Short Course: Theory & Principles of AAC Interface Design for Aphasia

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Abstract

• Intermediate

• This short course will review current literature that supports the use of AAC during aphasia rehabilitation. Participants will gain an understanding of how interface design impacts successful AAC implementation for people with aphasia. Finally, theoretical underpinnings that support the use of AAC as a language recovery tool will be explained.

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• Statistical Support
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Learner Outcomes

• At the conclusion of the session, participants will be able to
  1. state the pros and cons of various interface designs when thinking of people with aphasia.
  2. cite recent evidence in the literature supporting the use of augmentative and alternative communication (AAC) in aphasia rehabilitation programs.
  3. explain theoretical the underpinnings that support the use of AAC as a language recovery tool.

Language Recovery & Communication Technology Lab

Aphasia: A Chronic Disease

• 250,000 new diagnoses each year
• Of the newly diagnosed, 50% experience incomplete recovery
  — Even after Usual Care
• AAC often used to compensate for language deficits
  — Especially with advent of iPad™ & proliferation of communication apps
• Not generally accepted practice to use as a language recovery tool
  — But...could it be??????
YES….LET ME TELL YOU **HOW**...

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)

- Early proponents of constraint-induced aphasia therapy (CIAT) posited that restoration of spoken language may be impeded by learned use (Pulvermuller et al., 2001)

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)

Theory of “learned non-use” in post-stroke language recovery...

How does this influence the way AAC should be implemented?

So....how do we help?

1. **Partner training!!**
   - Nina Simmons-Mackie
   - Aura Kagan

2. We have to rethink **how** we implement AAC for people with aphasia
   - Aimee Dietz
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.

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.

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.

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.”

Successful Facilitation of Neural Plasticity

• When neuronal networks are co-activated, the connections between them are strengthened
  • “Hebbian Learning”
  • Neurons that “fire together wire together” (Hebb, 1949)

• “…neurons that fire out of sync lose their link…” (Artola & Singer 1993; Hebb, 1949; Pulvermuller & Berthier, 2008)

• Recently, CIAT researchers have modified their view on how constraints should be applied during intervention
  – AAC techniques are appropriate if they are not used as a SUBSTITUTE for language.

AAC as a Language Recovery Tool: What does the Literature Say?

• Recent proliferation of studies in aphasiology that document how low-technology AAC techniques such as:
  – drawing
  – gesturing
  – multimodal approaches facilitate word retrieval
AAC as a Language Recovery Tool: What does the Literature Say? (2)

- Several small N studies suggest linguistic improvements following high-technology AAC interventions designed to promote non-verbal communication
  - Decreased aphasica severity (Hough, & Johnson, 2009; Johnson, Hough, King, Vos, & Jeffs, 2008)

Introduction to Interface Designs for People with Aphasia

...much more Saturday morning at 9am!!
Finding, Analyzing, & Using Communication Apps for People with Aphasia (Session 73 Room: 32-34)

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?

Traditional Grid/Home Page/ Semantic Design

Grid Displays

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easily generate novel messages</td>
<td>• Inventory each cell to</td>
</tr>
<tr>
<td>• ENDLESS message opportunities!</td>
<td>• Relies on heavily on</td>
</tr>
<tr>
<td></td>
<td>semantic &amp; syntactic knowledge</td>
</tr>
<tr>
<td></td>
<td>• Requires learning a ‘new’ language</td>
</tr>
<tr>
<td></td>
<td>• High levels of working memory &amp; attention</td>
</tr>
</tbody>
</table>

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

Visual Scenes Displays

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

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

VSDs: What do the data reveal?
2/21/2019

2014-Disability & Rehabilitation: Assistive Technology

Treatment: Backwards Chaining with vanishing cues

Bottom Line

• Both participants improved accuracy and efficiency of AAC navigation with both interfaces, following instruction
• Navigation ring layout seemed to be more transparent and facilitated generalization to home page layout
Purpose of Dietz et al. 2014

1. What available modalities did the people with aphasia use during the narrative retells?
2. What patterns of communication breakdowns and repairs emerged during the narrative retells?
3. What was the impact of non-personally relevant photographs on off-topic talk time and communication breakdowns during the retells?
4. What elements of the VSD interface did the participants perceive as helpful?
5. What elements of the interface did the communication partner perceive as helpful?

Procedures

Case-Series Design
1. Story Co-construction: 8 stories from life events
2. 4 experimental & 4 familiarization programmed into Dynavox Vmax
3. Familiarization: Researchers provided a preview of the VSO formats. They also informed them that some pictures would be PR and other NPR and that text would be present at some times and not others (showing examples of each)
4. Narrative Retell: The participants retold their narratives to a naïve communication partner, who journaled her impressions after each session.
5. Debriefing: The people with aphasia rated using a Likert Scale (1= strongly disagree and 5= strongly agree) their perceived helpfulness of photographs and text after each retell.

Analyses

• The retells were transcribed for all modalities and analyzed for several communication measures:
  • Expressive Modality Units
    • spoken, written, drawn, photograph, text box, & speak button
  • Trouble Sources
    • % Repaired Trouble Sources, % Trouble Sources Caused by NPR Talk, & % Time on Off-Topic NPR Commentary
  • Spoken Discourse
    • Counted words, correct information units, mazes, & t-units

AAC Strategy Codes: Expressive Modality Units

Spoken Expressive Modality Unit (SEMU): A thought combined under a single, coherent intonation contour.
Written Expressive Modality Unit (WEMU): Written and/or reference to written text.
Drawn Expressive Modality Unit (DEMU): Drawn and/or reference to drawing.
Text Box Expressive Modality Unit (TBEMU): Reference to word(s) located in a text box.
Picture Expressive Modality Unit (PEMU): Reference to a picture, part of a picture.
Speak Button Expressive Modality Unit (SBEMU): Activation of a speak button.
AAC Strategy Codes: Trouble Sources

Trouble Source (TS)
- Repaired Trouble Source
- Abandon

A lack of information provided impedes the transition or flow of the interaction

Trajectory
- Partners move on to new topic

Average # EMUs to repair the TS

RESULTS

Expressive Modality Units

- ~ 70% Spoken Expressive Modality Units (EMUs)
- Varied patterns for other EMUs:
  - Written
  - Drawn
  - Gestural
  - Text box
  - Speak button

Summary of Communicative Behaviors

Expressive Modalities Used

Narrative Retell Duration, Off-Topic Talk time, & Trouble Sources Due to Off-Topic Talk

Breakdown: Trouble Sources & Repair Trajectory

- Relatively low across all stories
- Trend for more trouble sources in NPR conditions
Perceived Helpfulness of Pictures and Text Boxes

Communication Partner Journal

• The presence of text emerged as a critical element in her perceived understanding of the accuracy of the narrative retells:
  
  “...sometimes I understood everything the participants said, but when there were no text boxes, I wasn’t sure if what they were saying was actually the story or not.”

• She clarified later in her writing that she:
  
  “...I may have misunderstood what they meant since [she] didn’t see what was written [when text was not present].”

• She also perceived the presence of the personally relevant photographs as critical during the retells:
  
  “…the story more like a conversation, [and] I got to see actual artifacts/personal items. In reference to the personally relevant photographs, she commented that, “…they used the pictures to help explain the story.”

Purpose of Griffith, Dietz, et al., 2014

The purpose of this investigation was to describe the:

(a) expressive modalities used,
(b) trouble sources experienced,
(c) patterns in repair of trouble sources,
(d) perceived helpfulness of visual and linguistic supports, and
(e) perceived helpfulness of the high-tech AAC VSD device when four people with aphasia retold personal narratives using four variants of a high-technology AAC VSD interface.

Summary of Spoken Language

(in preparation)

<table>
<thead>
<tr>
<th>Task 1</th>
<th>Total Mean Scores</th>
<th>Task 2</th>
<th>Total Mean Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Measure 1</td>
<td>Measure 2</td>
<td>Measure 3</td>
</tr>
<tr>
<td>Mean</td>
<td>5.74</td>
<td>5.00</td>
<td>6.00</td>
</tr>
<tr>
<td>95% CI</td>
<td>5.88 to 5.74</td>
<td>4.80 to 5.20</td>
<td>6.10 to 5.90</td>
</tr>
<tr>
<td>% valid</td>
<td>96.00</td>
<td>95.00</td>
<td>96.00</td>
</tr>
<tr>
<td>NA</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>NA</td>
<td>0.00</td>
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<tr>
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</tr>
</tbody>
</table>

Overall performance on measures of discourse improved in the PR conditions—either with or without text.

For Anne & Randy they fared better in the NPR with text.

Randy’s performance explained by:
- Aphasia type?
- Story content?

Participants
Procedures & Analyses

• Same as “textbox,” with different Line Drawings instead of NPR Photographs

<table>
<thead>
<tr>
<th>Participant</th>
<th>PR + TB</th>
<th>PR/NO TB</th>
<th>LD + TB</th>
<th>LD/NO TB</th>
<th>Overall rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellen</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Jack</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Sarah</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Perceived Helpfulness of Pictures and Text Boxes

<table>
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<tr>
<th>The pictures helped me tell the story?</th>
<th>The words helped would have helped me tell the story?</th>
<th>How helpful was the computer (AAS device)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant: PR + TB</td>
<td>PR/NO TB</td>
<td>LD + TB</td>
</tr>
<tr>
<td>Ellen</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Jack</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Sarah</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Researcher: Was it better this time?
Jack: Yeah, better more places and names.
Researcher: What if there were words here [pointing to the PR NO TB interface]? Would that have helped you?
Jack: Yeah :03 sec but pictures.
Researcher: More pictures would have been ideal?
Jack: Yes, helpful.

Perceived Helpfulness of Pictures and Text Boxes

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<td>5</td>
</tr>
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Researcher: Were the written words helpful?
Sarah: Words yes um :03 sec talking no.
Researcher: So it helped when the words wouldn’t come out that you could point here [pointing to the text boxes on the LD + TB interface]?
Sarah: Yeah [pointing to the text boxes].
• Researcher: So the pictures help? [gesturing to the displayed LD NO TB condition]
• Claire: Yeah, yes but :02 sec. [shaking head no while pointing to the LD pictures]
• Researcher: But you would prefer your own?
• Claire: Yes.

VSDs for People with Aphasia: The Story So Far
• 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

The Key Take Away Point: TIPz

- Technology
- Instruction
- Personalization

Dr. Cathy Binger & Dr. Jennifer Kent-Walsh

Hybrid Displays

PROS
• Best of both worlds

CONS
• High levels of syntactic and semantic demands required
• High levels of working memory and attention required
• The picture/scene changes when touched
Hybrid Displays:
What do the data reveal?

- What data?
- TBD.....
- THINK: TIPz
  - Technology
  - Instruction
  - Personalization

Google Image Search:
AAC Aphasia Stroke

We can do better!

Google Image Search:
Stroke Wheelchair

So NOW let me tell you how...

- To avoid using AAC only to **compensate** for language deficits
- And how to harness the principles of neural plasticity and intersystemic reorganization to use as a **language recovery tool**
Examine the Use of AAC as a Language Recovery Tool

Summary of a Pilot Study

Purpose

- To generate pilot data comparing the effect of a novel AAC treatment to traditional restorative intervention on the:
  1. restoration of personal narrative language skills in people with aphasia
  2. reorganization of the neural networks via functional magnetic resonance imaging (fMRI)

Design

- Pre-Post Treatment Design with Control Group
  - Novel AAC Treatment (AAC) (N = 6)
  - Traditional Restorative Treatment (N = 6)

Groups matched by aphasia type
- Fluent vs. Nonfluent
**Study Tasks and Sequence**

- **fMRI Verb Generation Test**
- **Western Aphasia Battery-Revised** (Kertesz, 2006)
- **Discourse Testing**
  - Retold two personal narratives to a listener.
  - Randomly assigned to retell
    - with AAC (AAC+), or
    - without AAC (AAC-)
- For the AAC Treatment Group
  - The AAC+ story was used during therapy.

**Usual Care**

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

**Usual Care 1 hr/day, 3/week, for 4 weeks**

**Focus:** Impaired Language System

**AAC Treatment**

- **Familiarization**
  - Step 1: Overview & Familiarization
  - Step 2: Guided Practice
  - Step 3: Segmented Story Elements
  - Step 4: Self-Analysis

**Focus:** Multi-Modality

**Step 1: Overview & Familiarization**

- The clinician demonstrates how to navigate the AAC to the desired page set and labels the various elements: pictures, text boxes, and speak buttons.
- The person with aphasia labels each of these interface elements and is prompted to explore the device and clarify questions.
**Step 2: Segmented Story Elements**

- Each text box is a story element.
- Clinician models how the photographs and words within textboxes, and speak buttons to self-cue during “anomic events”.

**Step 3: Guided Practice**

- Clinician models how to retell the entire story using the AAC interface by inserting “anomic events” and using the various elements to self-cue.
- Person with aphasia instructed to retell the story as if the clinician did not know the story using the self-cueing strategy to attempt word retrieval during anomic events.

**Step 4: Self-Analysis Part 1**

- Person with aphasia retells story to a familiar person
- Recorded for feedback
- Clinician takes notes of successful self-cueing and missed opportunities

**Step 4: Self-Analysis Part 2**

- Clinician plays video
  - highlights successful self-cueing and missed opportunities
- Person with aphasia replays video
  - Identifies what attempts at self-cueing and missed opportunities
  - Clinician provides feedback on whether she agrees and why.
NEUROIMAGING PROCEDURES

Lesion Overlap in People with Aphasia

- The participants exhibited regions of overlap in their lesions
- Lesion volume and location varied

fMRI: Verb Task

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

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

fMRI Analyses

- Lateralization Index (LI)
  \[ \text{LI} = \frac{\text{active voxels in the left ROI} - \text{active voxels in the right ROI}}{\text{active voxels in the left ROI} + \text{active voxels in the right ROI}} \]
  - Active voxels are those that are above the median value of positive voxels in both the left and right ROIs

RESULTS
Discourse Testing & Transcription Coding

USE OF AAC STRATEGIES

USE OF SPEAKEN LANGUAGE

Changes in Language Lateralization

Language Lateralization Index (LI)
- LI values ≤ -0.1 indicate right-lateralization
- LI values ≥ 0.1 indicate left-lateralization
- -0.1 < LI ≤ 0.1 represent bilateral, or symmetric language
### Correlation of LI with Behavioral WAB-R AQ

![Graph showing correlation between LI and WAB-R AQ](image)

#### SECONDARY ANALYSES

- **Responders**
  
<table>
<thead>
<tr>
<th></th>
<th>AAC</th>
<th>TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAB-R AQ</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>%CIUs</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CIUs/Min</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>%Counted Words</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>%Mazed Words</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>TUnits</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>22</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

- **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

- **AAC-induced Language Recovery: A Unique Neurobiological Mechanism?**

  **Left** = Visual Word Form Area
  **Right** = Object Recognition

  **Object & Face Recognition**

- **Summary (1)**

  - **Behavioral Performance**
    - The AAC group demonstrated greater gains on:
      - Aphasia severity and
      - 5 discourse measures (AAC+)
    - Different patterns emerged for people with fluent and nonfluent aphasia
Summary (2)

- **Neuroimaging Performance**
  - Pre-treatment, LIs were right lateralized.
  - Post-treatment, LIs moving leftward (but bilateral)
  - Anterior LI correlates with Aphasia Severity

Summary (3)

- **Non-Language ROIs (AAC Group only*)**
  - Compared to the Traditional Restoration group, the AAC demonstrated a trend for increased activation (Z scores), bilaterally:
    - Fusiform Gyrus
    - Occipital Poles
    - Inferior Lateral Occipital Gyrus

Clinical Implications (1)

- While not conclusive, this data suggests that we can induce cortical plasticity and improved spoken language performance in people with chronic aphasia following AAC intervention.
- AAC may be implemented earlier in rehab (i.e., 3-12 months post-stroke), in parallel to traditional restorative interventions to boost outcomes and provide a method to communicate when language fails.

Clinical Implications (2)

- 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

Visual Processing Systems

- **Dorsal Visual Stream:** *Where?*
- **Ventral Visual Stream:** *What?*

(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)

Neurobiology of Language: Classic versus Modern Models

- Immediately post-stroke, language function shifts to right homologues
- Those with better recovery shift back to left perisylvian language regions (Broca’s/Wernicke’s)
  - May not be possible for those with large lesions
  - Likely alternative bilateral, extrasylvian mechanisms to help support language recovery
  - Linking to canonical language regions of interest

(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)
Future Directions

• Researchers have begun to delineate the neural mechanisms supporting recovery of naming and syntactic processing
  – Establish functional and structural neurobiological markers of AAC-induced language recovery in people with aphasia has not been established
• What is the role of the ventral visual processing stream in stimulating language recovery for people with aphasia?
  – Exploit this in AAC by applying principles of intersystemic reorganization

• Importance of Broca’s and Wernicke’s areas cannot be dismissed
• Neither can the mounting functional and structural connectivity evidence that links canonical language ROIs to distal ROIs
  • Link between extrastriate cortex (ventral visual stream) may be tapped to support language
  • Responsible for recognizing and discriminating faces, objects and text (as on AAC interfaces)

Discussion

• We need to understand the role of the lesion size/location in neural reorganization.
  – all aphasia studies!!!!
• Does aphasia type (or severity) predict language recovery following AAC treatment?
  – all aphasia studies!!!!
• What is the role of the occipital regions in language recovery for people with aphasia
• What changes does this intervention evoke in white matter pathways via Diffusion Tensor Imaging (DTI)?
Learner Outcomes

At the conclusion of the session, participants will be able to
1. state the pros and cons of various interface designs when thinking of people with aphasia.
2. cite recent evidence in the literature supporting the use of augmentative and alternative communication (AAC) in aphasia rehabilitation programs.
3. explain theoretical underpinnings that support the use of AAC as a language recovery tool.

QUESTIONS?

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Selected References


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