. That’s from 18 and up, so drivers.

It does not matter—all the things on the road at the time this study was done, primarily after-market devices, telematics devices, pick four of these, subsequent studies, you can pick any one of these you want, and the same results show up. Also for on-the-road testing the same results show up. For this particular study, we had 94 research participants from mid-size vehicle owners in Detroit. Half were under 50, and half over, and balanced also for gender.

These were stationary vehicle tests, although, as I said later research shows extremely high correlations with on-road tests. I was surprised that some of the low correlations of some of the static vision testing talked about in earlier papers with on-road tests. In our work we get correlations of .8 and .9, or higher sometimes, between our static methods and on-road testing, for a given set of tasks. Our methods will be published soon. They have been authorized for release, and should be published by the end of 2001.

To perform these tasks under simulated driving conditions, all devices were tested by all participants with full counter-balancing, and we also did anchor tasks for ordinary tasks, in the vehicle. They were given prior instruction, sat in the vehicle, watched just a simple video monitor—although it is nice to have one, it is not required to have a $63 million driving simulator like in Iowa to do laboratory research work relevant to on-road studies (as long as you take the time to validate your laboratory work with some on-road testing). We had a little red light up there, and when they saw that, they had to step on the brake. And they performed telematics tasks, as well as control tasks -- adjusting the mirror, vents, and cruise control. They had to navigate to school and call their daughter. We had
video cameras on the forward scene with a microphone, and we took a bunch of measurements—the response time to the brake light, the task completion time, subjective ratings of situation awareness and workload. This was a typical setup here. Cameras mounted here and so forth, and this is now, like you’ll see in the videos, four-camera view of the face area to count eye glances and measure eye glance durations away from the driving scene. This is our scenario, with a simple driving scene on a monitor, and they were told to watch that as their primary task. They had to respond to a little light that came on—an on/off light like that, a little red light. In later experiments, we also had a peripheral light to look at the effects on peripheral vision, as well.

So, I’m going to show you some video examples—I’m not sure I have time to get through very many of them—and we’ll make the major point with these examples. Although with 94 people running every task, there were hundreds and hundreds of hours of videotape. But I just picked these to make the main point. So, for navigation tasks, you’re going to see an easy-use interface, and you see both the young and old person do pretty well on that. Then you’re going to have a communication task to call daughter with voice. This particular one was a hard-to-use interface. Again, it doesn’t matter; you might hear some names of these devices. It does not matter what the devices are. It’s just that it’s a hard-to-use interface, and you’ll see young and old both do very poorly. I’ll probably not have time for these others, but I could go on and on. Again another navigation task with a hard-to-use interface——same thing. Both young and old do poorly, and so forth.

Let’s just go through this couple of examples. Here’s a case with an easy-to-use interface. So, this was finding the school (showing video: video/audio and comments during video) So one person glanced there at the end, and another glanced at the beginning to hit the voice button. Otherwise, she did terrific there. Okay?

So, now here’s an older person with the same task (playing video/audio). Eyes aren’t going off the road much. She’s glancing down because in this particular one we had a visual display, so we did have more glances with this. So, she also does just fine.

That was a discrete voice system used for that, so this was some of our early research. We’ve now gone to continuous voice and respondents do even better with that.

Here is an example of a difficult task for a younger person, and you’ll see they have a lot of difficulty. This is our star performer, a young person (playing: video/audio). Look at how many times she’s glancing over to the display. They have a little light that zooms across the display every time she says something, so she keeps glancing over at that. Terrible voice feedback from the system; very hard to understand.

Okay. So that’s a poor score for that person, even though she’s young, and our top performer generally speaking.
Now, here’s an older person on the same task. (Video/audio) Eyes are almost continuously off the road. She’d be off the road at this point. As you notice, she’s missing the light. She’s totally missing the front light now. I won’t trouble you with the rest.

That’s basically the point. Hard tasks are hard, easy tasks are easy, no matter whether you are young or old. I’ll skip these, because time is short. Over the entire sample, older drivers took slightly longer, about 12% longer to complete them. Older drivers took slightly longer, 6%, to respond to the forward event. They had a slightly higher subjective workload, about 7%. They had slightly lower—which is subjective—outside vehicle awareness, which is bad to have lower. Older drivers have more unsuccessful trials, also by just a small percentage.

With older drivers we know there is some deterioration of functions as I stated. These measures indeed show they do slightly worse. But, here are all the results for this one measure: successful/ unsuccessful, and I’ll make the whole point with this one slide. I could show you all the other variables we measured, but all of them make exactly the same point. Here are three interfaces, R, S and T. You can see, first of all, and this is percent unsuccessful trial completion. So, this is bad. When you go higher, it’s bad. So, you can see there’s a main effect here. Interface T, these bars are bigger than these bars. So, there’s a main effect. Interface T is definitely worse than R and S. So, that’s a hard use interface. These two are relatively easy.

Now, there’s a second effect in this. You can see that older drivers are always slightly worse than younger drivers. So, there are two main effects in this. But, what’s the take-home message that I have from this? On a poor user interface, such as this interface T, look at the younger drivers here. They are far worse—they’re twice as bad as the older drivers on this interface; and they’re four times worse than the older drivers for this other interface. For exactly the same task. Call your daughter, find the map to school. What is that saying? If you have a bad user interface, everybody’s going to do badly. If you have a good user interface, everybody’s going to do well.

I conclude from this, that it’s more important to design a good user interface than it is to worry about whether you’re going to design—who exactly you’re going to design for—or these fairly minor differences between younger and older drivers.

Just in conclusion, the main critical factor is the degree of usability. And in conclusion, a poor design interface will cause both to do poorly. If you design for the older driver, who is your worst case, it should make them work well for the younger driver. That’s a logical deduction from this data, and these results argue for universal design philosophy in vehicle communication navigation systems. Thank you. (applause)

Dr Trick: Thank you very much, Dr Young. We have time for several questions, so, starting with Dr Owsley?

Dr Owsley: Thank you for the very interesting presentation. I’m wondering if—who are your older drivers? Whenever we do aging studies, we can get a sample of older
people and compare them to younger people. Your findings depend very much upon the levels of functional impairment. Or if there’s any functional impairment in your older group. I’m wondering if you looked at your data in terms of the actual functional capabilities of your older adults, and what you might see is a little more diversity in the performance. Your point is well taken about designing an interface that everybody, regardless of functional level, can do well at. But, if the data were stratified in a way where you could actually look at that issue, it could be that even the simple interface—the one that everybody did well in your study on—it could be that there are older adults who have functional impairments, be they visual or cognitive. Yet, they’re still legally licensed to drive; could possibly still have problems with that interface. I’m wondering if you could comment on that issue.

A: Sure. Okay. The way we picked these older drivers, as with the younger drivers, is a random sample of people of a certain age range. At times, for some of the studies, we do select for a particular target market as far as owners of certain types of vehicles. But, from that market, they are randomly selected. We did have functional testing. Everything I just showed you was an example of functional testing. We are testing them in the driving situation. We are measuring their response time to forward events. We are measuring their ability to stay in their lanes when we do road testing. So, every measure we take is a functional measure of their driving performance -- a direct functional measure of their driving performance. And as I have said, the functional impairment of older drivers is small compared to younger drivers when tested in actual driving situations in our studies, and in fact the differences between devices are larger than the differences between age groups in our studies. So the answer to your question is that we did study the functional performance of all drivers in our study samples, which would have included those who had clinically established physiological and medical impairments and those who did not.

Q: I’m a little impressed how usually the world copies us; and here, we’re copying, at least European automobiles, with all this fancy telematics. I want to ask, first of all, in the sampling of the younger patients, I’m sure you didn’t factor in blasting the radio and a little bit of alcohol or drugs that so commonly younger drivers utilize. To make a little more fair, the comparison of how older folks do compare with younger folks. Carrying this a little bit further, I wonder if there is any projection of what the increased morbidity and mortality will cost in terms of insurance over the long run, once you introduce widespread telematics. If you could comment on that.

A: I’m a human factors scientist, and what I can tell you about is driving performance with use of these devices. I am not an epidemiologist, and will not pretend to be one. There have been such studies done, though in the literature. One study was done by Donald Redelmeier from the University of Toronto, the same person who wrote the often-cited 1997 article in the New England Journal of Medicine, that has led in part to the widespread legislative efforts to ban cell phone use, or at least hand-held cell phone use while driving. He did a follow-up study that is not often cited [Redelmeier, D. A., Weinstein, M.C., Cost-effectiveness of regulations against using a cellular telephone while driving. Med. Decis. Making, 1999, 19, 1-8], that does a cost-benefit analysis in
terms of accident rates and expected mortality rates. He shows that the benefits from these devices far outweigh the cost to society as a whole. A recent study finds no evidence that use of the OnStar telematics system causes harm [R. A. Young, Recent human factors issues in the use of embedded telematics devices in a vehicle, Proceedings of the International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Aspen Colorado, in press].

Q: I’m Dev Kochar, Ford Motor Company. I have a couple of questions. First of all, this reference to your studies, number one, it’s not surprising that the older subjects didn’t do as well as the younger ones. However, our research has shown that if you provide enough of period of adaptation to the older drivers, or subjects, in this case, the results may indeed be a lot more comparable than actually what is shown. For example, if you provide the younger and the older subjects an equal amount of time, or prep time, you will find that there is a tremendous difference between the older and the younger. However, if you provide a much longer period of adaptation, or practice, to the older driver, then those differences disappear. I wonder if this can somehow be accommodated into the design of telematics or technology that somehow permits the older person to take as long as necessary to become adapted. Number one.

The second question pertains to the reference to 50 as being the defining moment, if you will, in life where you become suddenly older. Dr Drafol, who did much work in aviation circles, was principally, I think, involved with what’s called the age 60 rule in the licensing of pilots. This has been—age has been an issue even in aviation pilots. It seems to be that, again it brings up the old issue in our literature about defining a functional age, rather than a chronological age as being a mark of departure. I wonder if this is an opportune time for those of us who are in the auto industry to take up that cause, as well.

A: I’m going to talk about the training issue first, and then the age issue. On the training issue, we are further investing the effect of training, or methods of training, bring the people to a criterion level of performance. That is, further training does not increase their performance any further. In other words, in our studies it as if people had been highly trained for both the young and old participants equally. But your point is very well taken. Other studies have been done in the computer training literature that show that older people take longer to learn. Actually, seniors use the computers more than their younger counterparts once they become trained. But our methods do bring them to training to criterion. So, we believe we’ve controlled for the training variable, and again, I’ll emphasize, the results show very slight differences between younger and older, so that would be consistent with your observation that with high amounts of training younger and older drivers are comparable.

Secondly, on the use of 50 as a defining age, I thought I took great pains to point out that the huge variability in age—in functional performance with age—so 50 was a completely arbitrary choice of a number. I could have used 60; I could have used 40. I don’t think the results would have come out all that much different. It’s a random sample of those over 50, and under 50, but you’re right. That was my whole point, too, that the exact number of 50 makes very little difference.
Dr Trick: Thank you, Dr Young. Perhaps, at 11:30 we’ll have a chance for a little more discussion of this paper, as well.