

Conducting EEG-Based Brain-Computer Interface (BCI) Protocols with the people who need them

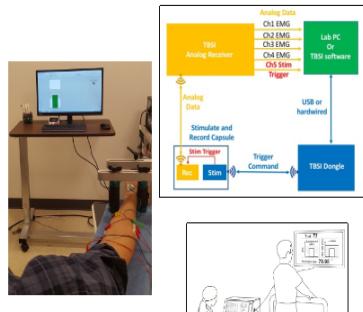
TM Vaughan
Albany, New York
USA



Garden Oct 17, 2023

Guiding Beneficial Plasticity

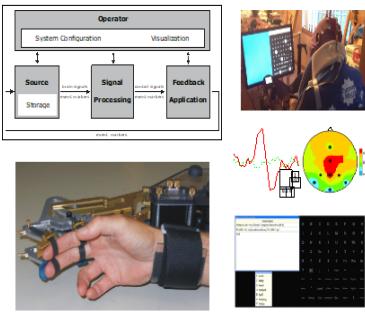
Program Director:
Aiko Thompson, Ph.D.



Spinal reflex
operant conditioning

BCI2000-Based Laboratory and Clinical Systems

Program Director:
Jonathan Wolpaw, M.D.

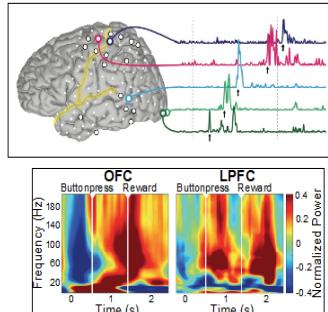


BCI2000 and multi-modal
data acquisition

Home BCI
System

Characterizing and Modifying Cortical Processes

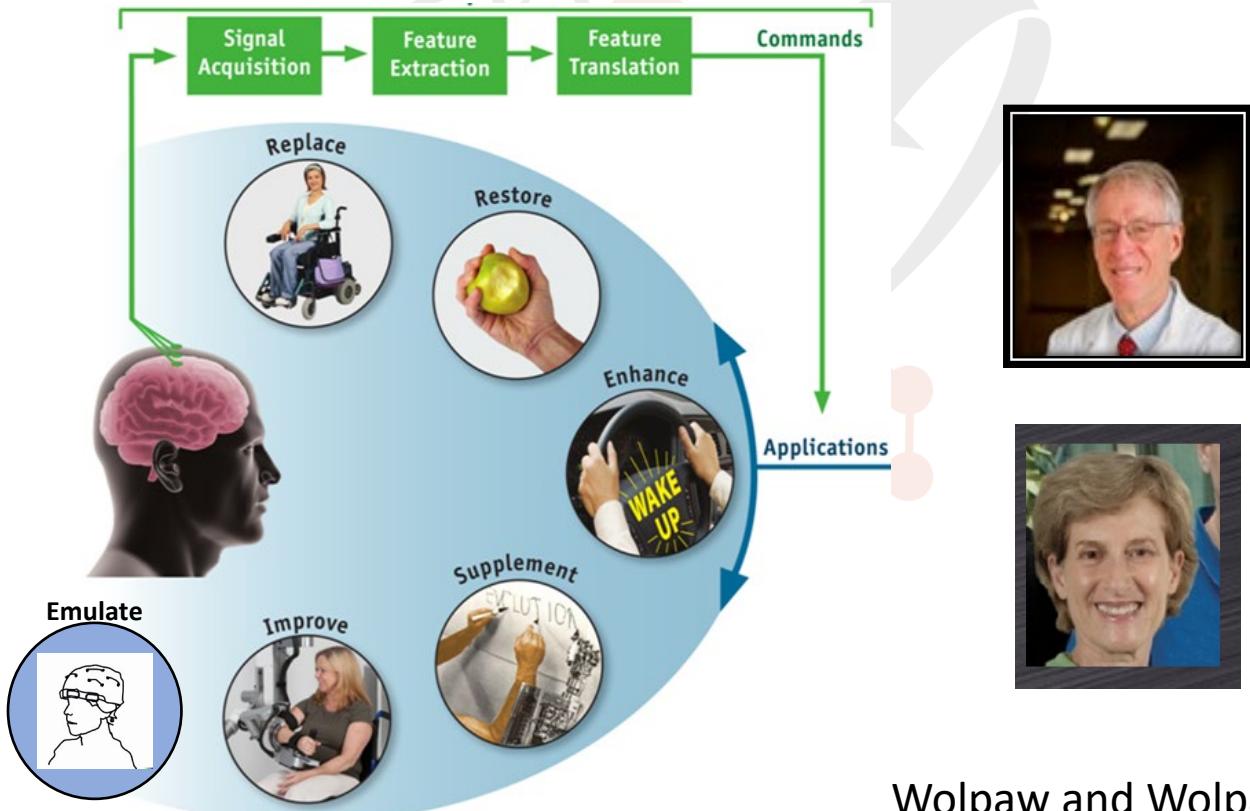
Program Director:
Peter Brunner, Ph.D.



Characterization of and interaction
with CNS using electrocorticography



NCAN researchers create and test real-time adaptive methods and technologies that interact with the central nervous system in three areas of concentration.



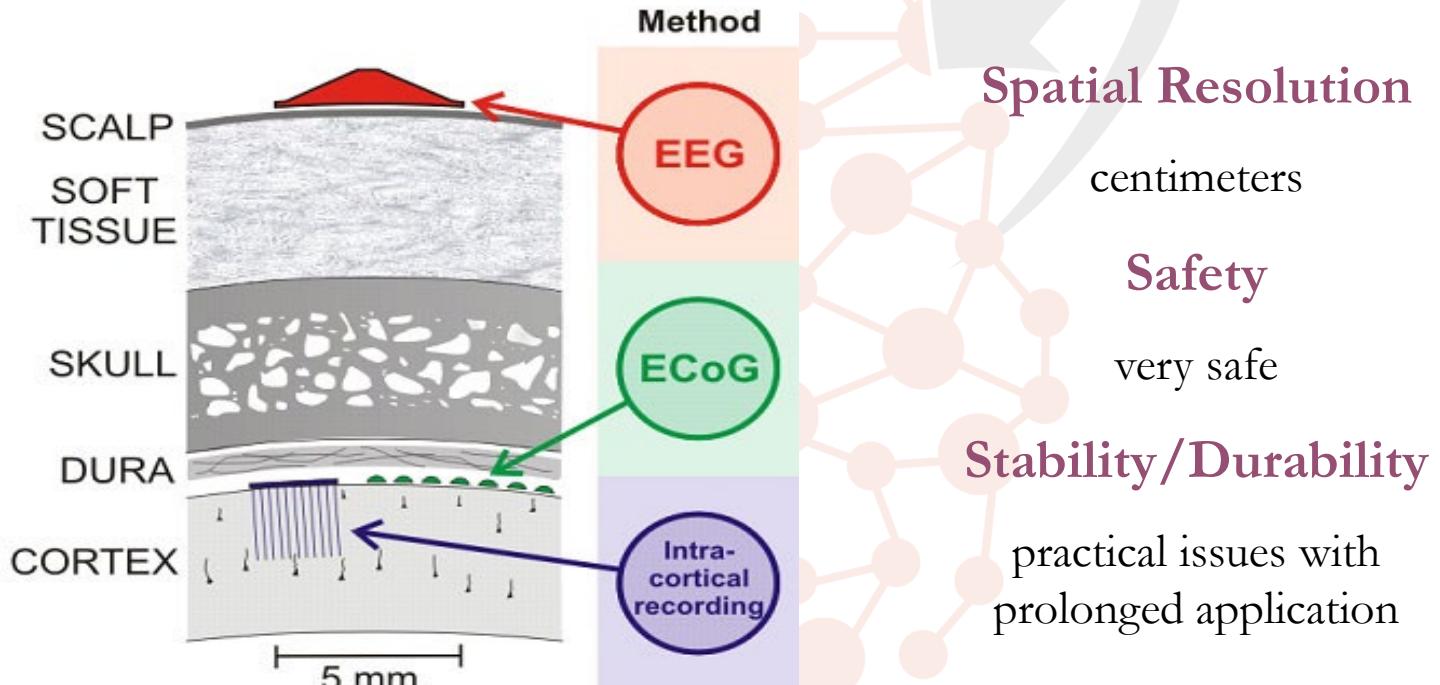
Wolpaw and Wolpaw, 2012

Question

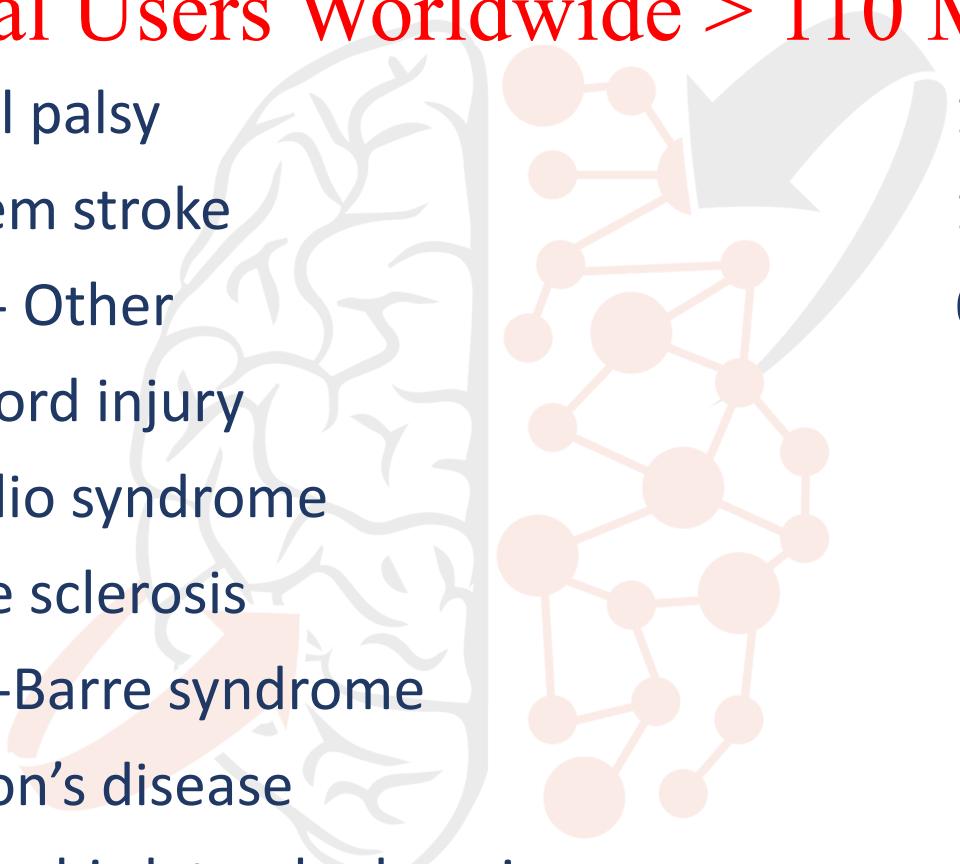
What are the practical considerations, problems, and challenges of developing BCIs for the people who need them.



Recording Electrical Signals



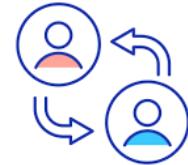
Potential Users Worldwide > 110 Million



Cerebral palsy	16,000,000
Brainstem stroke	10,000,000
Stroke - Other	60,000,000
Spinal cord injury	5,000,000
Post-polio syndrome	7,000,000
Multiple sclerosis	2,800,000
Guillain-Barre syndrome	500,000
Parkinson's disease	8,500,000
Amyotrophic lateral sclerosis	420,000

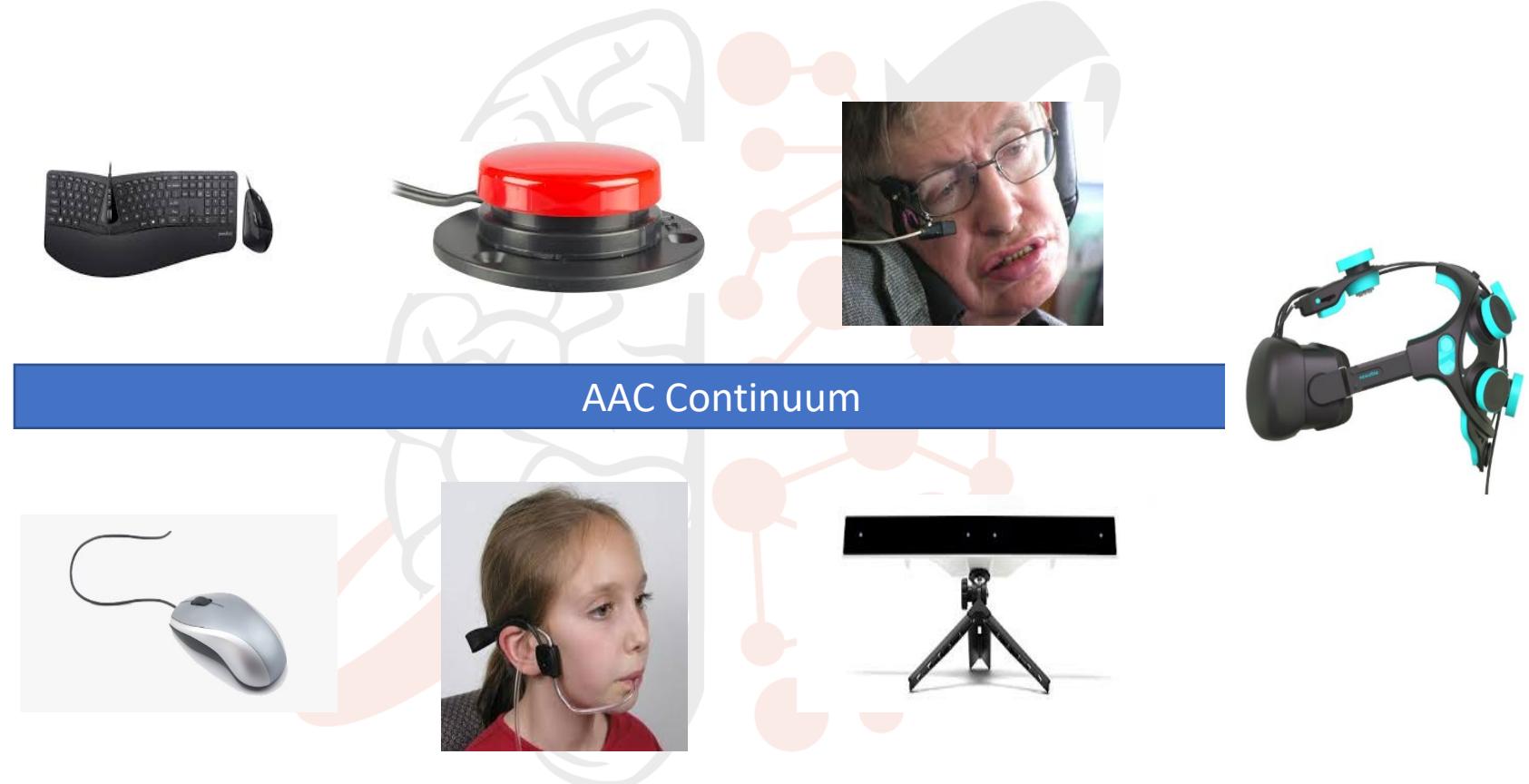
Augmentative & Alternative Communication (AAC)

Anything other than speech for communication

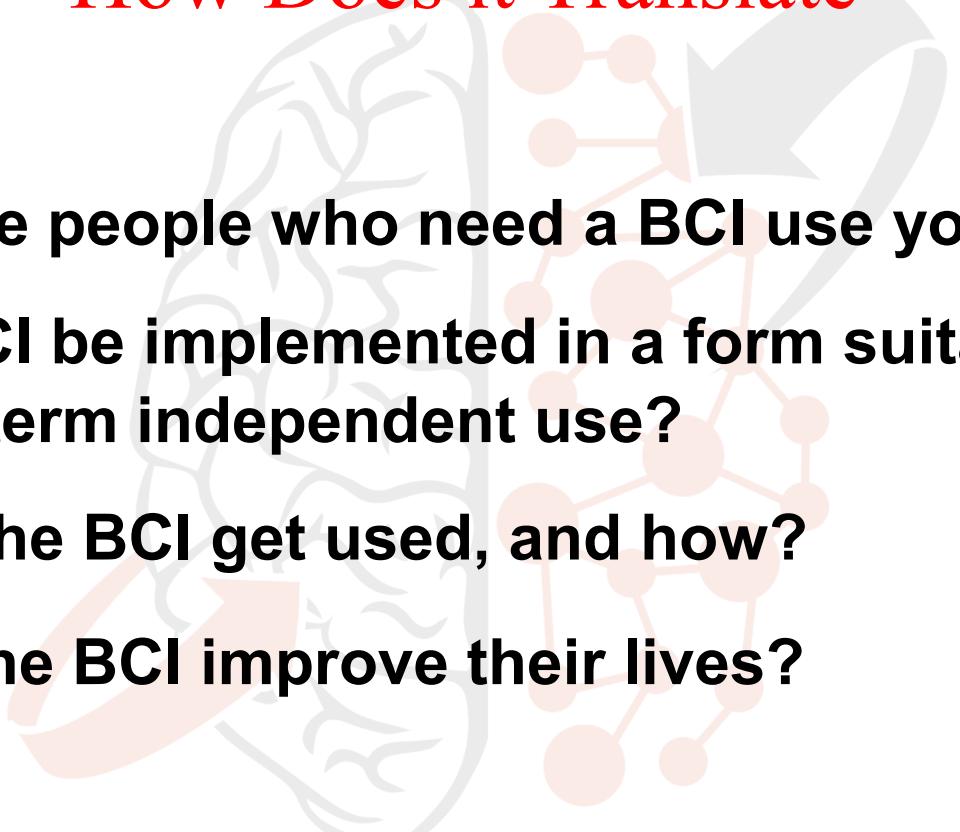


A well-designed AAC system is flexible and adaptable. It...maximizes the individual's abilities to communicate effectively and efficiently across environments and with a variety of communication partners

(Beukelman & Mirenda, 2013).

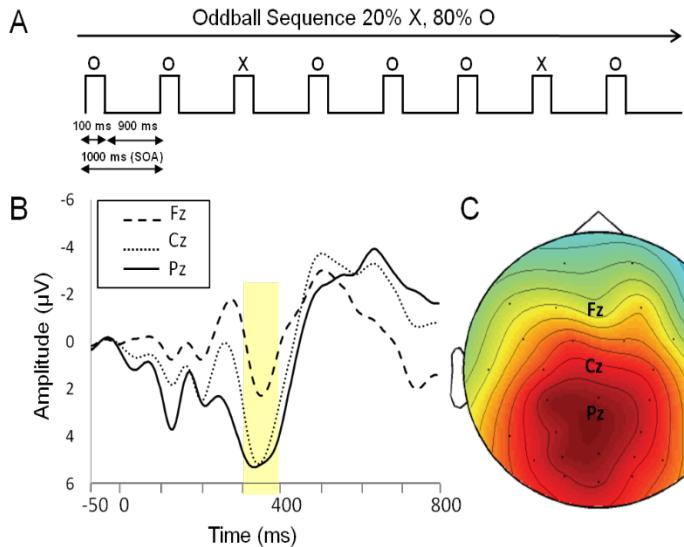


How Does it Translate

- 
- 1. Can the people who need a BCI use yours?**
 - 2. Can BCI be implemented in a form suitable for long-term independent use?**
 - 3. Does the BCI get used, and how?**
 - 4. Does the BCI improve their lives?**

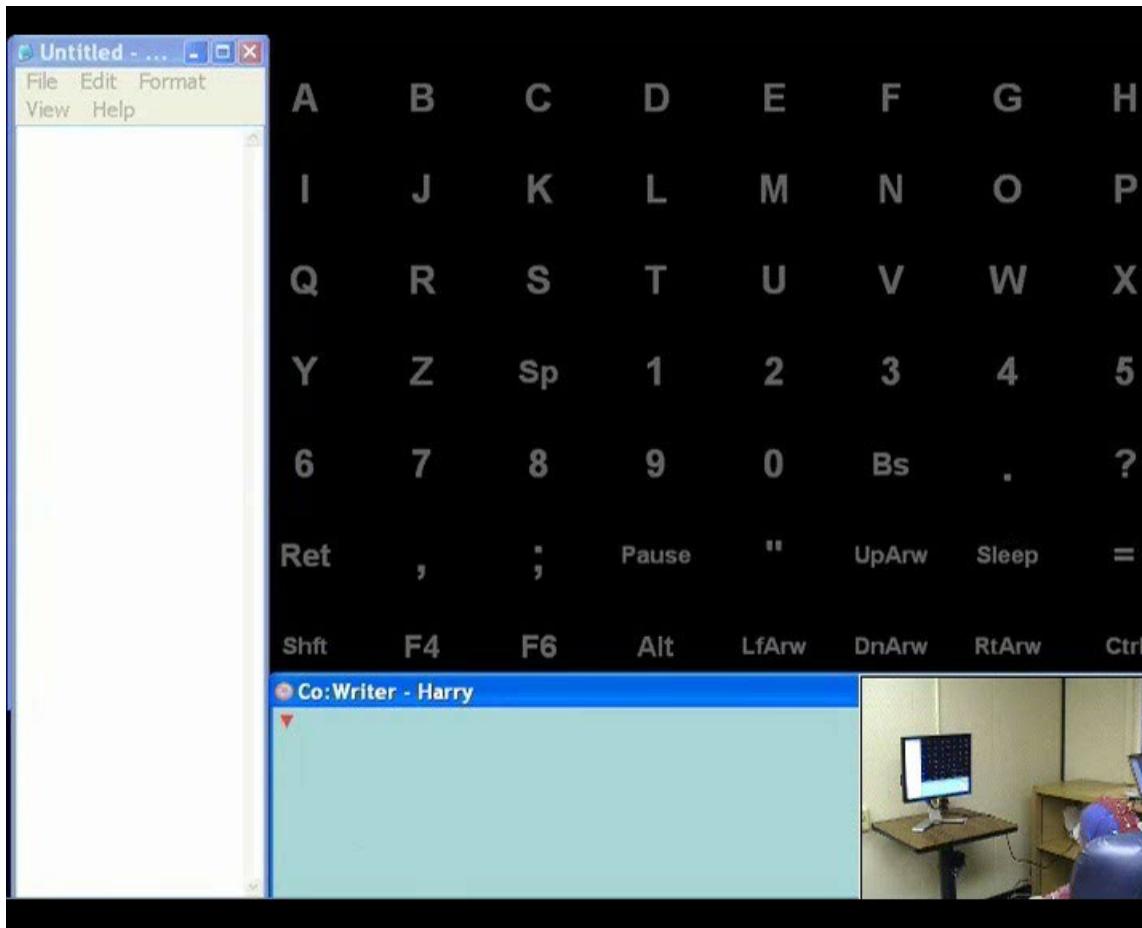
Vaughan et al., 2006

Event-Related Potentials (ERPs) in the EEG (averaged signals)



.S. Department
of Veterans Affairs
Stratton VA Medical Center





Farwell and Donchin, 1988



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1. Can the people who need a BCI use yours?

Vaughan et al., 2006

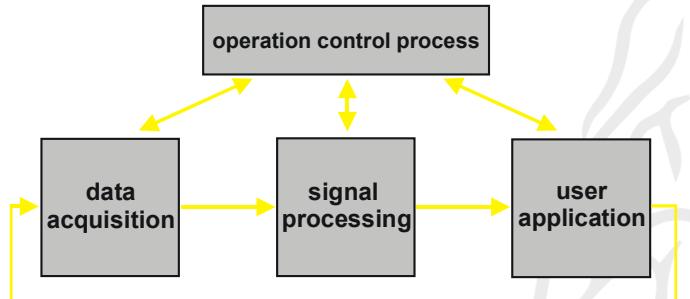




SELECTION CRITERIA: Recruitment and Retention

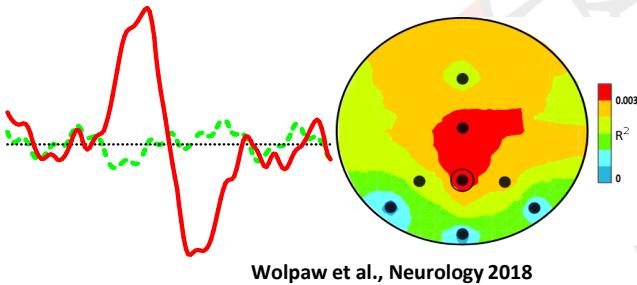
Chronic disorder of voluntary movement	<i>ALS, brainstem stroke, cerebral palsy, high level spinal cord injury, SMA</i>
Minimal remaining useful motor control	<i>Single muscle, eye movement</i>
Conventional communication technologies not adequate	<i>Single-switch EMG or eye-movement systems difficult, unreliable</i>
Stable environment	<i>Strong medical, physical, social support</i>
Technically capable caregivers	<i>Able and willing to master BCI Home system operation</i>
Realistic understanding of the BCI study	<i>Research enterprise, success not assured</i>
Located where staff can evaluate, train and support	<i>Located in the Northeast</i>

Can they use it?

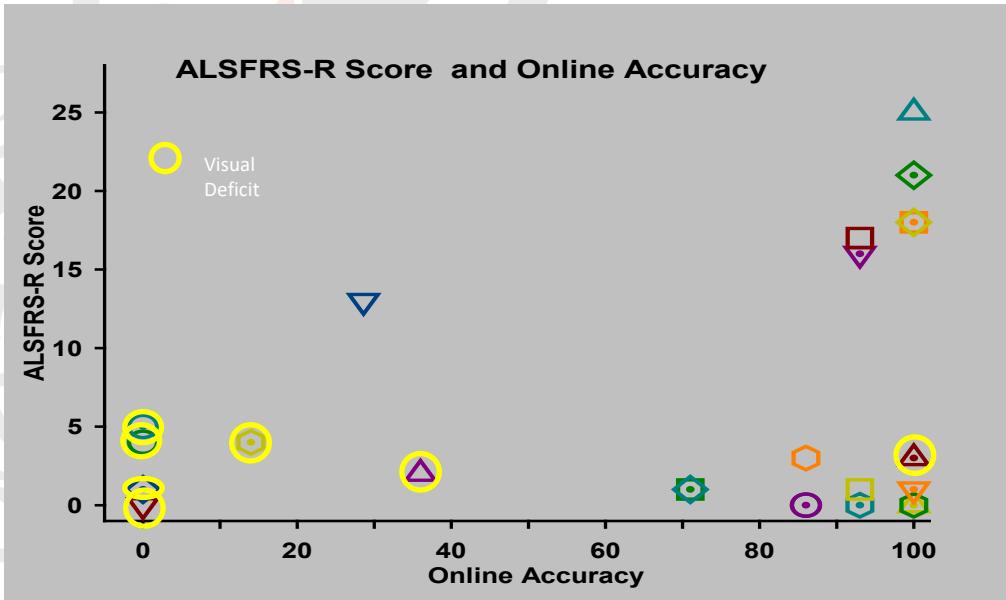


BCI2000 – A General Purpose BCI System

Schalk et al., 2004



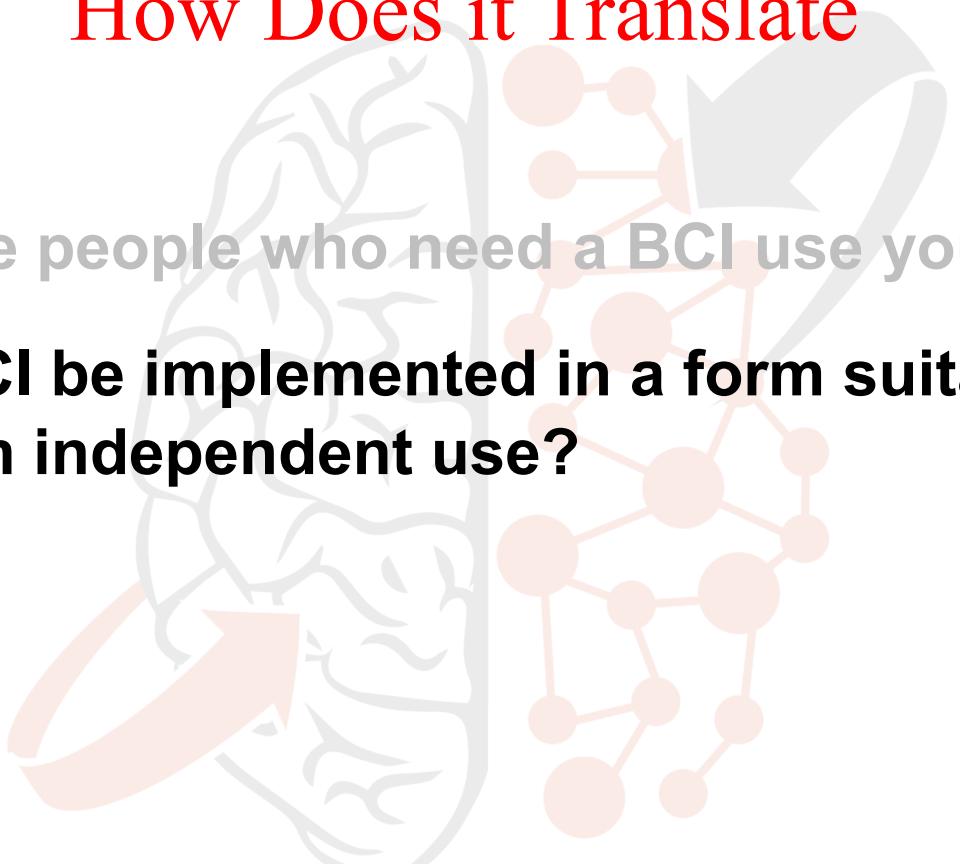
Wolpaw et al., Neurology 2018



People diagnosed with ALS have a reliable P300 Response

McCane et al 2015

How Does it Translate

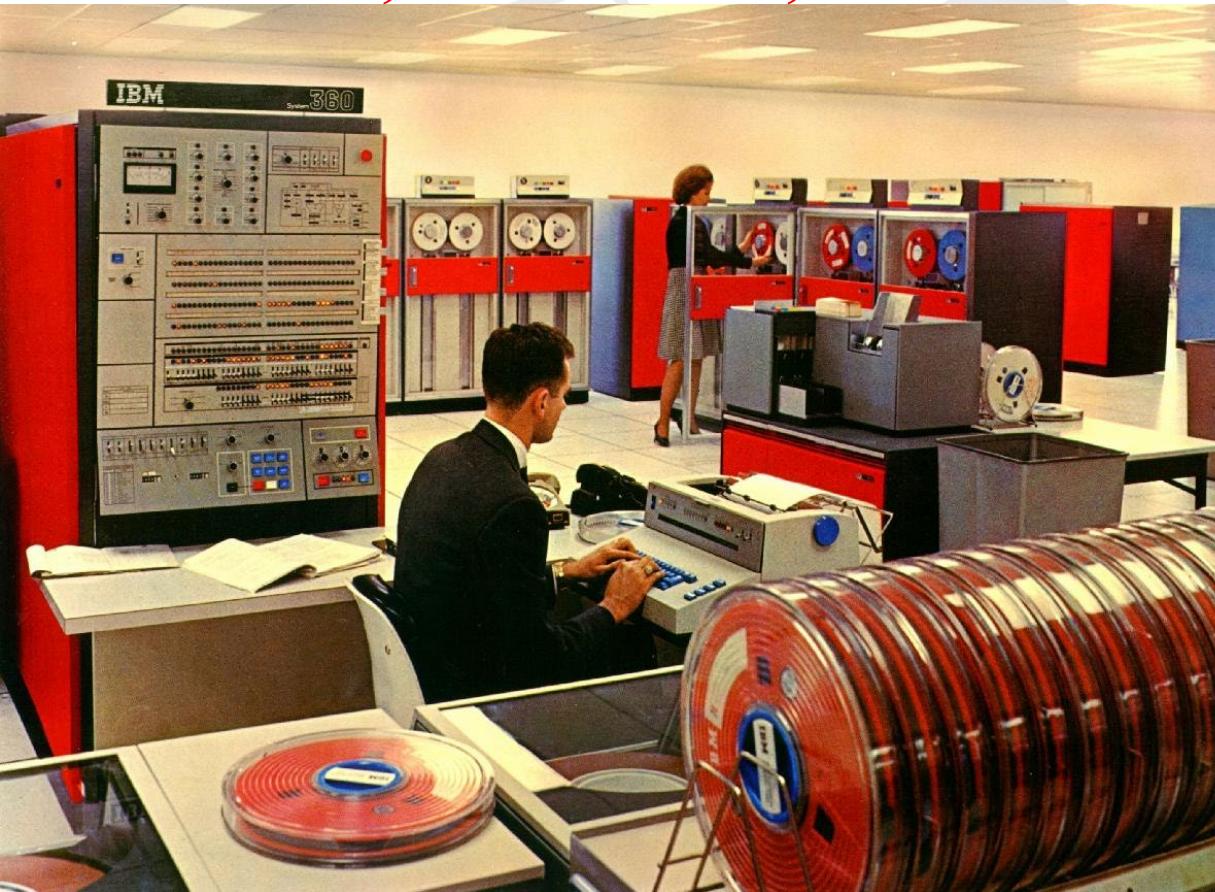
- 
1. Can the people who need a BCI use yours?
 2. Can BCI be implemented in a form suitable for long-term independent use?

Vaughan et al., 2006



Cap: easy to use with **reliable signals**

Portable, affordable, hardware

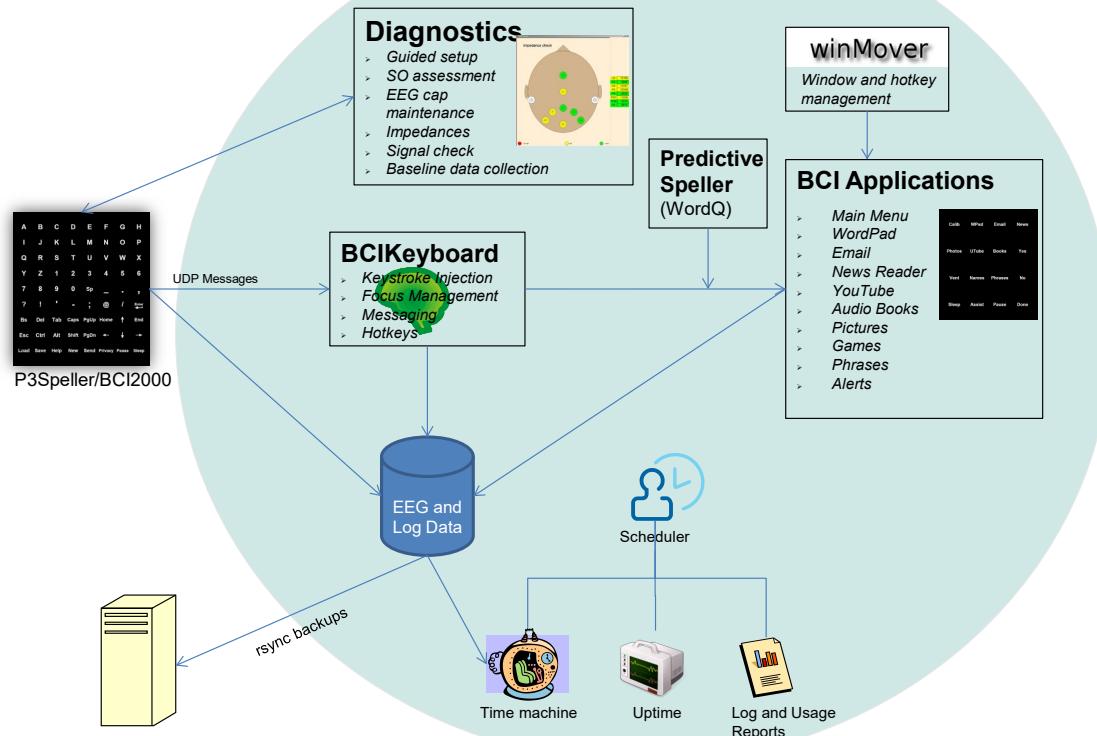


Portable, affordable, hardware



Safe and reliable data and data transfer

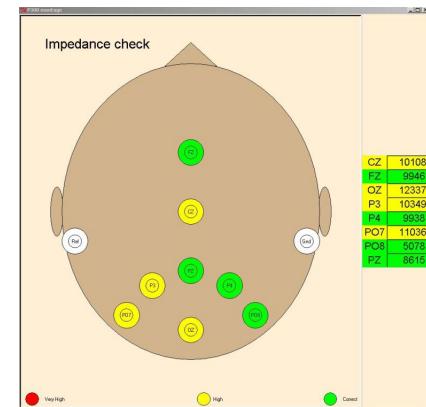
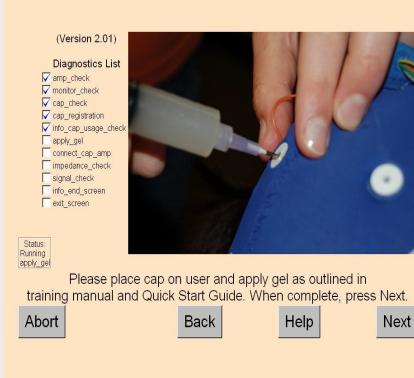
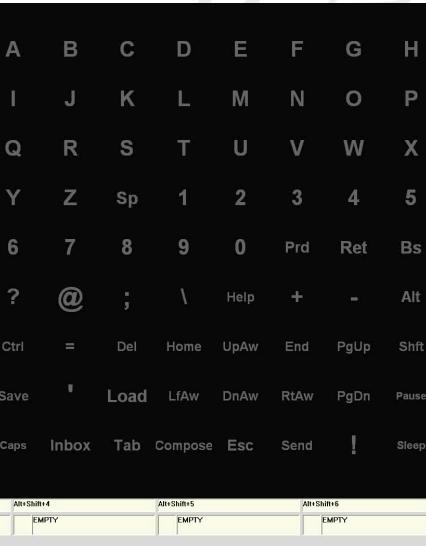
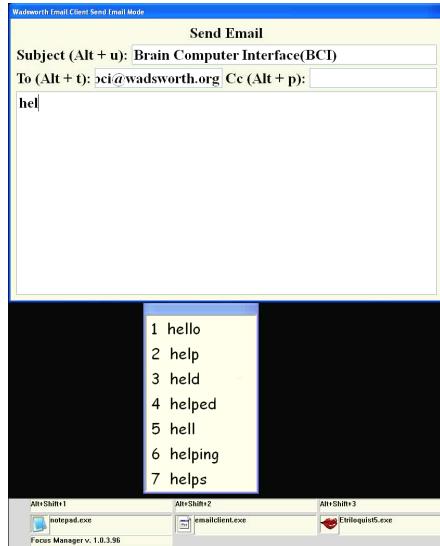
BCI-360



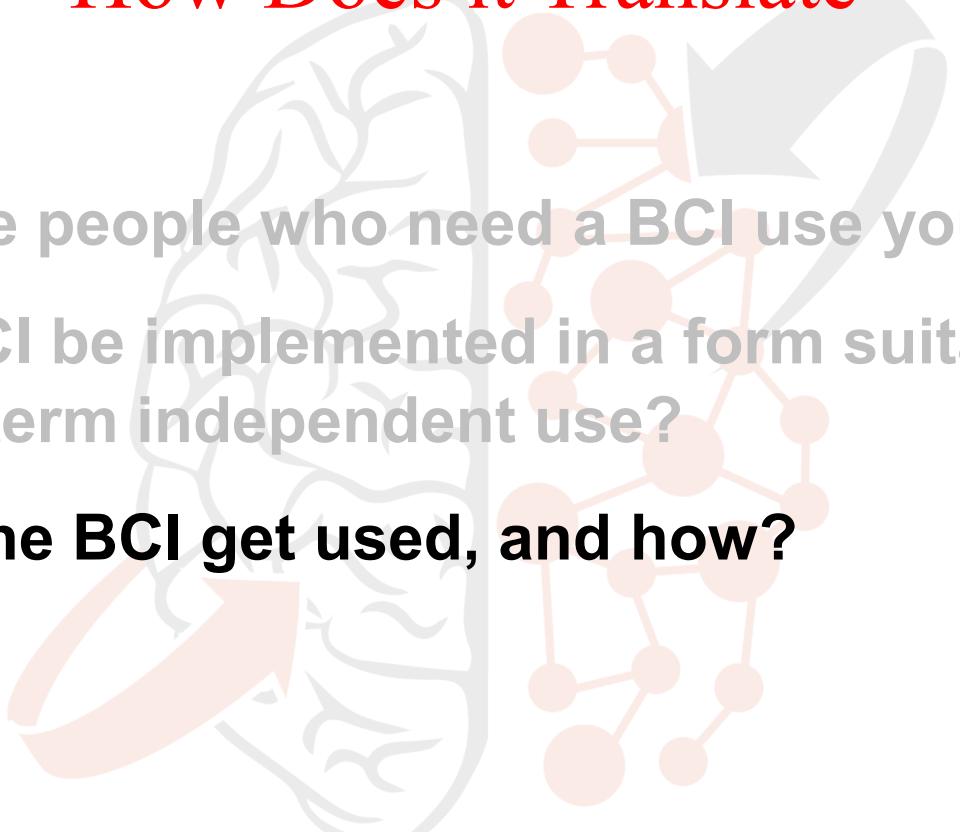
October 17, 2020



Something to use and training and support

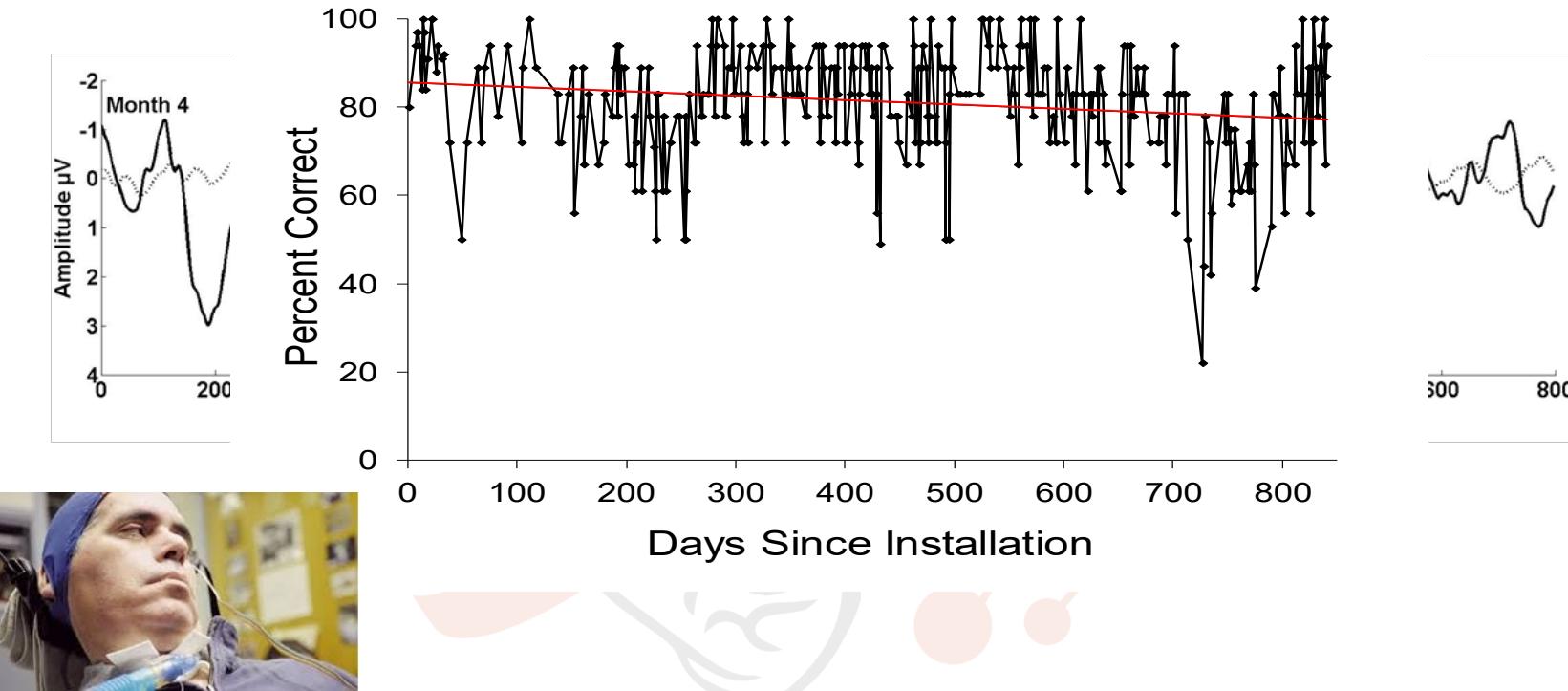


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Vaughan et al., 2006

Is it stable

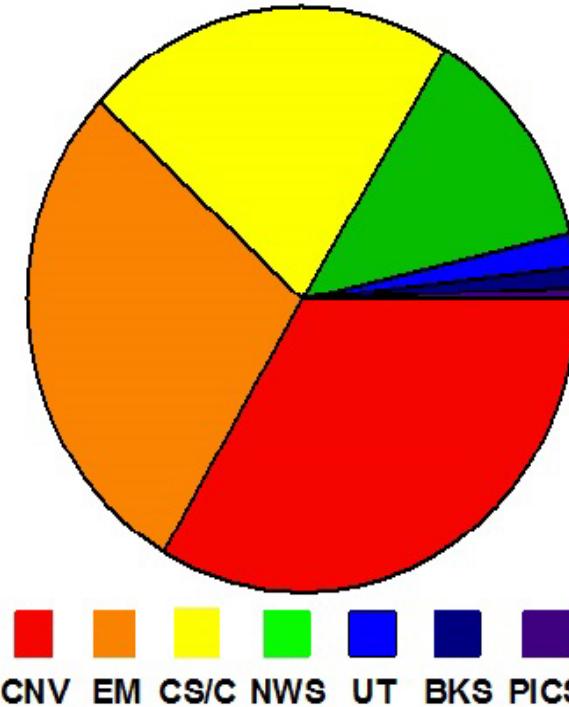


How do you know?

ID	LAST UPTIME	DATE LAST USED	LAST USED (DAYS)	RUNS TO DATE	CALIBRATION RUNS	INDEPENDENT RUNS
H3	9-30-2012 23:45	9-26-2012	4	219	46	173
X2	9-30-2012 23:45	9-23-2012	7	1548	326	1222

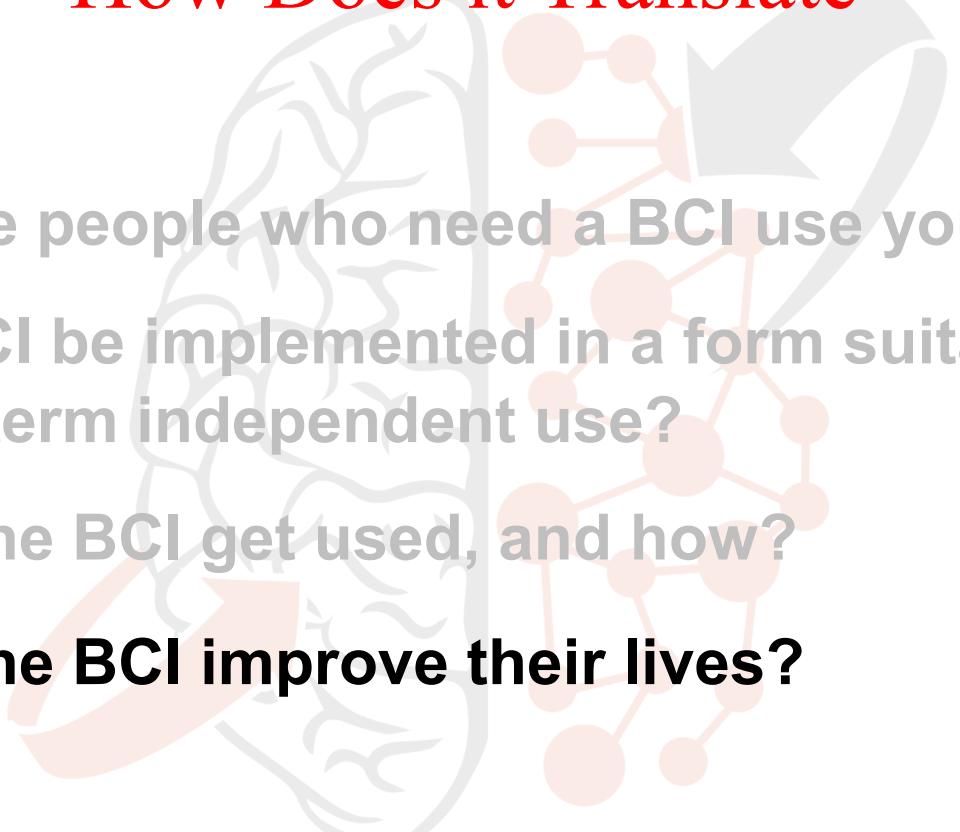
BCI at home: 14 Users, 8 without other means of computer control

Most independent use devoted to conversation, email, calibration and news readers.



Wolpaw et al., Neurology 2018

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Vaughan et al., 2006



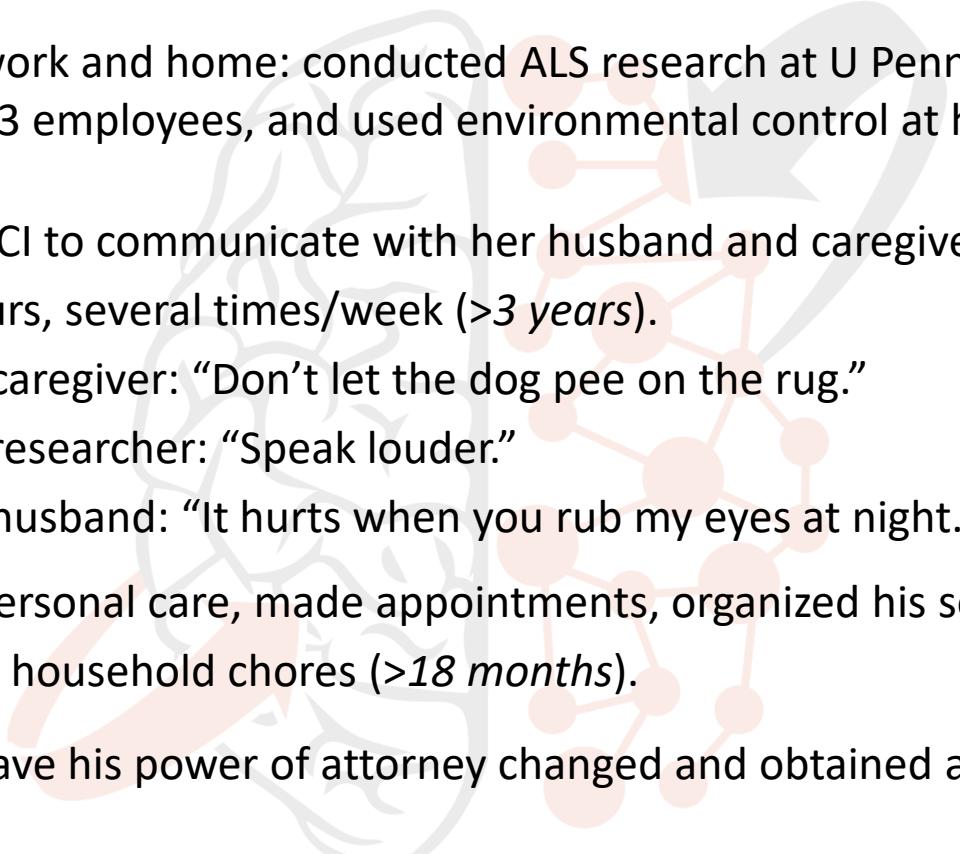
Asked to describe BCI impact on his life, the first user wrote:

▼ **Subject:** Re [REDACTED]
From: [REDACTED]
Date:
To: Jonathan R. Wolpaw [REDACTED]
Cc: [REDACTED]

No problem.

I couldn't run my lab without BCI. I do molecular neuroscience research and my grant pays three people.

I'm writing this with my EEG courtesy of the Wadsworth Center Brain-Computer Interface Research Program (www.wadsworth.org)



Used it at work and home: conducted ALS research at U Penn, supervised 3 employees, and used environmental control at home > 5 years.

Used the BCI to communicate with her husband and caregivers for several hours, several times/week (>3 years).

To her caregiver: “Don’t let the dog pee on the rug.”

To the researcher: “Speak louder.”

To her husband: “It hurts when you rub my eyes at night.”

Asked for personal care, made appointments, organized his social events, and household chores (>18 months).

Asked to have his power of attorney changed and obtained a divorce (>2 years).

accurate but slow.	R&D, e.g., FACES	200%
functional but not spontaneous.	MSAA Screen Reading	OTS Software
difficult to set-up.	Online Diagnostics & Manuals	Onscreen Setup & manual
too many components.	BCI as Access Method	Works on a laptop
time consuming to wash hair after & can be uncomfortable.	Gel Cap upgrades & new technology	Greater comfort and dry sensors
difficult to position.	Now using adjustable stands (e.g., DAESSY, Rehadapt)	3D & folding joints

The way we see the near future



AUTOMATIC CALIBRATION

An automatic algorithm that calibrates the BCI Home System with actual use data could improve system reliability and simplify support for people who depend on BCI for communication and control.



	ACCURACY	BITS/MIN
TAG on TAG	92<u>+16</u>	9<u>+4</u>
CM on CM	98<u>+4</u>	14<u>+6</u>
TAG on CM	99<u>+2</u>	13<u>+5</u>
CM on TAG	92<u>+16</u>	9<u>+3</u>

vBCI June 2021





Telehealth

Garden Oct 17, 2023

Dennis J. McFarland, Ph.D.
1949-2020



NCAN Support

NIH NIBIB P41 BTRC Center
Department of Veterans Affairs
NIH NINDS
NIH NCMRR/NICHD
NYS Spinal Cord Injury Research Board
Empire State Development
Stratton VA Medical Center



.S. Department
of Veterans Affairs
Stratton VA Medical Center



MUSC
Medical University of South Carolina

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U.S. Department
of Veterans Affairs



NCAN
National Center for Adaptive Neurotechnologies





THANK YOU



QUESTIONS?

