Evidence-based Practice in Rehabilitation – Theory, Mechanism and Intervention

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Points of Interest

• Evidence-based Practices

• Knowledge Validation versus Acquisition

• The “Bat-ears” Study – Cross-Modal Learning

• The Chinese Calligraphy Study – Attention and Working Memory Process

• Relevance of Social Neuroscience to Rehabilitation
Policy Statement on Evidence-Based Practice in Psychology

EBPP is the integration of the best available research with clinical expertise in the context of patient characteristics, culture, and preferences. ..

Generally, evidence … should be based on systematic reviews, reasonable effect sizes, statistical and clinical significance, and a body of supporting evidence.

The validity of conclusions from research on interventions is based on a general progression from clinical observation through systematic reviews of randomized clinical trials, while also recognizing gaps and limitations in the existing literature and its applicability to the specific case at hand (APA, 2002).

Evidence-Based Practice in Rehabilitation

(Dijkers et al., 2012)
Motivational Enhancement Therapy in Addition to Physical Therapy Improves Motivational Factors and Treatment Outcomes in People With Low Back Pain: A Randomized Controlled Trial

Sinfla K. Vong, MPhil, Gladys L. Cheing, PhD, Fong Chan, PhD, Eric M. So, MSc, Chetwyn C. Chan, PhD

Purpose:
To examine whether the addition of motivational enhancement treatment (MET) to conventional physical therapy (PT) produces better outcomes than PT alone in people with chronic low back pain (LBP).

Results:
The addition of MET to PT treatment can effectively enhance motivation and exercise compliance and show better improvement in physical function in patients with chronic LBP compared with PT alone.

Conclusion: The mental imagery intervention was useful for improving patients’ ability on performing the tasks which they did not previously train on and in places different from the training environments. These involves generalization of the skills learned at the task performance level.

(Liu, Chan et al. Stroke 2009)
Visual Neglect

Effects of Sensory Cueing on Voluntary Arm Use for Patients With Chronic Stroke: A Preliminary Study

Kenneth N. Fong, PhD, OTR, Pinky C. Lo, BSc, Yoyo S. Yu, BSc, Connie K. Cheuk, BSc, Toto H. Tsang, BSc, Ash S. Po, BSc, Chetwyn C. Chan, PhD

Prototype Cueing Wrist Watch

Conclusion: A combination of sensory cueing and movement-based strategies is useful and feasible in improving paretic upper-extremity performance in participants with chronic stroke; however, additional studies with a larger sample size and longer treatment period in a randomized controlled trial would be beneficial.

(Fong et al., 2010)
Our Research Agenda

The Research Enterprise

- Basic Research
- Applied Research
- Clinical Investigations and Trials
- Demonstration and Education Research
- Knowledge Acquisition
- Knowledge Validation
- Knowledge Transfer
- Knowledge Dissemination

http://nihroadmap.nih.gov/clinicalresearch/presentations.asp
Model

Draft Framework for Translational Research

- **MU**
  - Mechanistic Understanding:
    - Biomarker ID
    - Susceptibility Pathways

- **PV**
  - Phenotypic Validation:
    - Whole organism
    - Phenotypic anchoring
    - Biomarker Correlation

- **ET**
  - Emerging Technology:
    - Engineering Database Research Resources

- **CA**
  - Clinical Assessment:
    - Whole organism
    - Phenotypic anchoring
    - Biomarker Correlation

- **AI**
  - Application and Intervention:
    - Preclinical validation
    - Prevention
    - Public Policy
    - Remediation
Example 1

The “Bat-ears”
The “Bat-ears” Device

- 40Hz ultrasonic waves of 40 kHz are emitted with 2m bursts from a generator (in middle of the device)
- Echoes are received by the two receivers (at the sides) and then converted to 800Hz audio signals
- designed to enhance the navigation potentials of people with blindness by converting spatial information obtained from the environment into auditory signals
The “Bat-ears” Device
Method

- **Stimuli**
  - Generated from the “Bat-ears” device
  - Recorded by KEMAR Manikin

(Burkhard & Sachs, 1975)
An Experimental Trial

- Use event-related design
- Cue sound delivered for 500ms
- Sounds generated from “Bat Ear” at 1m, 3m and 5m delivered for 3,000ms (B/C/D)
- Subjects were to make judgment on the distance by pressing on the keyboard
- 30 trials per run, a total of 4 runs per session
Research Questions

• What are the processes involved when individuals with blindness learn localizing the “Bat-ears” sounds?
• What are the roles of prior visual experience on influencing the sound localization processes?
• How would prior visual experience modulate the learning of sound localization?
The Theory – Cross-modal Processing

• … refers to situations in which the presentation of a stimulus in one sensory modality can be shown to exert an influence on [the] perception of, or ability to respond to, the stimuli presented in another sensory modality

(Spence et al. 2009)
Cross-modal Learning using a Blind Model

Cross Auditory-Spatial Learning in Early-Blind Individuals

Chetwyn C.H. Chan,¹* Alex W.K. Wong,¹ Kin-Hung Ting,¹
Susan Whitfield-Gabrieli,² Jufang He,³ and Tatia M.C. Lee⁴,⁵*

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⁵Laboratory of Cognitive Affective Neuroscience, The University of Hong Kong, Hong Kong, China
Cross Auditory-Spatial Processing

(A)

(B)

(C)

Figure 2.
Activation maps of neural activities associated with perception of Bat-Ear sounds (Target contrast with Reference sounds) obtained at the baseline (A) and post-training (B) occasions, blind subjects (N = 11), and the post-training occasion (C), normal vision subjects (N = 14).

(Chan et al. HBM 2012)
Cross Auditory-Spatial Learning

- Rt. IPC: spatial localizations associated with auditory signals; linking temporal and frontal lobes
- Lt Hippocampus: general learning binding auditory with distance
- Rt Cuneus (BA17): general occipital-enhanced learning centre involved in tactile, sensori-motor learning

(Chan et al. Human Brain Mapping 2012)
Cross Auditory-Spatial Learning (Chan et al. 2012)

Conclusion:

• Cross auditory-spatial learning requires the reinforcement of linkages between sounds and locations
• The binding process was mediated by the hippocampus and enhanced by the cuneus in the striate cortex
• Consistent and repeated association between the two novel modalities are essential for such learning
Visual Experience Modulating Cross Auditory-Spatial Processing

The left superior frontal gyrus (SFG) (relate to visuospatial working memory) predicted the late-blind participants performance on sound localization task, $\beta=0.543$, $P=0.024$.

The right middle occipital gyrus (MOG) predicted the early-blind participants’ performance on sound localization task, $\beta=0.530$, $P=0.042$;

(Tao, Chan et al., *Brain Topography* 2014)
How Does Experience Modulate Auditory Spatial Processing in Individuals with Blindness?

Tao Q¹, Chan CC, Luo YJ, Li JJ, Ting KH, Wang J, Lee TM.

Author information

¹Applied Cognitive Neuroscience Laboratory, Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China.

Abstract

Comparing early- and late-onset blindness in individuals offers a unique model for studying the influence of visual experience on neural processing. This study investigated how prior visual experience would modulate auditory spatial processing among blind individuals. BOLD responses of early- and late-onset blind participants were captured while performing a sound localization task. The task required participants to listen to novel "Bat-ears" sounds, analyze the spatial information embedded in the sounds, and specify out of 15 locations where the sound would have been emitted. In addition to sound localization, participants were assessed on visuospatial working memory and general intellectual abilities. The results revealed common increases in BOLD responses in the middle occipital gyrus, superior frontal gyrus, precuneus, and precentral gyrus during sound localization for both groups. Between-group dissociations, however, were found in the right middle occipital gyrus and left superior frontal gyrus. The BOLD responses in the left superior frontal gyrus were significantly correlated with accuracy on sound localization and visuospatial working memory abilities among the late-onset blind participants. In contrast, the accuracy on sound localization only correlated with BOLD responses in the right middle occipital gyrus among the early-onset counterpart. The findings support the notion that early-onset blind individuals rely more on the occipital areas as a result of cross-modal plasticity for auditory spatial processing, while late-onset blind individuals rely more on the prefrontal areas which subserve visuospatial working memory.
Summary Cross-Modal Learning

- The new sensory modality – “auditory” needs to be an intact function of the individual

- The associated sensory modality – “spatial” needs to be neurologically linked to the new sensory modality

- The cross-modal learning is likely to take over the impaired function – visuo-spatial working memory, which would augment the functions mediated by the associated sensory modality – navigation

- Learning was found influenced by prior visual experiences
A Model Representation

Visual system

Cognitive Map – Survey representation
Route representation

Sensori-motor function

Navigation in Space

Spatial Learning

Long term memory

Visuospaital working memory

Auditory system/input

Impaired Modality / Function

Associated Modality / Function
Example 2

Writing Chinese Calligraphy
Mild Cognitive Impairment

Progression rate
- aMCI: 12% /yr
- Normal: 1-2% /yr

(Petersen, 2004)
Cognitive Deficits in MCI

71% attention
57% and 50% verbal learning and memory
44% executive function
43% processing speed
33% language

(Twamley et al., 2006)
Chinese Calligraphy As Intervention
Conclusion: Pictographic orthographs were easier and faster to be inspected than their non-pictographic counterparts … less intense activations found in the fontal and parietal regions suggest that facilitation could be attributable to the visuospatial symmetry and regularity of the strokes borne by pictographic orthographs.
Chunking and Visualization Processes

- Encoding strokes in *Kai* form
- Recalling *Hang* Representation
- Visualizing strokes in *Hang* form
- Producing character in *Hang* form

Attention / Long Term Memory / Working Memory
Our Hypotheses

• Eight-week calligraphy writing training will enhance attentional control of patients with MCI (due to encoding and chunking processes)

• Eight-week calligraphy writing training will enhance working memory and executive control of patients with MCI (due to *Hang to Kai* transformation and visualization)

• Differences in amplitude of P/N200 complex in MCI patients between the calligraphy writing and control group (attentional control and working memory)
Interventions

Experimental:
Calligraphy writing (from Kai to Hang form) with assistance from iPad practice (20 min)
2 session/week x 8 weeks

Control:
Learning use of iPad functions and copying Kai characters on plain paper
2 session/week x 8 weeks
Demographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No of Subjects</strong> **</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td>Female (%)</td>
<td>27 (66%)</td>
<td>33(77%)</td>
</tr>
<tr>
<td><strong>Age (SD)</strong></td>
<td>69.17(5.99)</td>
<td>68.47(5.98)</td>
</tr>
<tr>
<td><strong>Attendance (SD)</strong></td>
<td>14.39(2.77)</td>
<td>14.35(3.18)</td>
</tr>
<tr>
<td><strong>MoCA [30] (SD)</strong></td>
<td>24.44(3.05)</td>
<td>24.21(3.14)</td>
</tr>
</tbody>
</table>

Maximum score in square bracket [ ]; SD = Standard Deviation; ** Among 84 subjects, two did not complete post-testing and three did not complete 6-month follow up.
# Outcome Measures

<table>
<thead>
<tr>
<th>Tests</th>
<th>Construct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Digit span backward (DSB) test</td>
<td>Working memory</td>
</tr>
<tr>
<td>2. CERAD-NAB – Word List Memory</td>
<td></td>
</tr>
<tr>
<td>J4</td>
<td>Memory – encoding</td>
</tr>
<tr>
<td>J6</td>
<td>Memory – delay recall</td>
</tr>
<tr>
<td>J7</td>
<td>Memory – word recognition</td>
</tr>
<tr>
<td>3. Color Trails Test (CTT)</td>
<td></td>
</tr>
<tr>
<td>Part 1</td>
<td>Visual Scan / Attention</td>
</tr>
<tr>
<td>Part 2</td>
<td>Task switching</td>
</tr>
<tr>
<td>4. Symbol-digit Modalities Test (SDMT) in verbal form</td>
<td>Attention span and scanning</td>
</tr>
<tr>
<td></td>
<td>abilities</td>
</tr>
<tr>
<td>5. SF36 Health Survey</td>
<td>Quality of life</td>
</tr>
</tbody>
</table>
Preliminary Results
Working Memory

Digit Backward (sequence)

Total score

Pre-testing | Post-testing | 6-month follow up

** P<0.01
Preliminary Results
Working Memory

Digit Backward (span)

Total score

Pre-testing | Post-testing | 6-month follow up

* $P < 0.05$; **$P < 0.01$
Preliminary Results
Visual Scan and Attention

CTT Part I Self-corrected Errors

* \( P \leq 0.05 \)
Preliminary Results
Attention and Visual Scan

SDMT Accuracy (verbal form)

* P=0.02
Preliminary Results
Subjective Physical Health

SF-36 Physical Functioning

* P=0.01; **P<0.01

Total score

Pre-testing  | Post-testing  | 6-month follow up
---|---|---
Experimental group  | Control group

1. Physiological Health
2. Mental Health
3. Social Functioning
4. Role Physical
5. Role Emotional
6. Vitality
7. Social Functioning
8. General Health

** Experimental group vs. Control group

* P=0.01; **P<0.01
## Calligraphy Performance Scores

<table>
<thead>
<tr>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
<th>Score 4</th>
<th>Score 5</th>
</tr>
</thead>
</table>
| 1. 參加者學習基本技巧的程度 (質量)  
Basic skills in learning (quality)* | 2. 參加者學習基本技巧的程度 (數量)  
Basic skills in learning (quantity)* | 3. 參加者在寫書法上應用基本技巧的程度 (質量)  
Basic skills in writing (quality)* | 4. 參加者在寫書法上應用基本技巧的程度 (數量)  
Basic skills in writing (quantity)* | 5. 整體來說，書法作品的質量 (和樣本的相似度)  
Overall quality of handwriting (profession comparison)* | 6. 參加者的整體表現  
Overall performance* |

* Scores 1-5 (higher the better)

Best rating with score 4 in overall performance.

Poor rating with score 2 in overall performance.
## Calligraphy Performance and Cognitive Functions

<table>
<thead>
<tr>
<th>Cognitive Functions</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit backward task (Sequence)</td>
<td>NS</td>
</tr>
<tr>
<td>Digit backward (Span)</td>
<td>NS</td>
</tr>
<tr>
<td>SDMT in verbal form (Accuracy rate)</td>
<td>Post-test occasion with basic skills in learning (quantity) ( r=0.32, p=0.045 )</td>
</tr>
<tr>
<td>CTT Part I (Self corrected errors)</td>
<td>NS</td>
</tr>
<tr>
<td>SF-36 (Physical functioning)</td>
<td>NS</td>
</tr>
</tbody>
</table>

* NS = not statistically significant
ERP Study

Numerical 2-back Tasks

Detection Task

500ms

Target

5 sec With fixation +

Target

500ms

2-back task

Department of Rehabilitation Sciences

THE HONG KONG POLYTECHNIC UNIVERSITY
ERP Study

Chinese Stroke
2-back Tasks

Detection Task

500ms

Target

5 sec
With fixation
+

500ms

Target

500ms

Target

500ms

2-back task
RCT Pilot - Summary

• Significantly more negative-going N200 elicited at frontal area in both stroke- and number-conditions in the calligraphy writing than control group; and less positive-going P200 elicited at frontal area in both conditions in the calligraphy writing group.

• Practicing calligraphy for an extended period of time may enhance the efficiency of the network related to attention orientation and working memory of individuals with MCI.

• The training effect appears to be generalized to working memory of other types of stimuli.

• Potentials for calligraphy writing training as an effective therapeutic intervention to delay the progression of MCI to Alzheimer’s disease.
Conclusion

- Identify neurophysiological markers relevant for MCI such as N/P200, P550, LPC
- Interventions should be more specific for modulating neural processes such as attentional control, encoding and chunking, visualization and transformation
- Combination with other biological markers for better understanding of therapeutic effects of rehabilitative interventions
Implication to Rehabilitation Counseling Research
Summary:
… Studies of cognitive behavioural therapy (CBT) effects in obsessive-compulsive disorder (OCD) were consistent in showing decreased metabolism in the right caudate nucleus…. Cognitive behavioural therapy in phobia resulted in decreased activity in limbic and paralimbic areas... indicating commonalities in the biological mechanisms of psycho- and pharmacotherapy.
Mindfulness practice leads to increases in regional brain gray matter density

Britta K. Hölzel¹,⁴,*, James Carmody³, Mark Vangel¹, Christina Congleton¹, Sita M. Yerramsetti¹, Tim Gard¹,⁴, Sara W. Lazar¹

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³University of Massachusetts Medical School, Worcester, MA, USA

Summary:

... increases in gray matter concentration within the left hippocampus. Whole brain analyses identified increases in the posterior cingulate cortex, the temporo-parietal junction, and the cerebellum ... associated with changes in gray matter concentration in brain regions involved in learning and memory processes, emotion regulation, self-referential processing, and perspective taking.
The neural bases of uninstructed negative emotion modulation

Jennifer A. Silvers,¹ Tor D. Wager,² Jochen Weber,¹ and Kevin N. Ochsner¹
¹Department of Psychology, Columbia University, New York, NY 10027, USA, and ²Department of Psychology, University of Colorado, Boulder, CO 80309, USA

Summary:
… associated with recruitment of dorsolateral and dorsomedial prefrontal cortex (PFC) brain regions also active during instructed reappraisal … recruitment of the amygdala a region that responded more strongly overall to negative than neutral stimuli… self-reported negative affect were associated with recruitment of ventromedial PFC. These results suggest that uninstructed modulation of emotion involves a combination of two types of regulatory processes, with moment-to-moment modulation depending on prefrontal regions that support reappraisal and individual differences in modulation depending on ventromedial PFC, a region involved in fear extinction.
Our Research Agenda

The Research Enterprise

http://nihroadmap.nih.gov/clinicalresearch/presentations.asp
Conclusion

• Going beyond evidence-based practice creates opportunity for developing new theories and research paradigm for the discipline

• Mastery of new enquiry methods - experimental designs, neuroimaging, neurophysiology, epidemiology, big-data analytics
Conclusion

• Promote interdisciplinary research – health psychology, rehabilitation counselling, cognitive neuroscience, neuropsychology, neurophysiology, behavioral scientist etc
• Revisit the needs of research among scientists, educators and practitioners
• Enrich student/intern training in experimental design and mechanism research
• Drive new research agenda to stakeholders and research fund agencies
Applied Cognitive Neuroscience Laboratory, PolyU
# Neuroscience and NeuroRehabilitation

- Prof. Chetwyn Chan
- Prof. Jufang He
- Dr. Karen Liu
- Dr. Kenneth Fong
- Dr. Sam Chan
- Dr. Ada Leung
- Dr. Alex Wong
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- Dr. Leonard Li (TWH)
- Christina Yau (TWH)
- Ivan Kwan (QMH)
- Dr. Jian-jun Li (CRRC)
Thank You!

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