Music Therapy in the Assessment and Rehabilitation of Prolonged Disorders of Consciousness: Lessons from Research

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Royal Hospital for Neuro-disability
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### Prolonged DOC (4 weeks+)

(Royal College Physicians Guidelines, 2013)

<table>
<thead>
<tr>
<th>Table 1.2. Definitions of disorders of consciousness.</th>
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</thead>
<tbody>
<tr>
<td><strong>Coma</strong> (Absent wakefulness and absent awareness)</td>
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<tr>
<td>A state of unrousable unresponsiveness, lasting more than 6 hours in which a person:</td>
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<tr>
<td>• cannot be awakened</td>
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<tr>
<td>• fails to respond normally to painful stimuli, light or sound</td>
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<tr>
<td>• lacks a normal sleep–wake cycle, and</td>
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<tr>
<td>• does not initiate voluntary actions.</td>
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<td><strong>Vegetative state (VS)</strong> (Wakefulness with absent awareness)</td>
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<tr>
<td>A state of wakefulness without awareness in which there is preserved capacity for spontaneous or stimulus-induced arousal, evidenced by sleep–wake cycles and a range of reflexive and spontaneous behaviours.</td>
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<td>VS is characterised by complete absence of behavioural evidence for self- or environmental awareness.</td>
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<tr>
<td><strong>Minimally conscious state (MCS)</strong> (Wakefulness with minimal awareness)</td>
</tr>
<tr>
<td>A state of severely altered consciousness in which minimal but clearly discernible behavioural evidence of self- or environmental awareness is demonstrated.³</td>
</tr>
<tr>
<td>MCS is characterised by <em>inconsistent, but reproducible</em>, responses above the level of spontaneous or reflexive behaviour, which indicate some degree of interaction with their surroundings.</td>
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</tbody>
</table>

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41% (of n 103) rate of misdiagnosis in specialist units unchanged for 15 yrs (Schnakers et.al 2009)

Functional Locked in Syndrome (Owen et. Al 2006,Bruno et. al 2011)

35% sensory cortex & higher-order associative areas / 5% high level language processing (Celisia 2013)

PET study: in 13/41 ‘VS’, 13 found to have MCS levels of activation. 9 regained consciousness within year (Stender et. al 2014)
### Electroencephalogram (EEG)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description and Function</th>
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<tbody>
<tr>
<td><strong>Beta (β)</strong> 13-30 Hz</td>
<td>alert, thinking &amp; acting consciously, anxious. Cortically generated, associated with motor activity, attention and higher cortical functioning &amp; local processing.</td>
</tr>
<tr>
<td><strong>Alpha (α)</strong> 8-13 Hz</td>
<td>relaxed, reflective, inhibitory control, creative visualisation. Important for Widespread long-range cortical functioning; level related to cortical activation, consciousness. Associated with specific perceptual, attention &amp; memory functions.</td>
</tr>
<tr>
<td><strong>Theta(θ)</strong> 4-8 Hz</td>
<td>If widespread: deep relaxation, meditation, drowsiness. Fontal midline theta (FMT) associated with hippocampal and anterior cingulate cortex regions emotion, concentration, and memory processes, -ve correlation with anxiety. [Mitchell et al., 2008; Aftanas &amp; Golocheikine, 2001; Caplan et al., 2003; Ekstrom et al., 2005; Fachner et al., 2013; Sammler et al., 2007].</td>
</tr>
<tr>
<td><strong>Delta</strong> 0-4 Hz</td>
<td>Slow waves recorded in EEG. Mostly associated with sleep and anaesthesia phenomena.</td>
</tr>
</tbody>
</table>

Slow waves recorded in EEG
- Mostly associated with sleep and anaesthesia phenomena

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Neurophysiological and behavioral responses to music therapy in vegetative and minimally conscious states

Julian O'Kelly1,2, L. James1, R. Palaniappan3, J. Taborin4, J. Fachner5 and W. L. Magee6

Assessment of awareness for those with disorders of consciousness is a challenging undertaking, due to the
Healthy frontal and temporal EEG responses to stimuli
(Error bars: 95% CI)

*Post Hoc F Statistics from 1-way repeated measures ANOVA’s where sig ≤ 0.05

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Liked Music has a similar effect of increasing cortical activity for MCS patients as controls albeit with less power.
Music Therapy Rehabilitation with Disorders of Consciousness: A Neurophysiological and Behavioural Study

- Using behavioural, EEG and ANS measures to explore potential of music therapy to support the rehabilitation process for PDOC patients and provide prognostic indicators
Music Therapy Rehabilitation with PDOC: Neurophysiological and Behavioural Study

Timeline: Day one

Auditory Brain Stem Test

(intact response only)

Assessment (A) 1 Neurophysiological tests + CRS-R SMART- Tr

Preferred text

Music Therapy

Two Weeks

Three Weeks Washout

Two Weeks

3 Months

6 Months

A2

A3

A4

A5

A6

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# Measures

<table>
<thead>
<tr>
<th>Neurophysiological</th>
<th>Behavioural</th>
</tr>
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<tbody>
<tr>
<td>• EEG</td>
<td>• Coma Recovery Scale- Revised</td>
</tr>
<tr>
<td>• Respiration</td>
<td>• Blink Rate</td>
</tr>
<tr>
<td>• Heart Rate</td>
<td>• Arousal Level</td>
</tr>
<tr>
<td>• O2 saturation</td>
<td>• Smart Tracker</td>
</tr>
</tbody>
</table>
Assessed for eligibility (n = 36)

Excluded (n = 25)
- Not meeting inclusion criteria (n = 11)
- No initial assessment (n = 5)
- Declined to participate (n = 3)
- Early discharge (n = 2)
- No response (n = 4)

Healthy participants (n = 10)

Randomized (n = 11)

MCS (n = 4)
- Allocated intervention 1 n = 2
- Allocated intervention 1 n = 2

VS (n = 5)
- Allocated intervention 1 n = 3
- Allocated intervention 2 n = 2

Borderline (n = 2)
- Allocated intervention 1 n = 1
- Allocated intervention 2 n = 1

Healthy participants (n = 10)

MCS (n = 4)
- Ax1- Ax6 n = 3
- Ax1- Ax4 n = 1

VS (n = 5)
- Ax1- Ax6 n = 3
- Ax1- Ax4 n = 2

Borderline (n = 2)
- Ax1- Ax5 n = 1
- Ax1- Ax4 n = 1

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VS Delta

VS Baseline Changes: Delta

VS Frontal Delta Conditions Compared

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MCS Theta

Global Theta Baseline Changes

MCS Frontal Midline Theta Conditions Compared

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VS Theta

**Global Theta Baseline Changes**

**VS Pooled Frontal Midline Theta**

- BSL
- LM
- TXT

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MCS/VS Respiration

MCS/VS Rep Rate Compared

VS/MCS Compared  Resp Variance (SDNN)

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Coma Recovery Scale Scores

VS CRS

MCS CRS

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Blink Rate: MCS & VS Compared

<table>
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<tr>
<th></th>
<th>MCS</th>
<th>VS</th>
</tr>
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<tbody>
<tr>
<td>Sig</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Value</td>
<td></td>
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</tbody>
</table>

- a basic arousal response where blink rate increases (VS Music), OR
- decreased spontaneous blink rate characterizes the early stages of conscious recovery (MCS overall & in favour of Text? Or more relaxed MCS for Music?). (Bonfiglio et al. 2005)
Behavioural Data: MCS

During Music

Mean 3.14 SD 0.88

During Text Narration

Mean 2.9 SD 0.94

Wilcoxon Signed Rank Test:
Music Arousal Level Significantly higher (z:-10 sig (2 tailed: < 0.001 })
Behavioural Data: VS

During Music
Mean 3.15 SD. 0.94

During Text Narration
Mean  SD. 3.31 SD 0.8

Wilcoxon Signed Rank Test:
Text Arousal Level Significantly higher
(z:-6.76 sig (2 tailed: < 0.001 )
Case Study MCS

- Male patient, late 20s
- Traumatic brain injury following road traffic accident
- Admitted 3 months post injury
- Entered study approx. 4mths post injury

SMART - MCS
MATADOC – borderline VS/ MCS
CRS-R – initial score 5 (indicative of MCS due to high score in visual scale)
Correlation over time:
Music / Time $r=0.621$ sig 0.021 2 tailed
Text/time $r=-0.25$ non sig
Normalised EEG Power Changes after MT Treatment Block

<table>
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<tr>
<th>Baseline Silence</th>
<th>Preferred Text</th>
<th>Preferred Music</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td><img src="image1" alt="Theta Baseline" /></td>
<td><img src="image2" alt="Theta Preferred Text" /></td>
</tr>
<tr>
<td><strong>Alpha 8-10.5 Hz</strong></td>
<td><img src="image4" alt="Alpha 8-10.5 Hz Baseline" /></td>
<td><img src="image5" alt="Alpha 8-10.5 Hz Preferred Text" /></td>
</tr>
<tr>
<td><strong>Alpha 10.5 – 13 Hz</strong></td>
<td><img src="image7" alt="Alpha 10.5 – 13 Hz Baseline" /></td>
<td><img src="image8" alt="Alpha 10.5 – 13 Hz Preferred Text" /></td>
</tr>
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</table>
Case study: Coma Recovery Scale Scores

- Most Responsive Domain – Visual Scale
- Highest Score After Music Therapy Treatment (9) – Due to Higher Score in Motor Function Scale
Conclusions & Implications

• Preliminary findings support hypothesis that Music Therapy has advantages as a non verbal, salient stimuli capable of optimising arousal to support the rehabilitation process

• More data needed to support hypothesis of a link between music therapy < neuroplasticity correlating with clinical improvements
This presentation is a combined effort of Julian O’Kelly, PhD and S Rappich


