Brain-computer interface: Current research efforts and considerations for implementation

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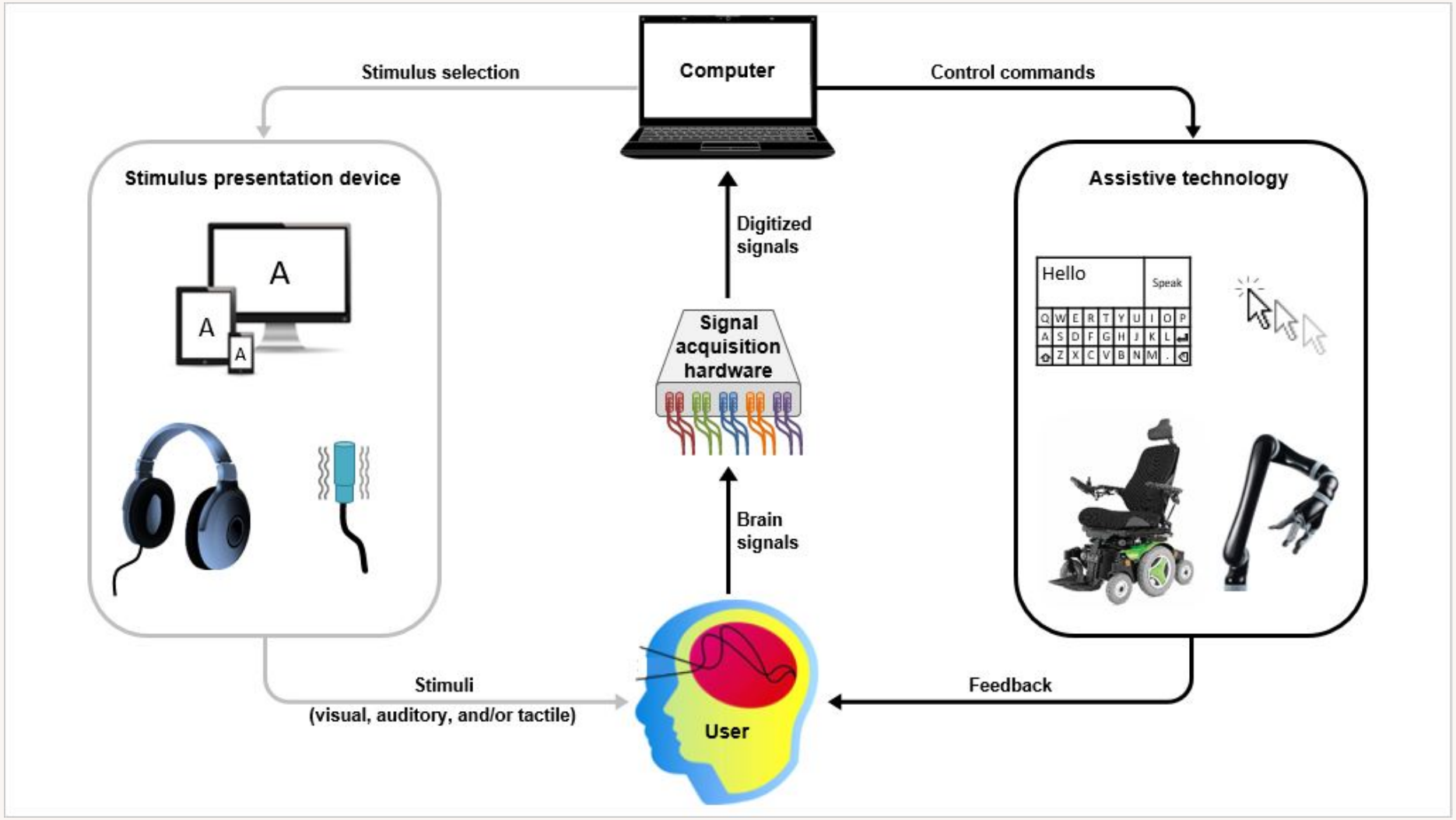
CAMBI: Consortium for Accessible Multimodal Brain-Body Interfaces

Brain-Computer Interface (BCI)

- Technology whereby a computer detects a ‘selection’ made by a person who does not rely on neuromuscular activity.

- The technology uses the person’s changes in brain waves as the intended action. This is our newest means to access an SGD or computer.

- Technology substitutes for the loss of typical neuromuscular outputs so that people can interact with their environments through brain signals rather than through muscle movement.


Computer
Stimulus selection
Control commands
Stimulus presentation device
A
A
A
Digitized signals
Signal acquisition hardware
Brain signals
Assistive technology
Hello
Speak
Stimuli
(visual, auditory, and/or tactile)
User
Feedback

Who would use a BCI for communication?

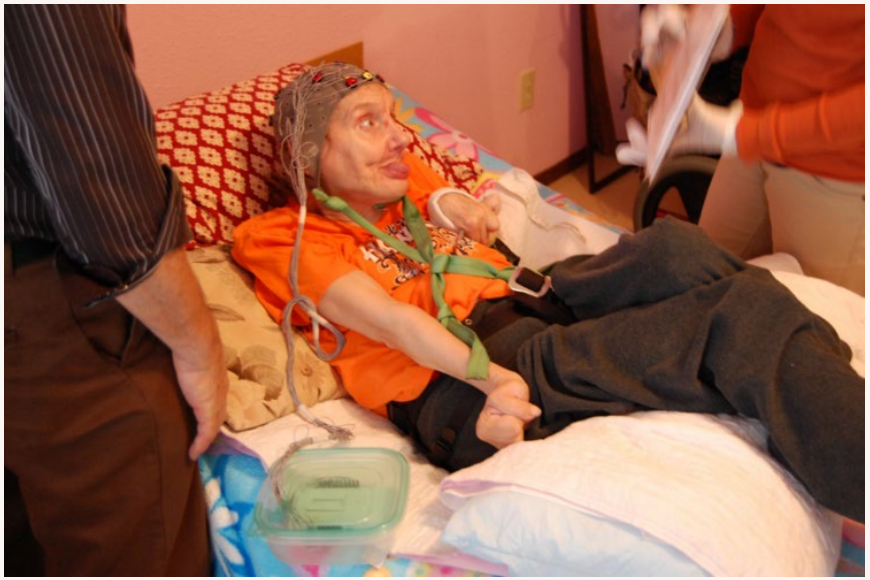
BCI is currently used in research studies with participants who present with incomplete or complete locked-in syndrome (LIS)

NOTE: BCI systems work best on individuals with minimal to no voluntary movement. It is very difficult to acquire brain signals from participants with extraneous or involuntary movement, for those with attention challenges, or those who cannot tolerate wearing a BCI cap.

We are working on better hardware and software to include more end-users.

GOAL: Expand LIS by function instead of diagnosis: severe speech and physical impairment (SSPI)

- Cerebral palsy
- Rett Syndrome
- Muscular dystrophies
- Multiple sclerosis
- Parkinson's disease
- Ataxia



GOAL: Include new populations as potential BCI users

- Children and adults who will not be spelling full sentences, but know first letters;
- Children and adults with IDD who want to meet the communication goal of participating in family life with pre-determined messages;
- Children and adults who rely on icons and pictures for communication.

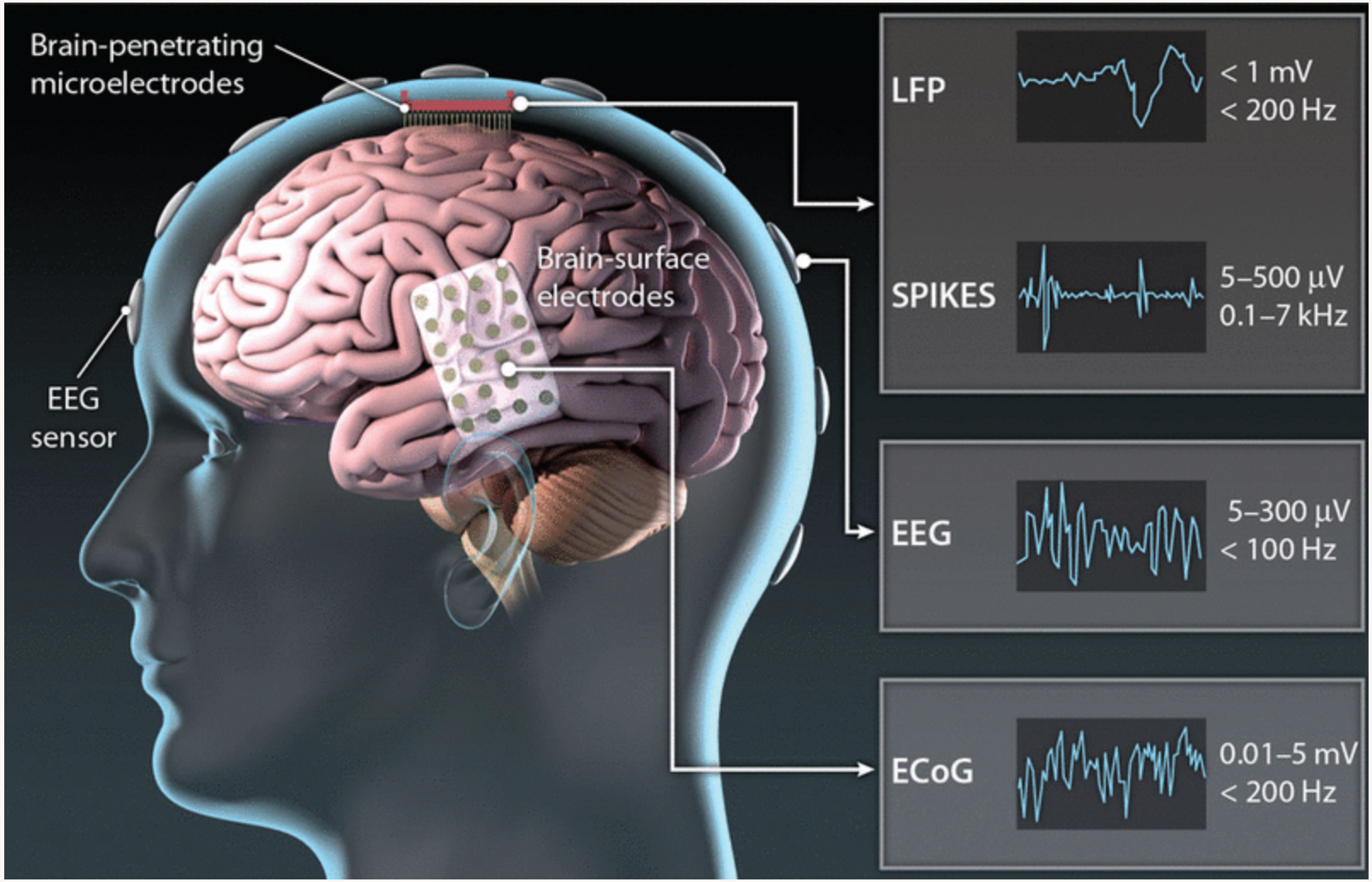
Current BCI Research

Current human BCI research for communication & control

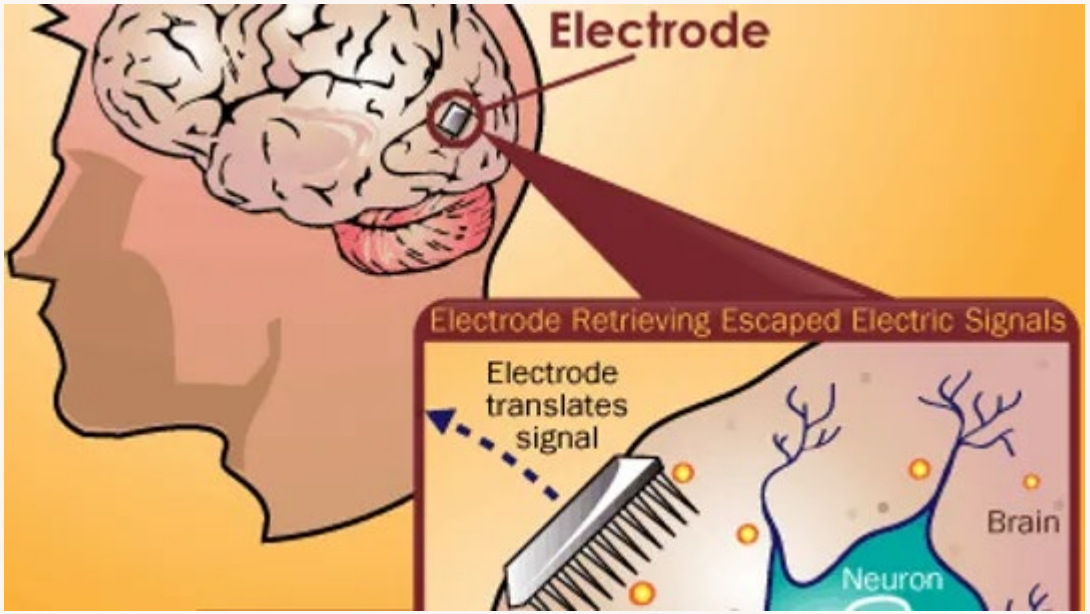
Implantable

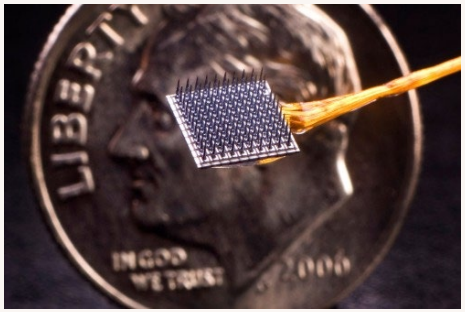
Non-implantable or wearable

Implantable vs. non-implantable



Implantable BCI chip





Most non-implantable BCI requires an EEG cap

Wet electrode cap

Dry electrode cap

Emotiv BCI headcap

Part 3: **Trial of electrode cap**

DSI 24 dry electrode cap

Flexible DSI dry electrode cap

Common brain signals acquired in BCIs for communication and computer control

- **P300-** the surprise evoked potential that can be acquired through multiple stimulus presentations
- **SMR-** sensory motor rhythm to detect movement (think right; think left)
- **SSVEP-** steady state visual evoked potentials- an averaged wave that occur in response to flashing stimulus presentations

RSVP Keyboard: CAMBI communication BCI

Our goal: Provide a means for individuals to communicate independent of neuromuscular output through EEG activity (P300 EPs) that is fused with language models.

Expand BCI for AAC uses

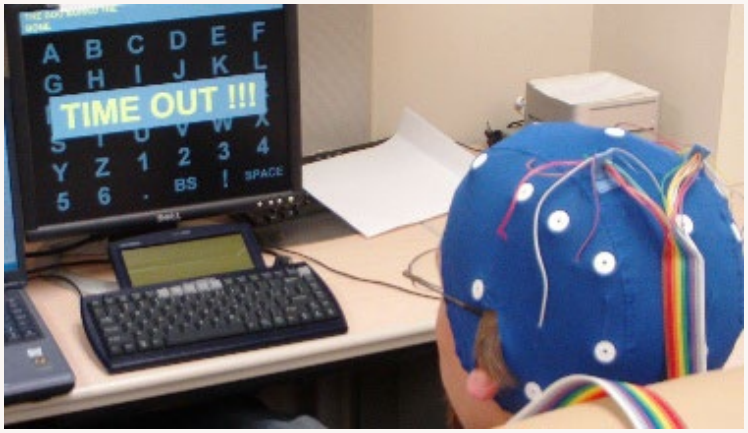
1. BCI as a switch (input)
2. BCI as a communication device
3. BCI as an assessment tool
4. BCI for AAC treatment
5. BCI for research

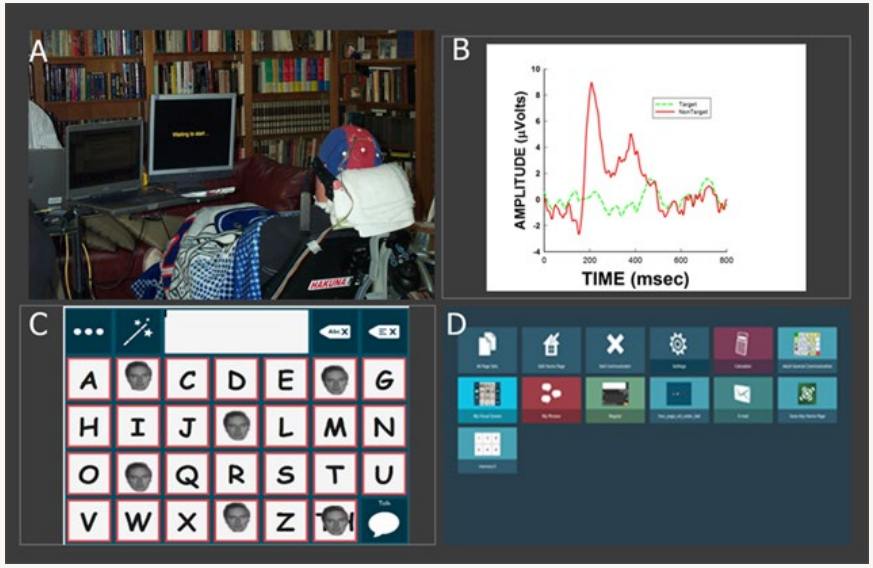
BCI as a switch

- Yes/no communication (binary choice) with binary switch using motor imagery (SMR)

- BCI as a plug and play device. P300 BCI as a switch to a marketed speech generating device

A plug-and-play brain-computer interface to operate commercial assistive technology
Thompson DE, Gruis KL, Huggins JE
Disabil Rehabil Assist Technol 2014;9(2):144-150





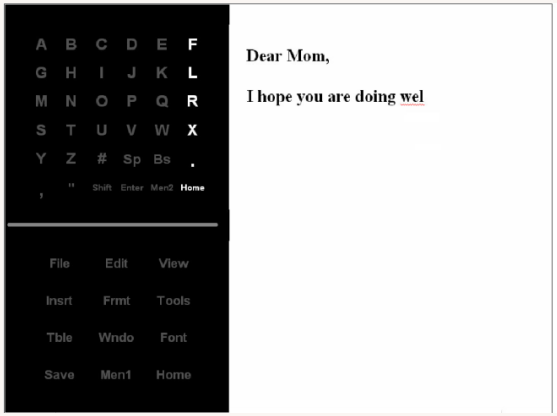
BCI as a switch to select letters for the DynaWrite speech generating device

Or with the TobiiDynavox Communicator 5 software

Gosmanova, K. A., Carmack, C. S., Goldberg, D., Fitzpatrick, K., Zoltan, B., Zeitlin, D. M., ... & Vaughan, T. M. (2017). Eeg-based brain-computer interface access to tobii dynavox communicator 5. Rehabilitation Engineering and AssistiveTechnology Society of North America, 4.

BCI as a communication device

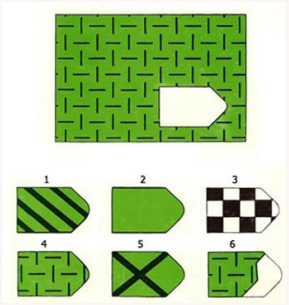
Matrix speller: Wadsworth BCI2000

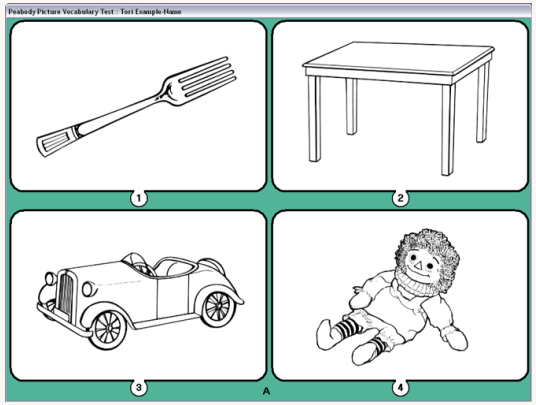


RSVP Keyboard

BCI as an assessment tool

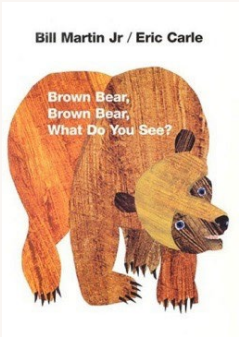
- BCI to determine cognitive status of patients with disorders of consciousness in the ICU
- Adapt standardized tests to measure cognitive or receptive language skills for people who cannot produce motor responses
- Use flashing stimuli for P300 or SSVEP signals, or binary choice motor imagery.
  - pALS
  - Rett syndrome
  - Severe spastic CP





BCI as an intervention tool

- Play: @BCI4kids at University of Calgary video game playing and painting
- Mobility: @BCI4kids (3:18) https://www.youtube.com/watch?v=3LgwYs&t=22s



- Conversation and reciprocal communication; literacy: *pre-stored messages for interaction and repetitive line reading*

BCI as a research tool

- How does receptive and expressive language change with the use of BCI?
- Does brain development change with the introduction of BCI?
- How does interaction with a person with LIS change with the use of BCI?
- How can we improve neuroengineering developments for individuals with additional movement or attention challenges?