Multimodal Sensory Stimulation Treatment for an Individual with Chronic & Severe TBI

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Introduction: Sensory Stimulation

- Sensory stimulation is a common intervention method for patients in coma following traumatic brain injury (TBI).
- Sensory stimulation activates the limbic system to help generate goal-directed behaviors $^1, ^2$.
- Emotion-provoking stimuli enhance amygdaloid activity to facilitate limbic system activation $^3, ^4$.
- Benefits from sensory stimulation are boosted if it is delivered by persons familiar to the comatose patient $^5$. 
Multimodal Sensory Stimulation

- Sensory stimulation can be provided through different modalities:
  
<table>
<thead>
<tr>
<th>Auditory</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactile</td>
<td>Olfactory</td>
</tr>
<tr>
<td>Gustatory</td>
<td>Kinesthetic</td>
</tr>
<tr>
<td>Vestibular</td>
<td>Proprioceptive</td>
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</tbody>
</table>

- Simultaneous use of two or more modalities are typically referred to as *multimodal stimulation*.

- Combined use of the following modalities have been the most efficacious ⁶, ⁷:
  
  - Tactile + auditory stimulation
  - Visual + proprioceptive stimulation
Research Need

• Literature supporting sensory stimulation is restricted to individuals recovering from acute TBI\textsuperscript{6, 8, 9, 10, 11}.
• Approximately 14\% of TBI patients remain in persisting vegetative state long after discharge from acute rehabilitation\textsuperscript{7}.
• There is no evidence on the delivery of sensory stimulation to chronic individuals with TBI.
• Systematic presentation of multimodal stimulation by persons familiar to the comatose individual remains unexamined.
Research Purpose & Design

• Influence of the following variables was determined:
  – Controlled combinations of sensory stimuli
  – Emotional ties to stimuli
  – Stimulation delivery by familiar personnel
• A longitudinal, single-subject (ABA) design was used:
  – Pre- and post-intervention assessment (A) phases
  – Intervening delivery of multimodal stimulation (B) phase
Subject Description

A 23 year old Caucasian male with severe TBI from a fall served as the subject.

The onset of TBI was at age 17, five years prior to the study.

Subject was a senior in high school at that time.

Subject remains in vegetative state since the TBI.

Subject currently resides in a nursing home.

Subject’s father (legal guardian) completed the institutionally approved Informed Consent Form.
Assessment Tools

• Three assessment protocols were used:
  – Glasgow Coma Scale (GCS)\textsuperscript{12}
  – Ranchos Los Amigos (RLA) severity rating scale\textsuperscript{13, 14}
  – Western Neurosensory Sensory Stimulation Protocol (WNSSP)\textsuperscript{15}

• Each of these procedures was completed at two intervals:
  – Prior to delivery of multimodal stimulation
  – One week following intervention.
Intervention Stimuli

• Five modality pairs were used for stimulation:
  – Auditory + tactile
  – Auditory + thermal
  – Auditory + visual
  – Auditory + olfactory
  – Auditory + gustatory

• Two sets of stimuli (familiar/pleasurable + unfamiliar/aversive) were selected for each modality pair, resulting in 10 total sets.

• Each stimulus pair was presented for at least 5 seconds.

• Each modality pair was presented in a consistent order.

• Two trials of each modality pair were presented in each session (refer to Table).
<table>
<thead>
<tr>
<th>Modality Pair</th>
<th>Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory-tactile stimulation</td>
<td>Light touch</td>
</tr>
<tr>
<td></td>
<td>Deep pressure</td>
</tr>
<tr>
<td>Auditory-thermal stimulation</td>
<td>Cold washcloth</td>
</tr>
<tr>
<td></td>
<td>Warm washcloth</td>
</tr>
<tr>
<td>Auditory-visual stimulation</td>
<td>Familiar pictures (scrap-/yearbook/photos)</td>
</tr>
<tr>
<td></td>
<td>Unfamiliar pictures (magazine / television)</td>
</tr>
<tr>
<td>Auditory-olfactory stimulation</td>
<td>Pleasant odor (cologne / lemon juice)</td>
</tr>
<tr>
<td></td>
<td>Unpleasant odor (vinegar/rubbing alcohol)</td>
</tr>
<tr>
<td>Auditory-gustatory stimulation</td>
<td>Positive taste (soda/ apple juice)</td>
</tr>
<tr>
<td></td>
<td>Negative taste (lemon juice)</td>
</tr>
</tbody>
</table>
Intervention Implementers

- 7 young adults ($M$ age 22.3), 4 females & 3 males
- They were classmates & friends.
- None had any training in speech-language pathology.
- They had a high school education & were employed.
- They received verbal & written instructions regarding:
  - Arranging equipment and positioning themselves
  - 5 modality pairs & their presentation
  - Delivery of each stimulus set
  - Observing and coding elicited responses.
Intervention Procedures

• Each session was videotaped and conducted in the subject’s room.

• The stimulation regime was provided daily, 7 days per week across 4 consecutive weeks (28 sessions).

• Each implementer delivered a session per week (4 sessions per implementer).

• Behaviors resulting from the delivered stimulus were coded for 4 possible vocal and/or 6 motor responses.

• Duration of each session was approximately 30 minutes.
Results: Assessment Performance

- No significant difference was found between pre- and post-intervention for the 3 protocols ($t -1.00; df 2; p.42$).
- GCS and RLA scores remained unchanged.
- WNSSP score showed improvement by 3 points.
  This protocol was more sensitive in detecting changes.
Results: Observed Responses

- Motor responses occurred in the following order:
  - Labial movements ($M = 13.68$)
  - Limb movements ($M = 11.75$)
  - Increased facial tension ($M = 8.50$)
  - Head turn/roll ($M = 7.29$)
  - Trunk movement ($M = 1.32$)
  - Eye opening ($M = .14$)
- Vocal responses increased by 4th week, and showed a hierarchy:
  - Deep breaths/sighs ($M = 4.57$)
  - Grunts/moans ($M = .93$)
  - Words or phrases never occurred.
Results: Vocal vs. Motor Responses

- Motor responses ($M=42.86; SD=11.42$) occurred more often than vocal responses ($M=5.54; SD=4.87$). This difference was statistically significant ($t=19.04, \ df27, \ p=.00$).
- Both types of responses increased from first to final (4th) week.
Results: Sensory Modalities

• Overall high and significant correlation was found between auditory-thermal and auditory-gustatory stimulations ($RHO = .79; p \leq .05$).

• Analysis of each stimulus type identified 20 (44%) moderate, yet statistically significant, correlations.

• The majority of these correlations were for the following stimuli:
  – Thermal (cold, warm)
  – Tactile (light touch, deep pressure)
  – Olfactory (pleasant, unpleasant odor)
Results: Stimuli Effect

- Gustatory: **positive taste** was more effective.
- Thermal: **cold sensation** was more effective.
- Tactile: **deep pressure** was more effective.
- Olfactory: **unpleasant odor** was more effective.
- Visual: **familiar picture** was more effective.
Results: Implementers

• Seventeen (89%) significant correlations were found between implementers in their scoring of observed responses ($RHO > .71, p \leq .05$).

• Five of the implementers maintained strong agreement in their coding of observed responses.
Conclusions

• Individuals with chronic and severe TBI can benefit from select forms of multimodal stimulation.

• Stimulation via primitive sensory modalities (regulating homeostasis and survival) was the most effective because these modalities may be relatively preserved in severe TBI; these sensory signals bypass the thalamus to directly activate the hippocampus and limbic system.

• Responses are facilitated by select types of stimuli that tend to be relatively intense or potent, and rouse an emotion.
Conclusions (contd)

• Motor responses are readily elicited to delivered stimulation.

• Familiar, yet diverse, individuals can be effectively trained to deliver multimodal stimulation. Their involvement may facilitate cognitive rehabilitation in severe TBI and be cost effective as well.

• Rigidity in the stimulation delivery protocol may have a potential drawback by not accommodating for implementers’ interaction styles.

• Single ½ hour sessions each day may be insufficient to effect significant improvement across four-week intervention.
References