Pain, Prosthetics, Aging and More

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Tech Curiosity

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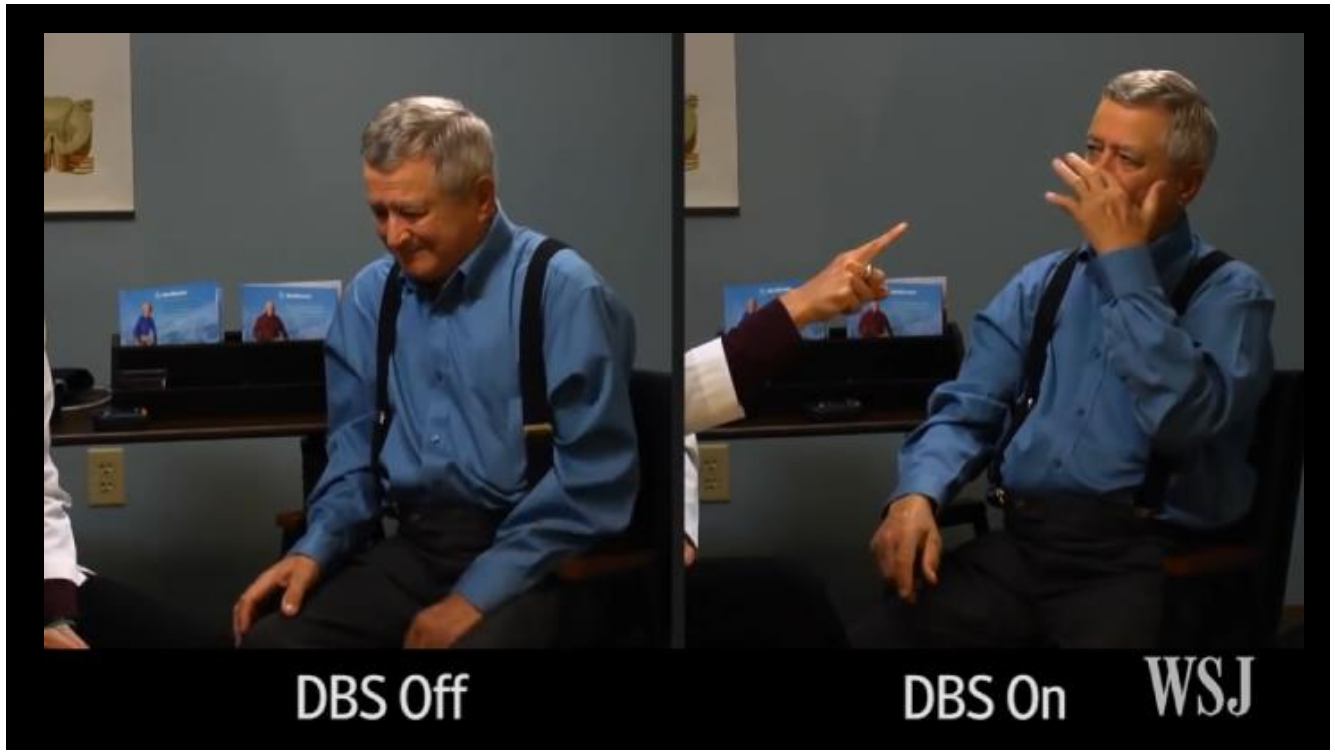
Let’s Talk About Pain!

Tailoring Deep Brain Stimulation to Treat Chronic Pain

- One in four U.S. adults suffer from chronic pain, many from chronic pain that is resistant to treatment. People with conditions like post-stroke pain, phantom limb pain, nerve pain and pain from spinal injuries are often left with in agony but little hope for relief.
- Deep brain stimulation (DBS) -Patients have electrodes implanted deep into the parts of their brain that control movement, and receive electrical current via a stimulator put into their chest.

Deep brain stimulation for chronic pain

- Deep brain stimulation (DBS) provides a further opportunity to **alleviate** pain in some individuals. Specific indications include central post-stroke pain, atypical facial pain, brachial plexus injury, and some patients who have failed SCS.



Tailoring Deep Brain Stimulation to Treat Chronic Pain

- The problem with current DBS treatment is that the electrical current is constant. It doesn't take in feedback or adjust based on what's really happening in the brain. Patients can suffer side effects like trouble speaking and change in personality – even seizure or stroke. Their brains can also become acclimated to the treatment so that it doesn't work anymore.

Read also: **The Current State of Deep Brain Stimulation for Chronic Pain and Its Context in Other Forms of Neuromodulation, and Deep Brain Stimulation for Pain in the Modern Era: A Systematic Review**

Tailoring Deep Brain Stimulation to Treat Chronic Pain

What's new?

- Instead of providing a continuous current, this grant is helping researchers make the electric charge more customized by first identifying new targets for stimulation, and creating systems that can take feedback from the brain and adjust the device accordingly.
- That means recording direct from patients' brains while they experience natural pain fluctuations. By combining their neural signals with their pain reports, we're trying to build a model of how their brain represents pain.

Technology for Chronic Pain

- Chronic pain is the greatest cause of disability worldwide. Tension-type headache, migraine, low back and neck pain, along with other musculoskeletal pain conditions, are among the most prevalent neurological causes of disability.
- Technology-based Interventions
  - Neuromodulation has the advantages of immediate delivery, reversibility and programmability, and a potentially lower risk of adverse effects
  - Spinal Cord Stimulation - treatment of various chronic pain conditions of the limbs and trunk
  - Deep Brain Stimulation - DBS involves surgical implantation of electrodes for electrical stimulation in pre-identified target sites located in deep brain structures
  - Motor cortex stimulation (MCS) for pain relief originated from epidural brain stimulation, a less invasive alternative to DBS
  - Transcranial Magnetic Stimulation - TMS is thought to achieve the same effect as MCS, but in a non-invasive manner through brief alternating magnetic fields on the scalp over the target; this stimulation induces electrical currents in the neurons of the cortex
  - Transcranial Electrical Stimulation (TES) - stimulates the cortex using weak electrical current.
  - Virtual reality (VR) and augmented reality (AR) environments are technologies aiming to form a relatively believable simulation of reality by creating sensory illusions

Technology for Chronic Pain

- Future Directions for managing chronic pain:
  - First, parallel advances in non-invasive wireless sensor technology, network technology, and big-data decoding mean that the ability to realize continuous domestic pain monitoring is feasible ('smart sensing').
  - Second, 'smart sensing' may allow for the development of novel neural engineering-based therapeutic devices that use feedback control in some manner.
  - Third, more sophisticated stimulation methods are needed, and the advent of optogenetics* has the potential of transforming the efficacy of pain neuromodulation.

    *Optogenetics is a newly recognized field that involves using genetic modification of neurons to render them sensitive to certain wavelengths of light.

PDF download: https://www.cell.com/current-biology/pdf/S0960-9822(14)00836-7.pdf

Enough about pain.
Let’s talk about the future of Prosthetics!

How we'll become cyborgs and extend human potential | Hugh Herr (10 min)

- Video

A prosthetic arm that feels - Todd Kuiken (7.5 min)

- Targeted reinnervation - video

The Future of Prosthetics Might Be in This Mind-Controlled Bionic Arm

- Researchers in Sweden have been studying a new type of mind-controlled prosthetic arm that could drastically improve the lives of people who've lost a limb.
- The technology used involves implanting electrodes that pick up on the brain's signals and allows people to move, feel, and use the new limb in an intuitive, natural way; if a person wants to move a finger, the prosthetic finger moves.
- The development is a huge win for people who've lost a limb, a population that's long had limited options for prostheses, many of which are uncomfortable and painful.
- Video

The Future of Prosthetics Might Be in This Mind-Controlled Bionic Arm

- The newest part of the technology, the sensation of touch, is possible through stimulation of the nerves that used to be connected to the biological hand before the amputation. Force sensors located in the thumb of the prosthesis measure contact and pressure applied to an object while grasping. This information is transmitted to the patients' nerves leading to their brains. Patients can thus feel when they are touching an object, its characteristics, and how hard they are pressing it, which is crucial for imitating a biological hand.

Osseointegrated Prosthetic Implants for People With Lower-Limb Amputation: A Health Technology Assessment

- Osseointegrated prosthetic implants are biocompatible metal devices that are inserted into the residual bone to integrate with the bone and attach to the external prosthesis, eliminating the need for socket prostheses and the problems that may accompany their use.
- Bottom line: Studies showed that functional outcomes and physical ability improved with osseointegrated prosthetic implants (GRADE: Low), but there was uncertainty about the impact of these implants on people's emotional health (GRADE: Low). Osseointegrated prosthetic implants can lead to serious adverse events such as bone infection and bone fracture in some patients, which may require additional surgeries (GRADE: High).
- Qualitative interviews with people with a lower-limb amputation and caregivers underscored the challenges of conventional socket prostheses, but cost remains an important barrier to pursuing osseointegrated prosthetic implantation.

Read also: **Technological Advances in Prosthesis Design and Rehabilitation Following Upper Extremity Limb Loss**

Implants enable man to control prosthetics with ‘thoughts’

- In a set of proof-of-concept experiments, Johns Hopkins researchers have implanted electrodes in both sides of the brain of a person who is mostly paralyzed — with minimal sensation in his hands — to enable him to have some “mind control” of motorized prosthetic arms.
  - Video
- The Johns Hopkins scientists say the electrodes can remain implanted in the brain for up to five years, with minimal risk of brain or skin scarring. However, like any surgery, there is risk of infections or bleeding. The team’s next steps are to test more complex bilateral movements and improve the connection between touch sense and motor control.

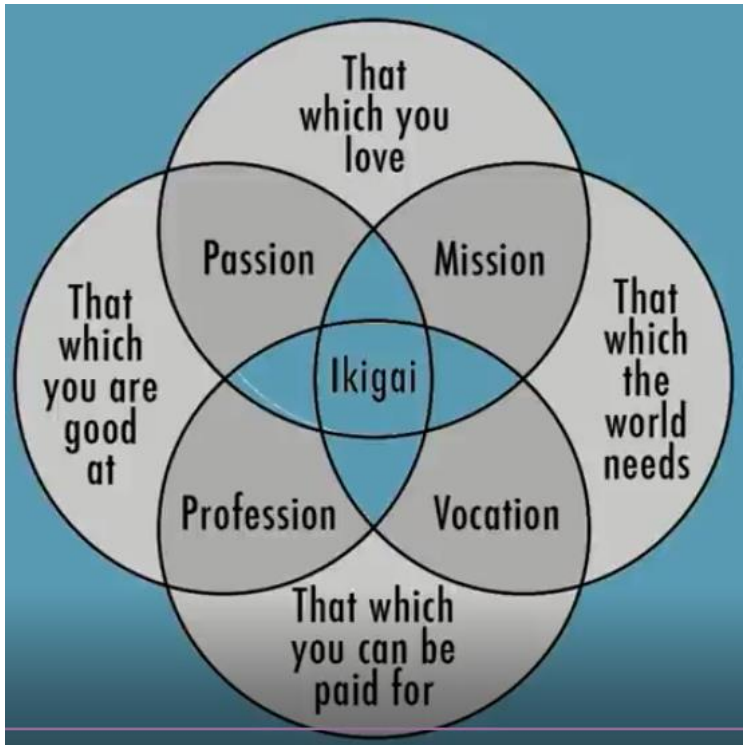
And finally,
A Word About Aging!

The Secret to Successful Aging _Cathleen Toomey (10 min)

- Video

The Secret to Successful Aging _Cathleen Toomey

- Why don't we approach aging with 'enthusiasm'?
  - Fear of aging and death
  - No roadmap – nobody expected this
- Instead
  - Don't think about it!
  - Stay 'connected' – volunteer, teach (I added this)…
  - Know your purpose – 'ikigai'*
    1. What are you passionate about?
    2. What does the world need?
    3. What are you good at?
    4. What is your 'vocation'?
  - Maintain relationships



*Ikigai = 'life' + 'what one hopes for' (aka 'a reason to get up in the morning')

The Secret to Successful Aging _Cathleen Toomey

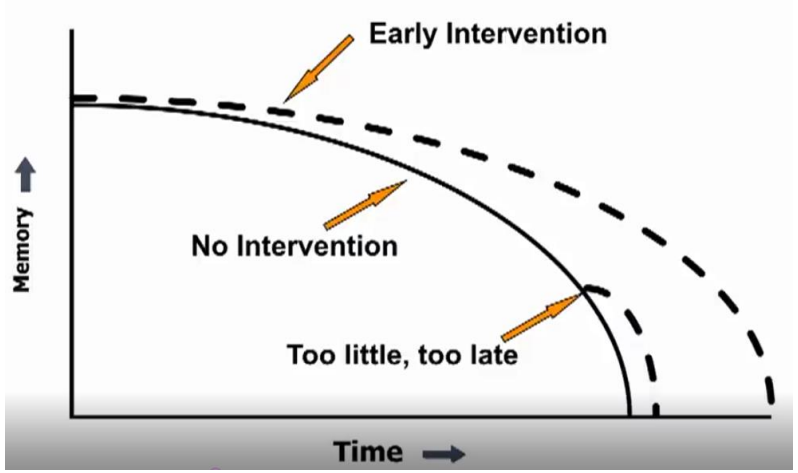
- What is the secret to successful aging?
  1. Don’t be an Ostridge – celebrate your age, where you are
  2. Defy expectations – find the reason to get up in the morning, find your purpose
  3. Grow friendships – relationships matter, get out of the house, connect
- Look forward

The Formula for Successful Aging - Gary Small (11.5 min)

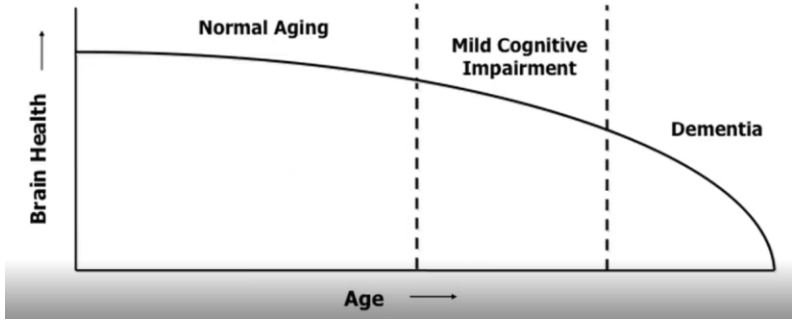
- Video

The Formula for Successful Aging _ Gary Small

- Blue Zones
  - Formula for successful aging
    1. Physical activity
    2. Mental exercise
    3. Stress management
    4. Healthy diet
  - Brain health
    - Early detection and intervention
  - Brain aging
    1. Normal aging
    2. Mild cognitive impairment
    3. Dementia

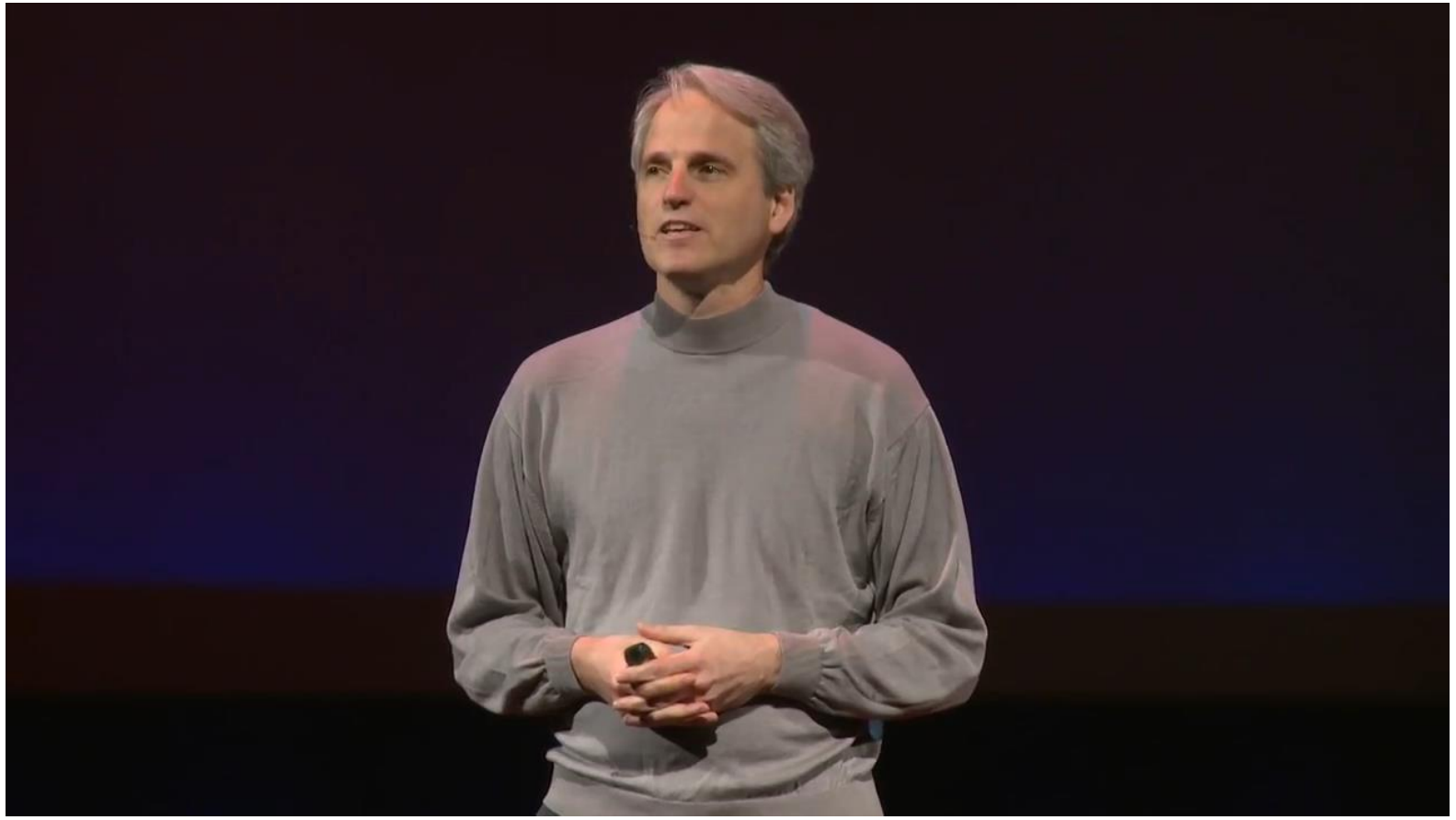


Stages of Brain Aging



Aging, It's Not What You Think - Thad Polk (14 min)

- Video



Aging, It's Not What You Think _ Thad Polk

- In the absence of disease, the mental aspects of aging are restricted to only a few cognitive processes
  - Fluid processing – can you think logically, recognize patterns, solve problems
  - Crystalized processing – knowledge, experience, acquired skills
- Impact of aging on both
  - Fluid processing declines (starting at age 20!)
  - Crystalized processing gets better
    - Procedural memory remains intact
    - Emotional processing improves – greater life satisfaction…

Aging, It's Not What You Think _ Thad Polk

- Research results
  - Leverages ‘functional’ MRI – looking for patterns of neural activation
    - Young subjects – distinctiveness activation patterns
    - Old(er) subjects – neural distinctiveness tends to decline (but not in everyone)
  - People with reduced neural distinctiveness have reduced fluid processing
  - Brains “don’t take aging lying down”
    - As you get older, you start recruiting new brain regions – this is great news!
      - High performing young – one hemisphere
      - Old(er) low performing – one hemisphere
      - Old(er) high performing – both hemispheres (helpful)
  - More accurately: aging is ‘transformation’ versus ‘deterioration’

Thriving Longer, The Future of Aging - Dr. Mark Allen (10.5 min)

- Video

Thriving Longer, The Future of Aging _ Dr. Mark Allen

- How to Cure Aging
  - Target and preserve ‘regenerative capacity’
  - Treat & prevent multiple age-related diseases
  - Extend ‘healthy’ lifespan

More on Aging

What is the biggest benefit technology will have on ageing and longevity?

An example of technological innovations have been deployed to keep people physically active and enable independent living

- technology for detecting falls
- smart home technology
- early detection of diseases and management of disease conditions
- maintenance of social connections by reducing social isolation and continued engagement in the workforce

Issue: Many older people have not enjoyed a digital education nor feel at ease with new technologies as younger people do.

- These innovative solutions, assistive technologies or digital services tailor-made to the needs and preferences of older people harbor great potential to improve the quality of life and support independent living, also later in life
- To reap those benefits, it is essential to ensure that everyone has the required digital skills – and stays curious

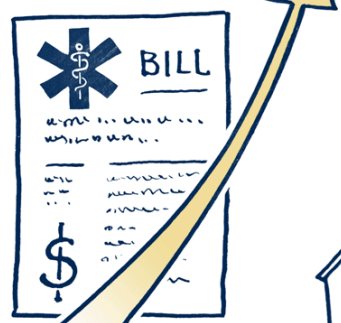
- Interesting factoid: Technology adoption and use increased tremendously, with 44% of those 50 and older becoming more comfortable with technology now than before the pandemic.

One in five households provides care to an elderly or disabled individual who requires assistance. The number is expected to grow to **one in two by 2030**

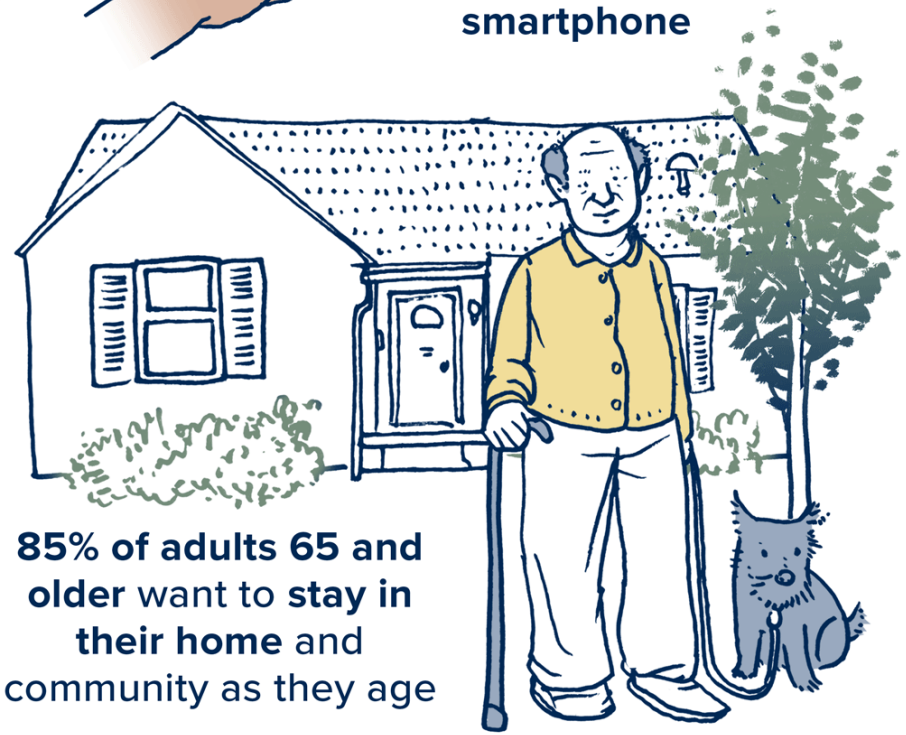
2015

2030

Health care spending is on the rise, with **75% of spending** due to **chronic disease**



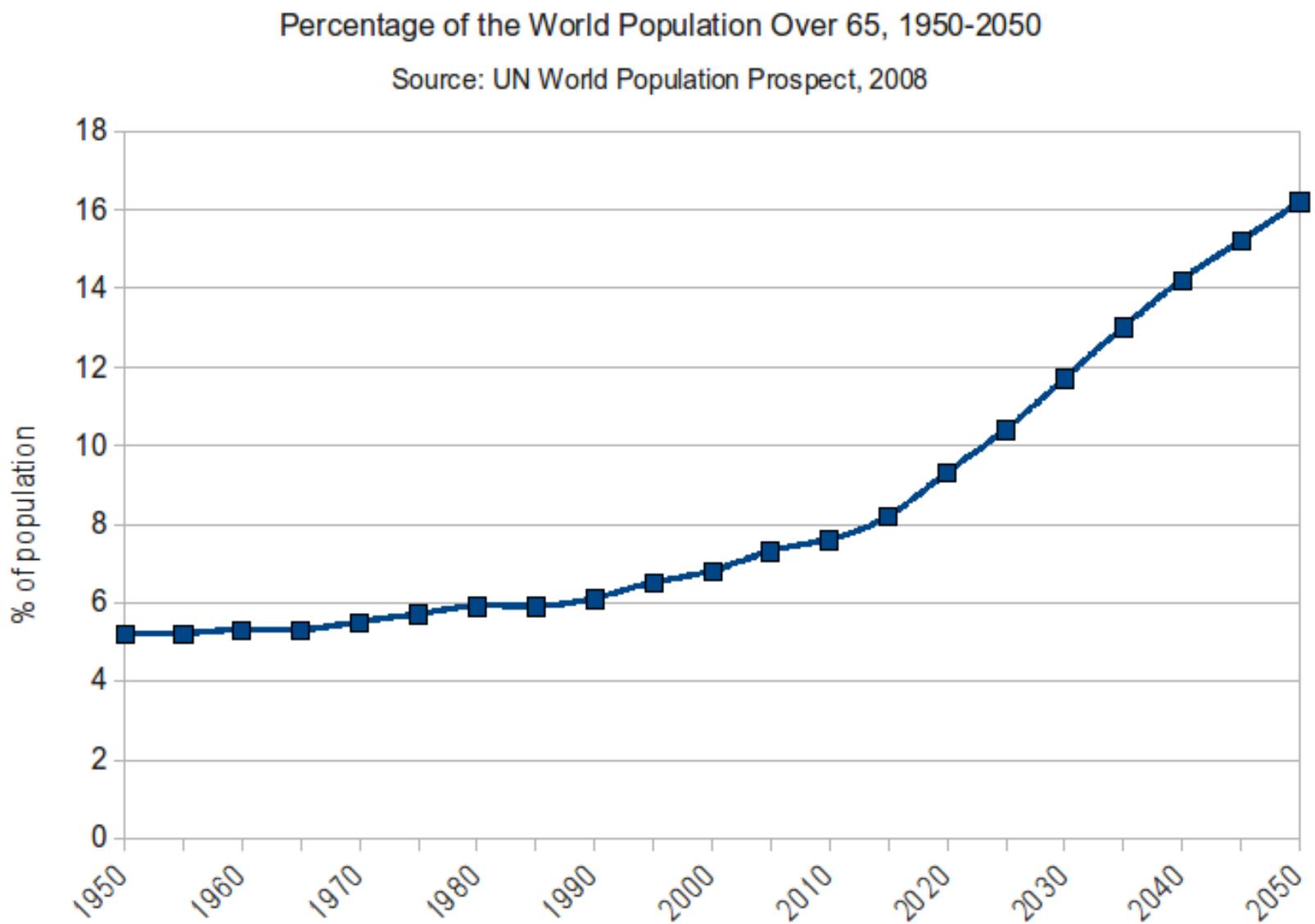
Of adults 65 and older: **67%** go **online**, **80%** own a **cellular phone**, **40%** own a **smartphone**



85% of adults 65 and older want to **stay in their home** and community as they age

6 Ways Technology Can Make a Big Difference for Aging Populations

- **1. Identify at-risk individuals early on**
  - Using Big Data, we can **shift to a predictive model** of helping people
- **2. Help seniors be more self-sufficient**
  - Internet of Things technology, we can provide people with simple tools to make a small but meaningful difference in their lives
- **3. Bring medical care into their own homes**
  - **Telehealth services** allow patients to contact doctors either by phone or via video calls
  - Voice Helper can send out **programmed reminders to take medication**
- **4. Protect them from fraud**
  - Banks can protect seniors from theft, with things like **fraud detection systems**. **Virtual wallets** specially designed for seniors are also available
- **5. Keep them feeling like part of a community**
  - **Video chatting apps** and **social media** can help seniors stay in touch, and **virtual reality** can connect them to their past memories, and **cognitive games** can help keep them mentally sharp
- **6. Identify problems before they become a full-blown crisis**
  - Data collected from the previous examples can help identify a problem before it becomes a crisis. We can **establish patterns** more easily, and **spot changes earlier on** than without data and caregivers can reach out to intervene early on.


Percentage of the World Population Over 65, 1950-2050
Source: UN World Population Prospect, 2008
% of population
18
16
14
12
10
8
6
4
2
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050

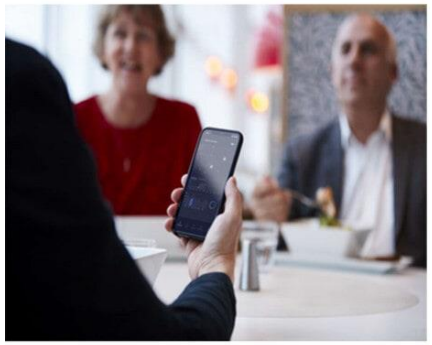
How technology for seniors can improve quality of life

- Here's a new category - the so-called 'young-old' seniors aged 65-74 years, who use the internet (aka digital seniors)
  - How new tech solutions can target seniors: five key areas

Home life
– safety, home tasks and consumption

Wellbeing
– Health and exercise

Social life
- Keeping contact and socialize

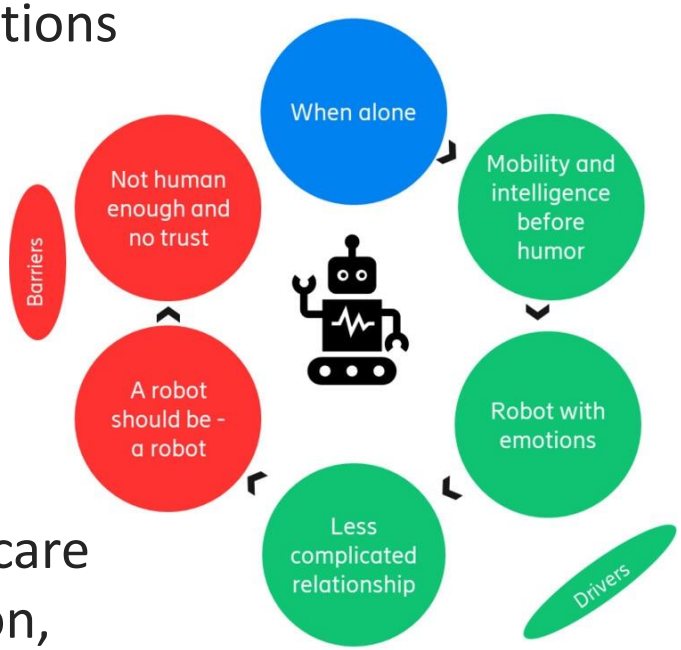


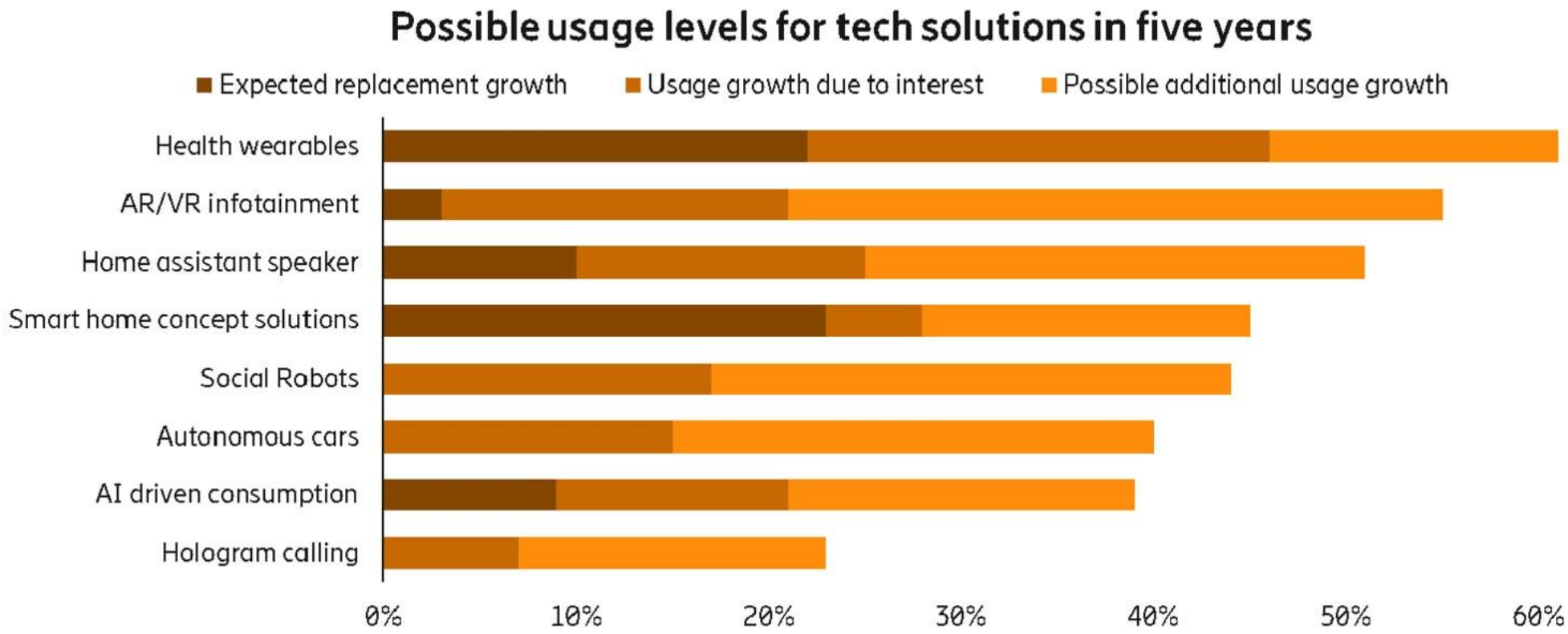
Mobility
– personal and goods transport

Infotainment
– to get informed and entertained

How technology for seniors can improve quality of life

- 5 tech solutions for seniors
  - **Home life**; an easier life for seniors with selected tech solutions
    - Better communication
    - Easier consumption
    - Better functionality
    - More convenience
  - **Social life**; a future companion can be a robot*
  - **Mobility**; ageing is obvious since convenience and safety are top of the list
  - **Health**; optimistic views on using tech solutions for healthcare and exercise, incl. wearables, online healthcare consultation, mobile medical clinic, robots in the hospital…
  - Having fun with **Virtual Reality** – but utility is more important




Possible usage levels for tech solutions in five years
Expected replacement growth
Usage growth due to interest
Possible additional usage growth
Health wearables
AR/VR infotainment
Home assistant speaker
Smart home concept solutions
Social Robots
Autonomous cars
AI driven consumption
Hologram calling
0%
10%
20%
30%
40%
50%
60%

7 (actually 6) new tech devices for elder care that help seniors live happier, healthier lives

- Intuition Robotics
  - The proactive cognitive artificial intelligence product initiates conversation to help the senior stay in touch with family or loved ones, engage in healthy behaviors — including nudges to take medication — and stay connected with the outside world.
- Joy For All
  - The robotic cats and pups have sensors that allow them to interact with a human companion as they would with a live pet. The cat responds to touch, rolls over and utters 32 different types of purring sounds. The pup's heartbeat slows down if a hand is placed on its back.

7 (actually 6) new tech devices for elder care that help seniors live happier, healthier lives

- Toi Labs
  - Created a toilet seat called TrueLoo. With the ability to fit on any toilet, TrueLoo has sensors that can determine who the user is. It then scans the toilet bowl to determine the size, color, consistency, frequency and shape of the excreta. The information is provided to the senior living managers so they can monitor their residents' health.
- VitalTech
  - VitalBand is an emergency voice call-out and fall-detection watch that provides a more subtle way to monitor for falls, while tracking vital signs like heart and respiratory rate and oxygen saturation, as well as physical activity and sleep quality. It also provides medication reminders.

7 (actually 6) new tech devices for elder care that help seniors live happier, healthier lives

- Embodied Labs
  - Provides an immersive program that uses virtual reality headsets. When worn, these headsets offer simulations in which caregivers to take on the persona of an aging person facing a variety of situations, including macular degeneration, Alzheimer's and Parkinson's disease.
- Neuro Rehab VR
  - By employing machine learning, the company tailors each exercise to a patient's specific therapy needs and ability. The customized virtual therapy exercises record physiological and kinematic responses, quantifying the progress of the patient with scores and metrics over time.

Videos

- What is pain?
- The most advanced prosthetic in the world
- The formula for successful aging - Gary Small
- The Secret to Successful Aging | Cathleen Toomey
- Thriving longer, the future of aging - dr mark allen
- A prosthetic arm that feels - todd kuiken
- Aging: It's Not What You Think | Thad Polk
- How we'll become cyborgs and extend human potential | Hugh Herr

Thank you!