Theories & Principles of AAC Interface Design for People with Aphasia

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Disclosures

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  - NIH-NCRR 8ULTR000077-05
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- **Collaborators**
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  Dr. Jerzy Szaflarski, MD, PhD – University of Alabama at Birmingham
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  - Cassandra "Cassy" Stall, BS – University of Cincinnati
- **Statistical Support**
  - Mekibib Altaye, PhD - Cincinnati Children's Hospital Medical Center

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Learning Outcomes *Intermediate*

Participants will be able to:

- … state the pros and cons of various interface designs when thinking of people with aphasia
- … cite recent evidence in the literature supporting the use of augmentative and alternative communication (AAC) in aphasia rehabilitation programs.
- … explain theoretical underpinnings that support the use of AAC as a language recovery tool.

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MYTH 1: AAC ***interferes*** with spoken language

MYTH 2: AAC is what you do ***after*** a plateau in restorative treatment

MYTH 3: AAC and language recovery are ***mutually exclusive***

MYTH 4: People with ***Broca's aphasia*** are best suited for AAC

(Dietz, Wallace, & Weissling, 2020; Wallace & Prentice, 2010)

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1. LPAA: Beyond Needs, Picture Boards, & Talking Boxes
2. Using AAC to Enhance Natural Abilities
3. Earlier introduction of AAC

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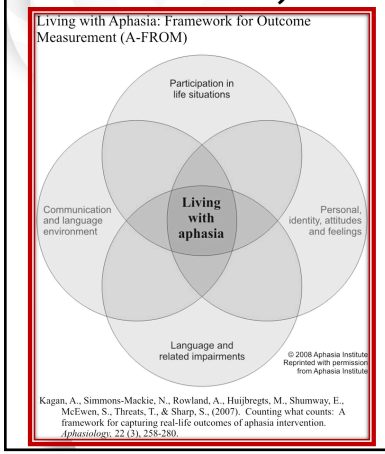
LPAA: Beyond Needs, Picture Boards, & Talking Boxes



Light's 4 Purposes of Communication (1988)

- Communicate basic needs
- Deliver information
- Maintain social closeness
- Social etiquette

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Garrett & Lasker: Categories of Communicators (2005)

https://cehs.unl.edu/documents/secd/aac/assessment/aphasiachecklist.pdf

- **Co-Construction** (Bloch & Beeke, 2008)
- **Dependent**
  - Adapt environment
  - Train partners
  - Develop AAC skills
- **Independent**
  - Self Advocacy
  - Refine AAC Skills

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Social Communication

- Mobile Technology is "normal"
- Incorporates photos and text
- Asynchronous communication decreases cognitive demands

- Supports Co-Construction
- Incorporates photos and text
- Asynchronous communication decreases cognitive demands

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Traditional Approaches

- Historically, aphasia rehabilitation aims to help people with aphasia recover as much of their pre-stroke language capacity as possible…leaving AAC as a last resort

(Dietz, Weissling, Griffith, McKelvey, & Macke, 2014; Garrett & Lasker, 2007; Simmons-Mackie, 1998; Weissling & Prentice, 2010)

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Earlier Introduction to AAC

- 50% of caregivers report receiving education about AAC approaches during first 3 months recovery. (Elman et al., 2016)
- ASHA NOMS Data (Rogers et al., 2014)

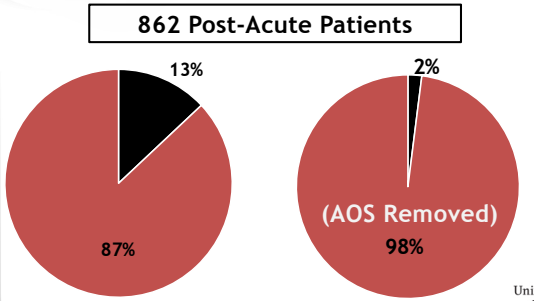

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Figure used with permission from Julie Griffith, PhD
Source: Griffith, J.D. (2014) *Post-stroke Language Remediation through Constraint-induced Aphasia Therapy.* University of Cincinnati, Cincinnati, Ohio.

Theory of Learned Non-Use: Rationale for AAC Resistance?

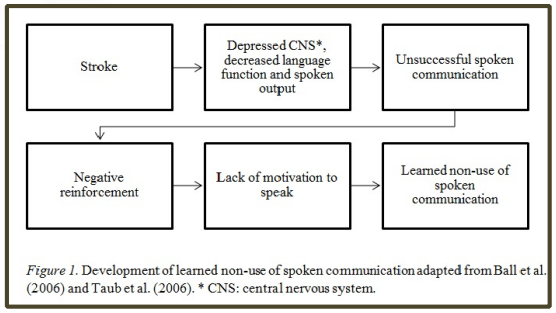

Figure 1. Development of learned non-use of spoken communication adapted from Ball et al. (2006) and Taub et al. (2006). * CNS: central nervous system.

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Learned Non-Use *is Real*

- "Ward Talk"
  - People with post-stroke aphasia have fewer interactions with nurses than post-stroke peers without aphasia
  - During these interactions, nurses tended to:
    - use closed questions
    - control the conversational floor
    - restrict conversation to physical care
    - Rarely used communicative repair strategies

(Hersh, Godecke, Armestrong, Ciccone, Bernhardt, 2014)

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Using AAC to Enhance Natural Abilities

- Self-cueing with low-tech or no-tech AAC to facilitate word retrieval permeates the literature
  - drawing (Farias, Davis, & Harrington, 2006)
  - gesturing (Lanyon & Rose, 2009; Rose & Sussmilch, 2013)
  - multimodal approaches facilitate word retrieval (Attard, Rose, & Lanyon, 2012; Rose, 2013)
- Several small N studies suggest linguistic improvements following high-technology AAC interventions designed to promote non-verbal communication
  - Decreased aphasia severity (Hough, & Johnson, 2009; Johnson, Hough, King, Vos, & Jeffs, 2008)
  - Increased linguistic form (non-verbal)

(Hough, & Johnson, 2009; Johnson, Hough, King, Vos, & Jeffs, 2008; Koul & Lloyd, 1998; Koul, Corwin, & Hayes, 2004)

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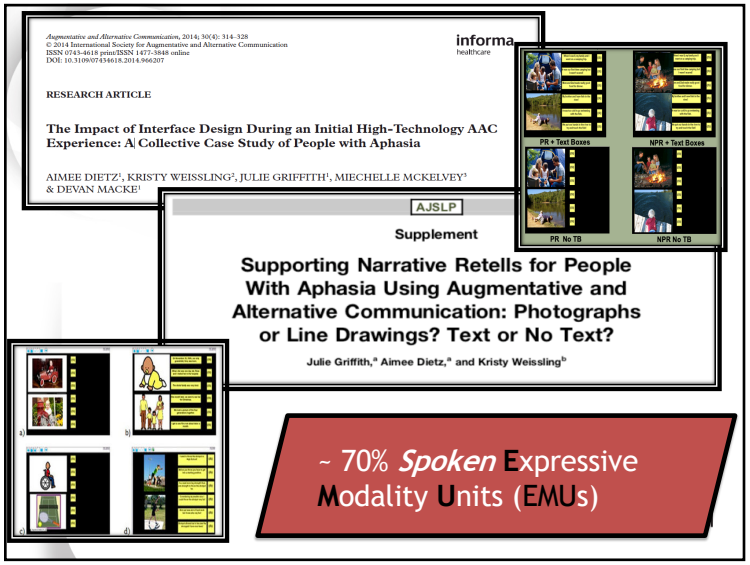

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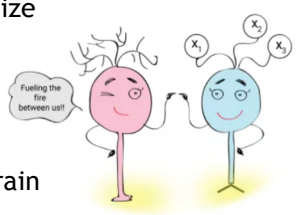
Neural Plasticity (MedicineNet)

- "The brain's ability to reorganize itself by forming new neural connections throughout life.
- Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease *and to adjust their activities in response to new situations or to changes in their environment.*



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FUZZY SYNAPSE

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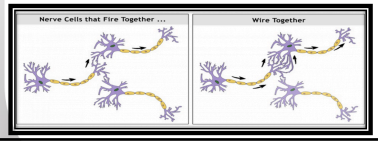
Continued…MedicineNet

- Brain reorganization takes place by mechanisms such as "axonal sprouting" in which undamaged axons grow new nerve endings to reconnect neurons whose links were injured or severed.
- *Undamaged axons can also sprout nerve endings and connect with other undamaged nerve cells, forming new neural pathways to accomplish a needed function.*



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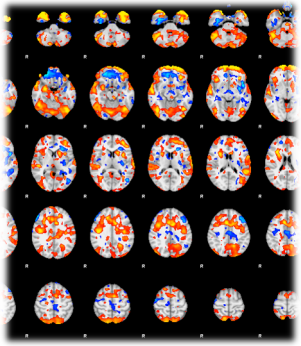
Continued…(MedicineNet)



- For example, if one hemisphere of the brain is damaged, the intact hemisphere may take over some of its functions. The brain compensates for damage in effect by reorganizing and forming new connections between intact neurons. In order to reconnect, the neurons need to be stimulated through activity.

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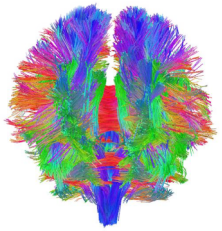
Continued…(MedicineNet)

- ***Neuroplasticity sometimes may also contribute to impairment.*** For example, people who are deaf may suffer from a continual ringing in their ears (tinnitus), the result of the rewiring of brain cells starved for sound. ***For neurons to form beneficial connections, they must be correctly stimulated.***



- Neuroplasticity is also called brain plasticity or brain malleability."

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AAC as a Language Recovery Tool: An Explanation

Luria's Intersystemic Reorganization

- ***Existing*** "performance acts" can be improved when paired with ***novel*** "performance acts"
  (Luria, 1972; Rose et al., 2013a; 2013b)
- Spoken Language → ***Existing*** Performance Act
- AAC → ***Novel*** Performance Act
  – Use AAC to self-cue for target words?

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But first….we must understand how interface design can affect communication and language.

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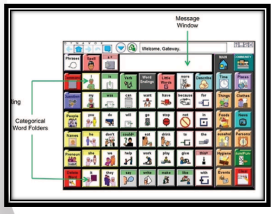
Traditional Grid/Home Page/ Semantic Design

PROS
- Easily generate novel messages
- ENDLESS message opportunities!



CONS
- Inventory each cell to
- Relies on heavily on semantic & syntactic knowledge
- Requires learning a 'new' language
- High levels of working memory & attention

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Grids: What do the data reveal?

In a nutshell….

- People with aphasia CAN learn to sequence iconic codes
- Generalization beyond learned sequences is fair to poor

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VSD Displays

CONS
- Limiting in terms of topics generated and novel creation of utterances

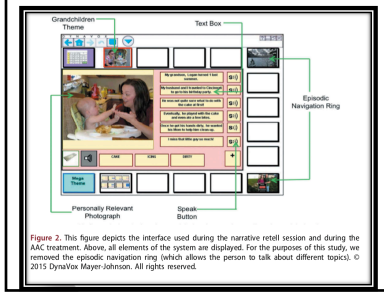

Figure 2. This figure depicts the interface used during the narrative retell session and during the AAC treatment. Above, all elements of the system are displayed. For the purposes of this study, we removed the episodic navigation ring (which allows the person to talk about different topics). © 2015 DynaVox Mayer-Johnson. All rights reserved.

PROS
- Builds on intact autobiographical memory
- Taps residual visuospatial functions
- Capitalizes on mobile technology

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VSDs: What do the Data Reveal?

- Presence of AAC alone does not create learned non-use.
  - *Learned non-use is indeed learned!*
  - *Instruction is critical*
- Personalization of AAC via VSDs
  - is overwhelming preferred by people with aphasia and communication partners
  - generates improved communicative success
  - facilitates improved spoken language
- VSDs promote quicker generalization and learned navigation of AAC

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Hybrid Displays

PROS

- Best of both worlds

CONS

- High levels of yntactic and semantic demands required
- High levels of working memory and attention required
- The picture/scene changes when touched

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Hybrid Displays: What do the data reveal?

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- What data?

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The Key Take Away Point: TIPz

Technology
Instruction
Personali***z***ation

Dr. Cathy Binger &
Dr. Jennifer Kent-Walsh

- Presence of AAC alone does not create learned non-use.
  - *Learned non-use is indeed learned!*
  - *Instruction is critical*

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- Spoken Language → ***Existing*** Performance Act
- AAC → ***Novel*** Performance Act
  – Use AAC to self-cue for target words?

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APHASIOLOGY, 2018
https://doi.org/10.1080/02687038.2018.1447641
Routledge Taylor & Francis Group

The feasibility of improving discourse in people with aphasia through AAC: clinical and functional MRI correlates

Aimee Dietz[a], Jennifer Vannest[b], Thomas Maloney[b], Mekibib Altaye[b], Scott Holland[b] and Jerzy P Szaflarski[c]

Purpose:

1. Examine the feasibility of providing high-tech AAC treatment to people with chronic aphasia with the goal of evoking changes in spoken language &
2. Identify evidence of AAC-induced changes in brain activation.

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Usual Care

1 hr/day, 3/week, for 4 weeks

- **Schuellian Approach**
  - Sentence completion tasks
  - Following directions
  - Listening to passages & answering questions
  - Confrontation naming
  - Category naming (verbal fluency)
  - Sentence completion
  - Picture description
  - Word repetition

Focus: "Impaired" Language System

(Coelho, Sinotte, Duffy, 2008)

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AAC Treatment

1 hr/day, 3/week, for 4 weeks

NOTE: AAC+ story was used during therapy

Step 1 Familiarization

Step 2 Segmented Story Elements

Step 3 Guided Practice

Step 4 Self-Analysis

Focus: "Multi-Modality"

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NEUROIMAGING PROCEDURES

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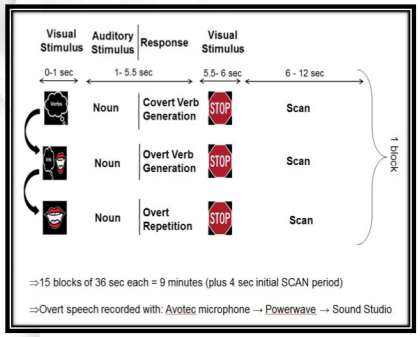
fMRI: Verb Task



Verb Generation Task
-Noun presented auditorily
-Respond:
a) Say Verbs
b) Think Verbs
c) Repeat Noun

- A ***sparse acquisition approach*** was used so that auditory stimuli could be presented and spoken responses recorded during periods of MRI scanner silence.

(Allendorfer, Lindsell, Siegel, Banks, Vannest , Holland, Szaflarski , 2012; Schmithorst & Holland, 2004)

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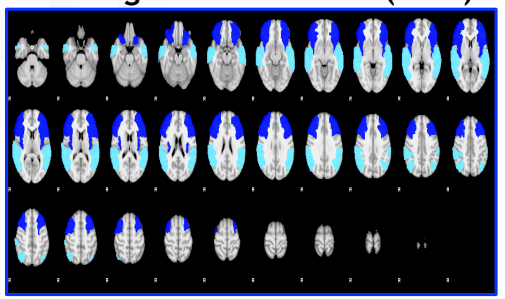
Canonical Language Regions of Interest (ROIs)



- **Frontal ROI:** inferior frontal gyrus, middle frontal gyrus, and anterior insula
- **Posterior ROI:** superior temporal gyrus, middle temporal gyrus, supramarginal gyrus and angular gyrus

Dietz et al., 2016; Szaflarski et al., 2006; Holland et al., 2001)

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fMRI Analyses

- **Lateralization Index (LI)**
  - Difference between active voxels in the left and right ROIs divided by the sum
  - Active voxels are those that are above the median value of positive voxels in both the left and right ROIs

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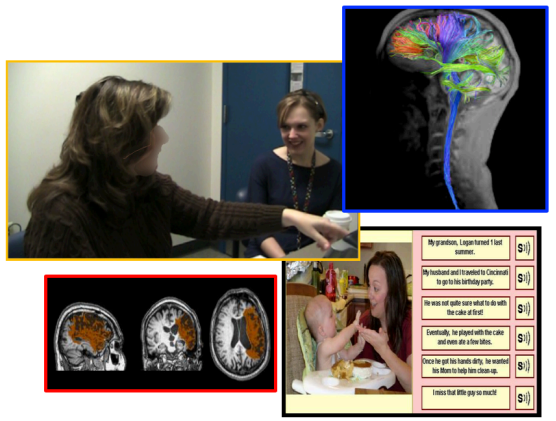

RESULTS

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COMMUNICATION

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AAC+ CHANGE: BETWEEN GROUP EFFECT

	AAC n = 6 M(*SD*)	Usual Care n = 6 M(*SD*)	Effect Size Cohen's *d*
Expressive Modality Units (EMUs)			
%Spoken EMUs	*-4.64(5.75)*	*2.24(10.9)*	-0.79
%Picture EMUs	5.16*(6.32)*	-0.36*(6.03)*	0.89
%Text Box EMUs	2.87*(9.27)*	3.29*(10.7)*	-0.04
%Speak Button EMUs	0.00*(0)*	0.00*(0)*	--
% Written EMUs	1.07*(5.38)*	0.24*(1.04)*	0.21
% Drawn EMUs	-0.13*(0.92)*	-0.21*(0.46)*	0.11
% Gestural EMUs	-2.25*(6.07)*	-3.67*(5.32)*	0.25

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AAC- CHANGE: BETWEEN GROUP EFFECT

	AAC n = 6 M(*SD*)	Usual Care n = 6 M(*SD*)	Effect Size Cohen's *d*
Expressive Modality Units (EMUs)			
%Spoken EMUs	1.83*(8.2)*	-0.87*(11.18)*	0.28
%Picture EMUs	NA	NA	NA
%Text Box EMUs	NA	NA	NA
%Speak Button EMUs	NA	NA	NA
% Written EMUs	-5.48*(5.81)*	2.77*(2.27)*	0.19
% Drawn EMUs	-1.00*(2.94)*	-0.69*(1.68)*	0.13
% Gestural EMUs	5.84*(9.80)*	-7.49*(8.99)*	1.14

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SPOKEN LANGUAGE

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AAC+ CHANGE BETWEEN GROUP EFFECT

	AAC n = 6	Usual Care n = 6	Effect Size[a]
			Cohen's d
Responders	6	2	--
	M(SD)	M(SD)	--
Spoken Language Measures			
% Counted Words	7.23(8.50)	1.58(4.60)	0.83
% CIUs	2.48(11.72)	-4.70(4.50)	0.78
% Mazed Words[c]	-.701(7.13)	1.09(4.04)	-0.31
% T-Units[d]	11.12(8.50)	0.71(10.50)	1.09

Note: [a]small effect = 0.2, medium effect = 0.5, large effect = 0.8; [b]Western Aphasia Battery-Revised Aphasia Quotient; [c]A decrease in % mazed words is a positive gain; [d]T-units (smallest grammatically correct utterance).

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AAC- CHANGE BETWEEN GROUP EFFECT

	AAC n = 6	Usual Care n = 6	Effect Size[a]
			Cohen's d
Responders	6	2	--
	M(SD)	M(SD)	--
Spoken Language Measures			
Spoken Discourse			
%Counted Words	−0.17(4.84)	−3.15(10.44)	0.37
%CIUs[c]	−1.44(8.70)	−2.32(5.34)	0.12
CIUS/Minute	0.92(2.91)	−2.92(6.40)	0.72
%Mazed Words[d]	0.68(2.11)	2.19(6.77)	−0.30
%Tunits[e]	8.18(7.97)	−0.03(12.92)	0.77

Note: [a]small effect = 0.2, medium effect = 0.5, large effect = 0.8; [b]Western Aphasia Battery-Revised Aphasia Quotient; [c]A decrease in % mazed words is a positive gain; [d]T-units (smallest grammatically correct utterance).

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Aphasia Severity

	Mean Change		
	AAC n = 6	Usual Care n = 6	Effect Size[a]
Measure	M(SD)	M(SD)	Cohen's *d*
WAB-R AQ[b]	3.20(5.75)	1.83(4.10)	0.27

Note: [a]small effect = 0.2, medium effect = 0.5, large effect = 0.8; [b]Western Aphasia Battery-Revised Aphasia Quotient

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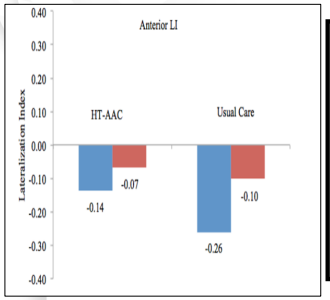
Changes in Language Lateralization



Language Lateralization Index (LI)

- LI values < -0.1 indicates right-lateralization
- LI > 0.1 indicate left-lateralization
- -0.1 < LI ≤ 0.1 represent bilateral, or symmetric language

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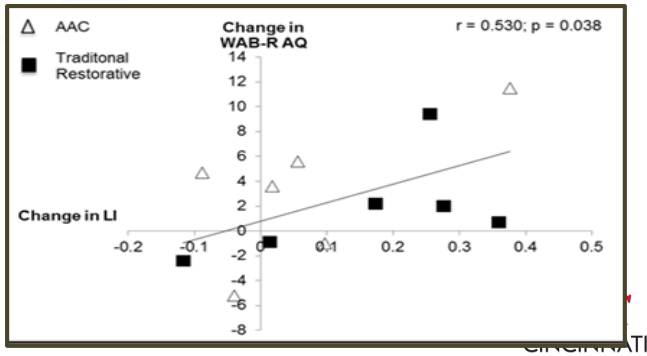
Correlation of LI with Behavioral WAB-R AQ



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AAC n = 5/6
TR n = 2/6

Responders: Behavioral

	AAC	Usual Care
WAB-R AQ	4	3
%CIUs	2	2
CIUs/Min	3	1
%Counted Words	5	2
%Mazed Words	3	2
TUnits	5	2
TOTAL	22	12

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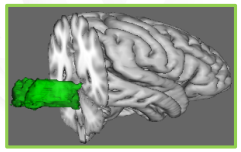
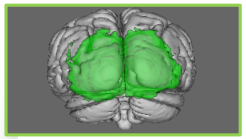
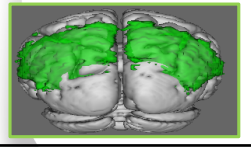
Change in Activation Intensity (z score)



Left = Visual Word Form Area (VWFA);
Right = Object Recognition



Left & Right: Primary Visual Processing



Left & Right: Secondary Visual Processing

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PCOR/CER Workshop February 2016

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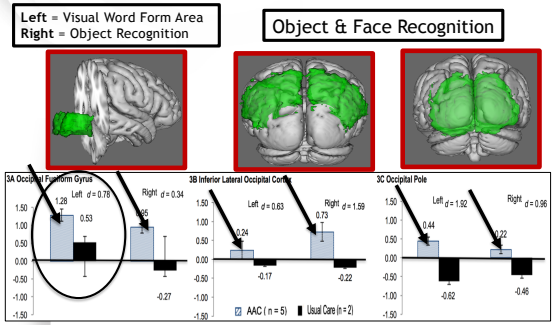
AAC n = 5/6
TR n = 2/6

Responders: Neuroimaging



- Likely alternative bilateral, ***extrasylvian*** mechanisms to help support language recovery
- Linking to canonical language regions of interest

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Clinical Implications

- Instruction is crucial
  - ***INTERSYSTEMIC REORGANIZATION!***
- A decrease in SEMUs does not necessarily correlate with decrease in language function
  - **Role of voice output?**
  - **Other communication purposes**
- AAC can be used as a dual-purpose tool that ***compensates for deficits*** and ***augments language recovery***

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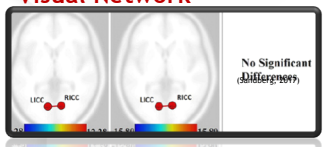
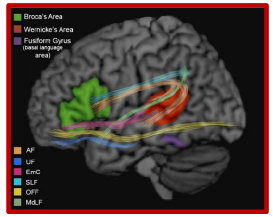
AAC-induced Language Recovery: A Unique Neurobiological Mechanism?

Language Network

Visual Network





(1) Ventral Visual Stream → (2) Anterior toward Inferior Temporal Lobe (semantics—left hemi) → (3) Tracts project to Inferior Frontal Gyrus (via inferior fronto-occipital fascicle-OFF)

Domain General Network

- **Multiple Demand Network**
  - Assists in effortful, non-linguistic tasks
    - "back-up" system in aphasia?

(Brownsette et al., 2014; Duncan,& Owen, 2000; Fedorenko, Duncan, & Kanwisher, 2013; Vallila-Rohter & Kiran, 2017; Vallila-Rohter, 2017)

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References

- A reference list will be included in a separate handout!

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