


COGNITIVE
IMPAIRMENT
and
ASSISTIVE
TECHNOLOGY



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Impact

- Over 20 million individuals have a cognitive disability in the United States
 - 27% - Mental Illness
 - 20% - Alzheimer's
 - 20% - Brain Injury
 - 22% - Developmental Disability
 - 4% - Stroke

Impact: A Closer Look

- But, there is probably more to these numbers
- As people live longer, age-related disabilities (dementia, stroke, etc) are likely to affect more and more people
- There are an estimated 526,000 people over age 60 with mental retardation and other developmental disabilities in the United States. This number is predicted to double by the year 2030
- Rates of LD's (like ADHD) are on the rise as well. Though there are potentially other issues at play here.

Components of Cognitive Impairment

- Cognition is complex
- 7 Major Components of Cognitive Function:
 - Perception
 - Attention
 - Memory
 - Orientation
 - Problem Solving
 - Knowledge Representation
 - Language and Learning

Perception

- How external sensation is taken in and interpreted by the brain

Attention

- Signal Detection
- Vigilance
- Sustained vs. Selective Attention
- Divided Attention

Memory

- Short-term vs Long-term
- Perceive > Retain > Encode > Store > Retrieve
- Recognition vs. Recall
- Implicit Memory vs Explicit Memory

Orientation

- Person (*Who am I?*)
- Place (*Where am I?*)
- Time (*When is it?*)
- Situation (*What's going on?*)

Knowledge Representation

- Declarative vs Procedural
- Grouping, Categorizing, Sorting, Sequencing

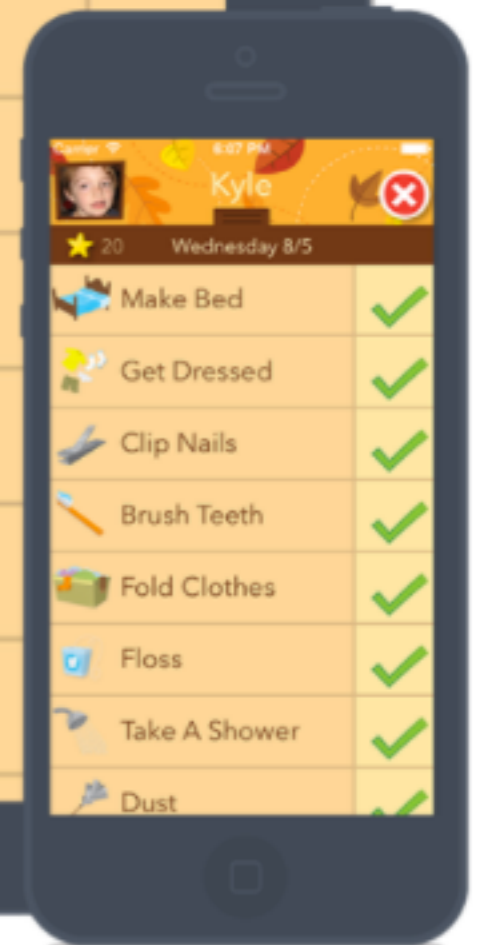
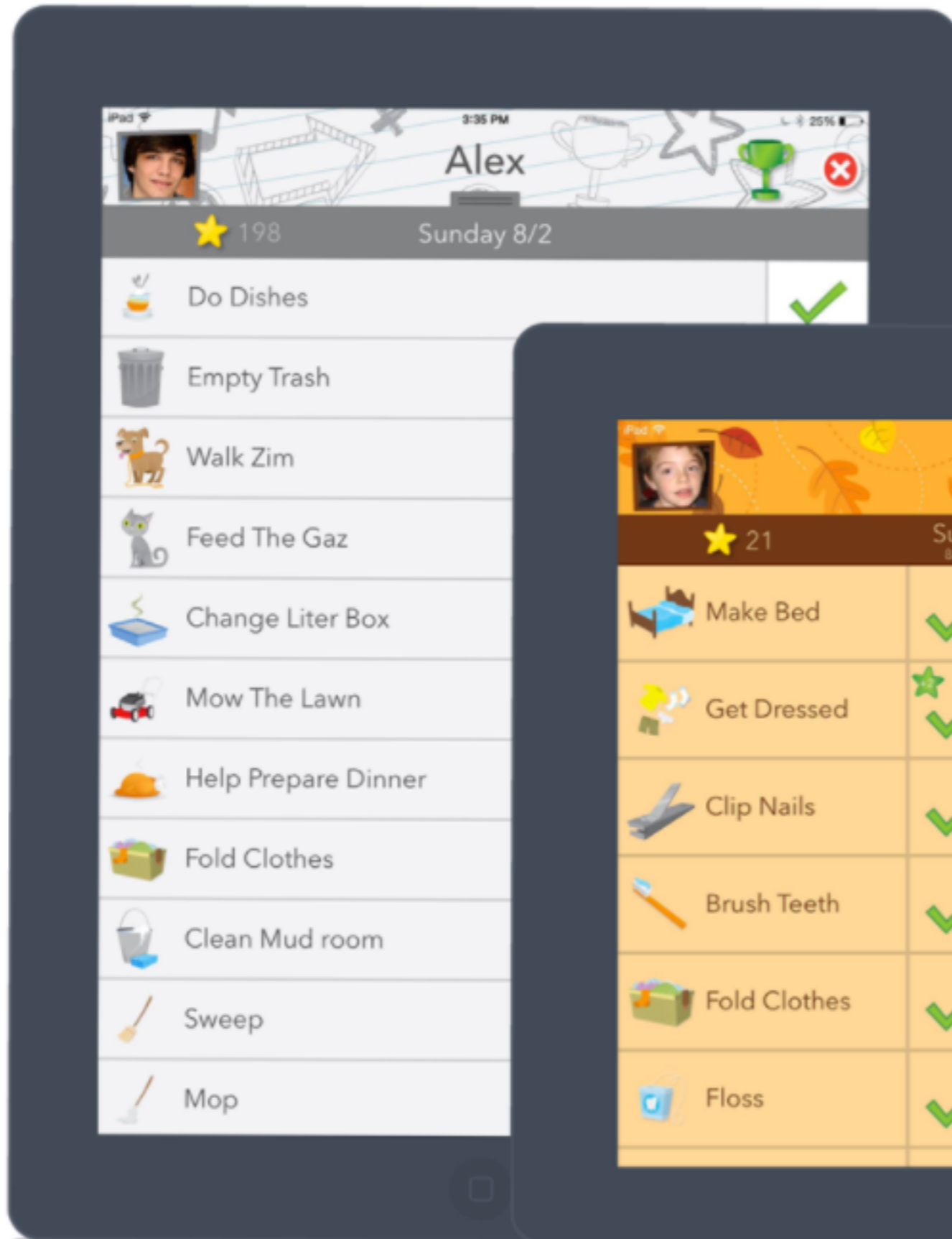
Congenital vs. Acquired

- Congenital disabilities include:
 - Developmental Disabilities
 - Learning Disabilities
 - Attention Deficit Disorders
 - Autism Spectrum Disorder
- Acquired disabilities include:
 - Dementia
 - Traumatic Brain Injury (TBI)
 - Cerebral Vascular Incidents (CVA)

Developmental Disabilities

- Can impact communication, self-care, communication
- Range from mild to severe
- Effects can span all aspects of cognitive function

Chore Pad



Learning Disabilities

- Unlike developmental disabilities, people with learning disabilities generally possess normal to near-normal mental ability
- Manifest in various forms
 - Dyslexia (reading)
 - Dyscalculia (math)
 - Dysgraphia (writing)
 - Dysphasia (language)
 - Dyspraxia (motor skills)
 - Social learning

Pluto

Pluto is the largest known object in the Kuiper belt, the largest and second-most massive known dwarf planet in the Solar System and the ninth largest and tenth-most massive known object directly orbiting the Sun.

It is the largest known trans-Neptunian object by volume but is less massive than scattered-disc dwarf planet Eris. Like other Kuiper belt objects, Pluto is primarily made of rock and ice and is relatively small—about one-sixth the mass of the Moon and one-third its volume. It has a moderately eccentric and inclined orbit during which it ranges from 30 to 49 astronomical units (4.4–7.3 billion km) from the Sun. This means that Pluto periodically comes closer to the Sun than Neptune, though an orbital resonance with Neptune prevents them from colliding. In 2014, Pluto was 32.6 AU from the Sun. Light from the Sun takes about 5.5 hours to reach Pluto at its average distance (39.4 AU).

Attention Deficit Disorders

- One of the more widespread cognitive disorders
 - Estimated 4-7% of population
- May result in:
 - Hyperactivity
 - Easily frustrated
 - Disorganization
 - Impulse control difficulties
 - Disruptive behavior



Autism Spectrum Disorders

- Impaired communication and social interaction skills
- May also exhibit repetitive behavior, extreme interest in a specific subject, difficulty with unexpected or interrupting stimuli

Simone Says

- Much of the AT for ASD facilitates non-verbal communication
- A visual stimulus is presented > user is prompted to provide a meaningful, verbal response > graphical animation rewards successful response
- Each interaction directly reflects the idea that meaningful spoken language influences the behavior of others.

Design Principles of Simone SAYS



Make every interaction rewarding.

Motivate active involvement.

Balance realism with fun.

Dementia

- 3 Components of Dementia
 - Declining cognitive capacity that impacts day-to-day function
 - Impairment to multiple areas of cognition
 - Normal level of consciousness
- Incidence increases with age
 - More than 1 in 10 (10%) adults over the age of 65 are affected
 - Increases to 1 in 5 (20%) above the age of 75
- Due to degenerative quality, impact on life advances over time, requires new adaptations

Traumatic Brain Injury

- Can impact a variety of different cognitive and behavioral abilities
 - **Cognitive:** sensory processing, memory, language, reasoning, learning
 - **Behavioral:** agitation, emotional lability, anxiety, socially inappropriate behavior, confusion
- There is often a 12 month period following accident where some brain function is recovered, but chance of improvement diminishes afterward
- About 2 million people a year have a brain injury, and about 10% of those have long term cognitive deficits which interfere with their everyday functioning.

Stroke (CVA)

- Impacts a variety of cognitive and behavioral functions
 - **Cognitive:** visual neglect, apraxia, attention disorders, memory problems, decreased executive functioning
 - **Behavioral:** Impulsiveness, mood alterations, confabulation, depression
- Like TBI, a recovery period after initial injury. In this case, tends to be 6 months.
- Studies show an increased number of people return home after sustaining CVA
- Children and women more likely to recover functions

AT for Cognitive Disabilities

- Needs can be harder to ascertain than physical disabilities, particularly in more mild cases
- CATs often have utility for a wider population. Things like text completion/prediction, voice-commands
- Wide range of impact areas requires special attention be paid to individual needs and contexts
- Strategy often relies on leveraging existing cognitive abilities to overcome deficits

Types of CAT

- Memory Aids
- Time Management Tools
- Prompting devices
- Stimuli Controls
- Language Tools
- Alternative Input
- Alternative Output
- Tracking and Identifying

Memory Aids



- Recorders
 - Store info that can be replayed at a later time
- Reminders
 - Devices that signal user to complete a certain task
- Word Completion/Prediction
 - Software that predicts words/phrases to be used in certain contexts
- Information Retrieval
 - Devices/software that categorize and organize words/phrases to improve recall through associations



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Time Management Tools

- Alternative Formats
 - Simplified displays, Quarter Hour Watch
- Reminder Devices
 - Context-aware reminders, WatchMinder
- Organization/Sequencing Tools
 - Graphical displays of schedules, sequencing of daily activities, MEMOplanner

Image-based Scheduling App

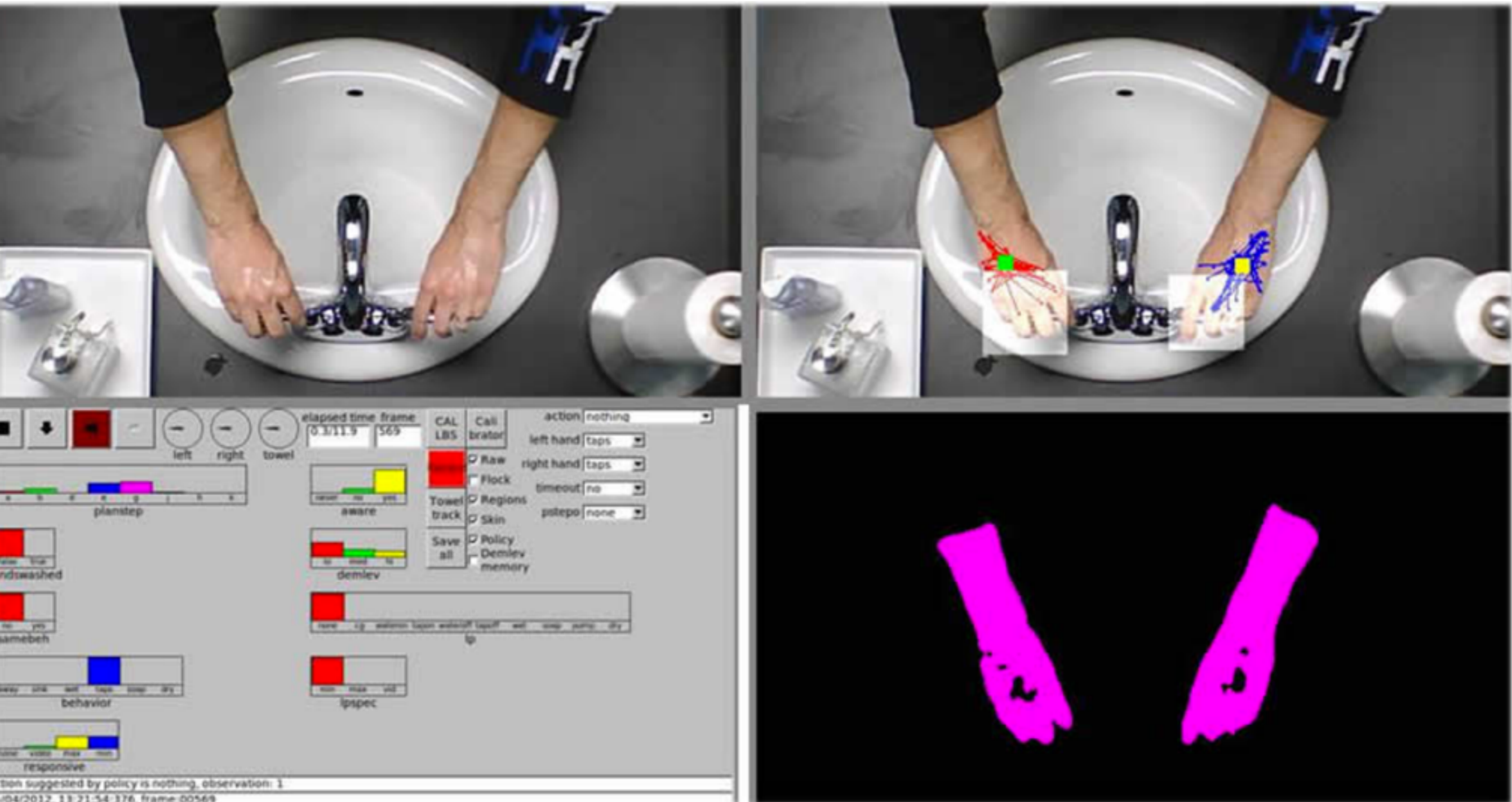


Prompting Devices

- Uses visual, auditory, and/or verbal cues to assist user with task completion
- Help with sequencing, recall, timing, navigation
- Opportunity Knocks
 - learns personal patterns to help user ID most familiar route, recover mistakes, and prompts
 - can also detect anomalies like wrong bus, wrong direction
- CanPlan
 - Sequences tasks into steps using audio and graphic identifiers

COACH

Cognitive Orthosis for Assisting with Activities in the Home



Stimuli Controls

- Address attention and perception difficulties by limiting or changing the way that info is presented
- Noise reduction, limited options, limited field of view, reduced clutter

Examples of Simplified Interfaces



Language Tools

- Many focus on the memory requirement of language by predicting or prompting word selection
- Often valuable to users of all kinds
- Spell check, word prediction, thesaurus

Dynavox





Alternative Input

- Alt Input AT utilize different modalities of input depending on the user's ability
- Voice commands are a common example
- Descriptive images may accompany inputs to aid performance
- AbleLink Pocket Discovery Desktop
 - Aids people who have difficulty with complex interfaces
 - Uses programmable picture and audio icons for any application on a phone

Examples of Alternative Input AT



SPEECH to TEXT
Dictation Software for OS X



Alternative Output

- Digitized speech output
- TTS, screen readers
- Ebooks, talking books
- Reading pen
 - move across word or text, words are spoken and can be defined
- Altered visual appearance

Examples of Alternative Output AT



Text-To-Speech Systems

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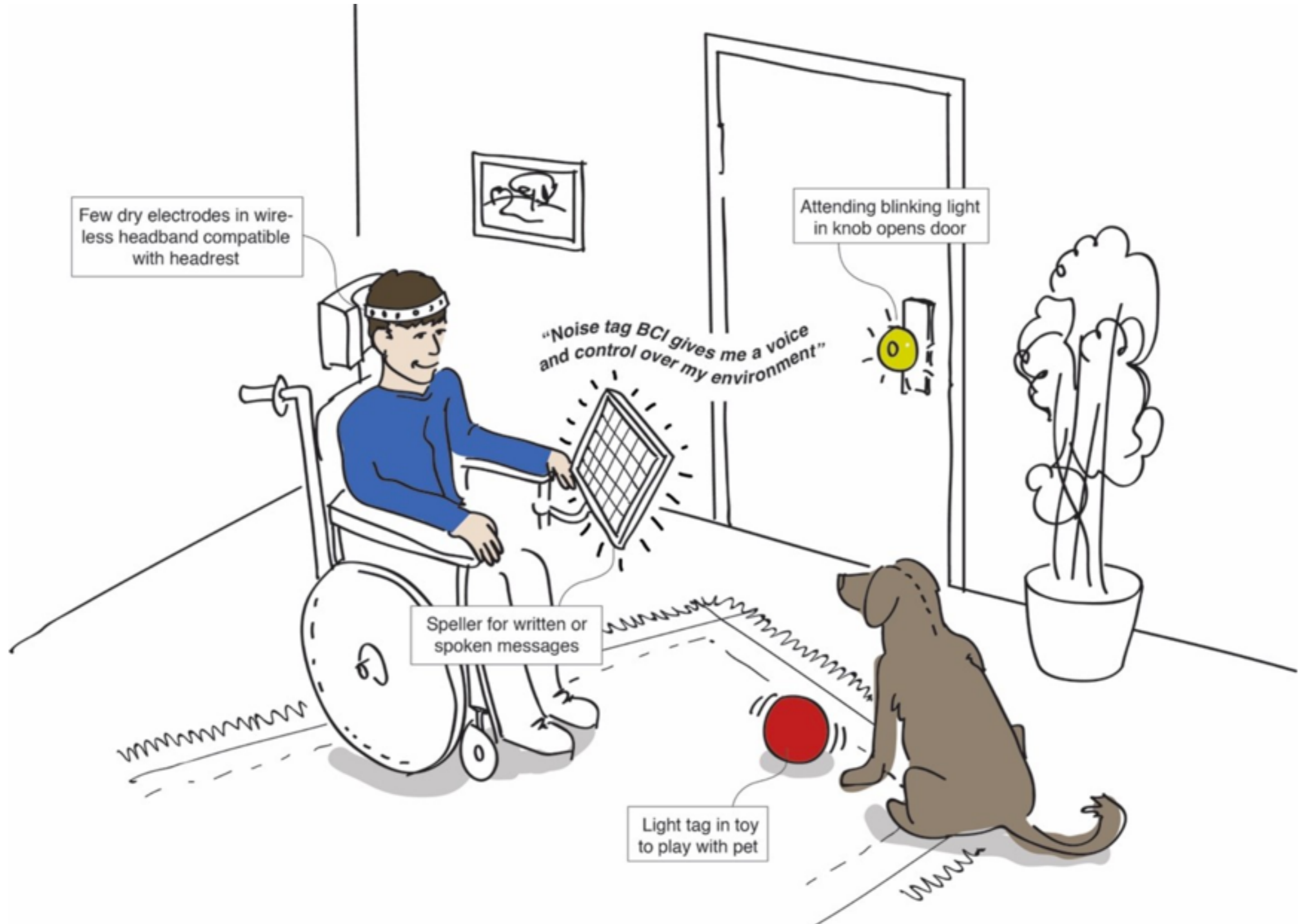
- Products involving hardware.
 - Quick Link Pen from WizCom Technologies:
 - Scan and read words.



Tracking and Identification

- Provide navigation assistance
- GPS to help family and caretakers track and locate
- Emergency assistance
- Wayfinder
 - Allows individuals with cognitive disabilities to travel by bus or train, communicates their position to observer (family, caretaker, etc.)

NoiseTag BCI



Adoption of CAT

On the surface, Brain-Computer Interfaces (BCIs) solve a lot of the issues with current CATs.

But, how will real users react to this sort of lifestyle?

Does this sort of technology empower its users?

Challenges to CAT Adoption

- CAT adoption is very individualized; even two individuals with a similar impairment performing the same task may require different type of ATC
- Cognitive disabilities impact people in widely different ways
- Comfort with technology and self-awareness are also critical factors in this selection
- Support structure, age, environment, attitude, and context all impact fitting an individual with the right CATs

Challenges to CAT Adoption

- One plausible explanation is that usage of the cognitive device reminded the user of his or her cognitive impairments and thus compromised his or her self-image
- Cognitive disabilities impact people in widely different ways
- Comfort with technology and self-awareness are also critical factors in this selection
- Support structure, age, environment, attitude, and context all impact fitting an individual with the right CATs

Customization is Key

- Provide cognitive support for specific subtasks which the target user was unable to perform
- Support a variety of tasks in multiple contexts
- Must be easy to learn and operate
- Customization must account for the specific individual and their needs

CATs are under-utilized

- Devices to accommodate physical impairments were more readily accepted and used than those for cognitive impairments (e.g. memory aids, safety assists) among seniors with cognitive impairments.
- Results from need surveys indicate that only a small percentage of adults with mental retardation use AT (Hammel, et al)
- Only 36% of the respondents had ever used AT in a professional setting and even less respondents (17%) used AT themselves (de Jooode, et al)

Under-utilized: But Why?

- In the de Joode article, users and providers agreed that CATs were effective and did not find learning a new tool to be a significant barrier to use
 - But CAT use is still not widespread
- Users consider cost a major barrier
- Provider familiarity and experience with CAT is a major factor as well
- de Joode argues that increasing use depends on educating users and providers about the value of CATs

Additional Challenges

- It seems that some components of cognitive disability are less addressed than others. For example:
 - Social interaction cues
 - Depression/Anxiety
 - Problem Solving
 - Orientation (to self)

How might technology assist these issues?

What about Robots?



What about Robots?

- Are robots acceptable replacements for human contact?
- Does the use of a robot violate the notion of empowering users to be independent?

Nootropics

- Amphetamines (Adderall, etc.)
- Methylphenidate (Ritalin, etc.)
- Eugeroic (Modafinil, etc)