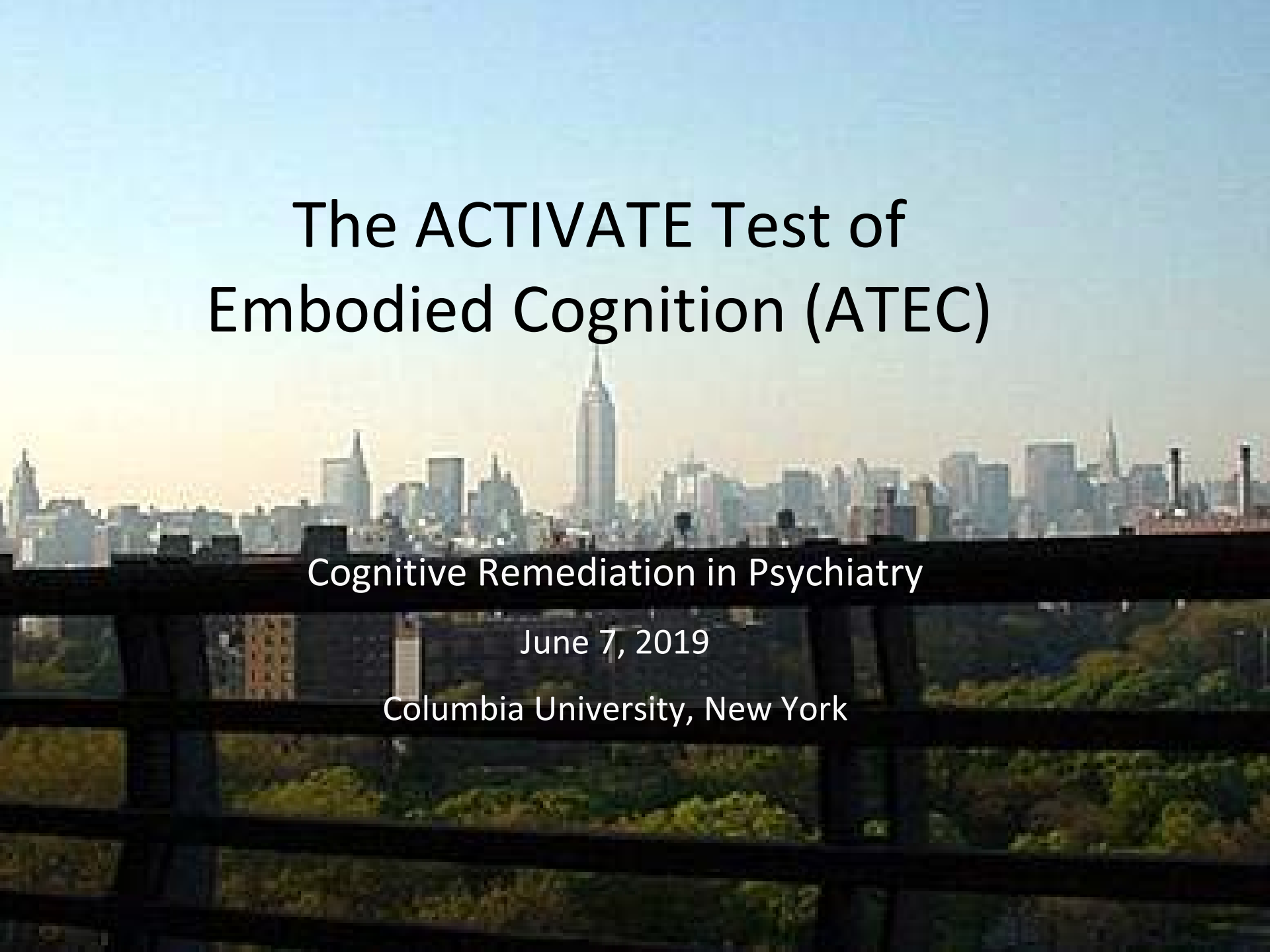

The ACTIVATE Test of Embodied Cognition (ATEC)

Cognitive Remediation in Psychiatry

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Columbia University, New York

Morris Bell, Ph.D., ABPP

Professor Emeritus of Psychiatry
Yale University School of Medicine
Senior Research Career Scientist
Rehabilitation Research & Development
Department of Veterans Affairs

E-mail: Morris.Bell@Yale.edu

YALE UNIVERSITY

School of Medicine

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CHS: Computational Science for Improving Assessment of Executive Function in Children

- Dr. Morris Bell at Yale
- Dr. Fillia Makedon and Dr. Vassilis Athitsos at University of Texas at Arlington

Disclosure

- Morris Bell, Ph.D. is on the scientific advisory board of Posit Science, but has no financial investment nor does he receive any consultation fees.
- Morris Bell, Ph.D. is on the scientific advisory board of C8 Sciences and is an investor in the company.
- These disclosures are unrelated to this presentation

CHS: III: Large: Collaborative: Computational Science for Improving Assessment of Executive Function in Children.
PI's Makedon and Bell

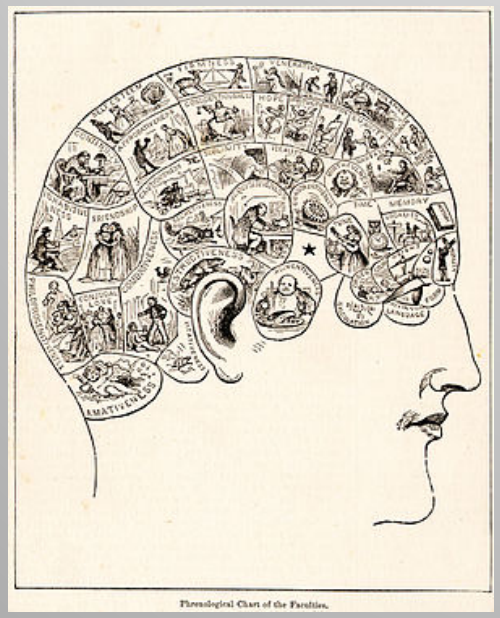
- Embodied cognition has a great tradition in philosophy and psychology.
  - Edmund Husserl, Martin Heidegger, Maurice Merleau-Ponty, Raymond Gibbs.

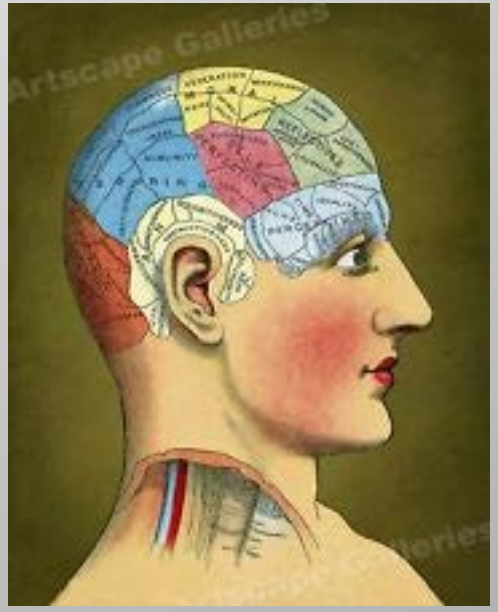
  "The mind is an embodied system in the world rather than a neural network in the head."

  2010 Evan Thompson

But how do we measure these abilities?

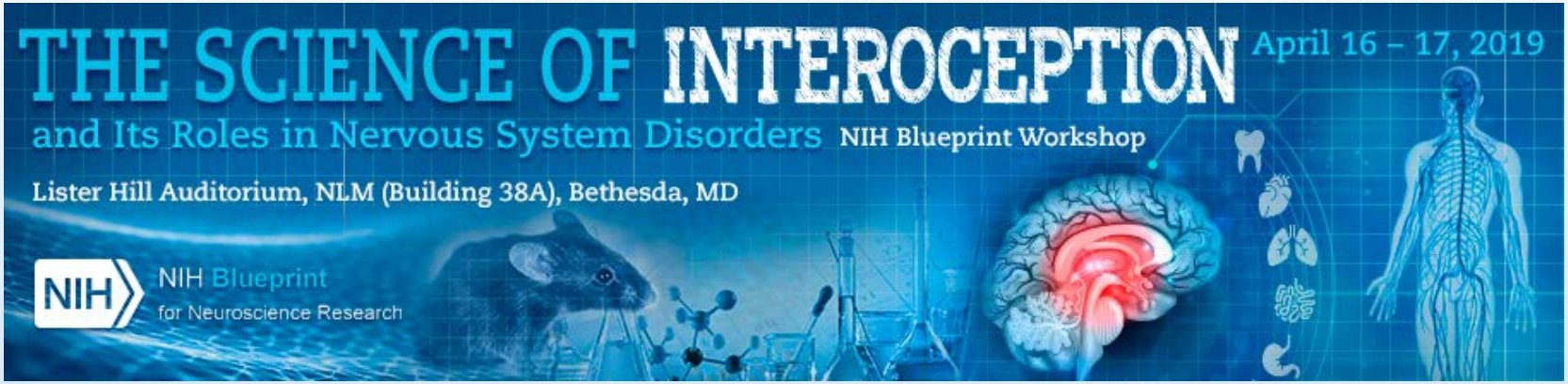
- The history and traditions of Western science separated the mind and body (dualism)
- The brain was the organ of the mind and divided in localized functional areas





Embodied cognition is how we function.

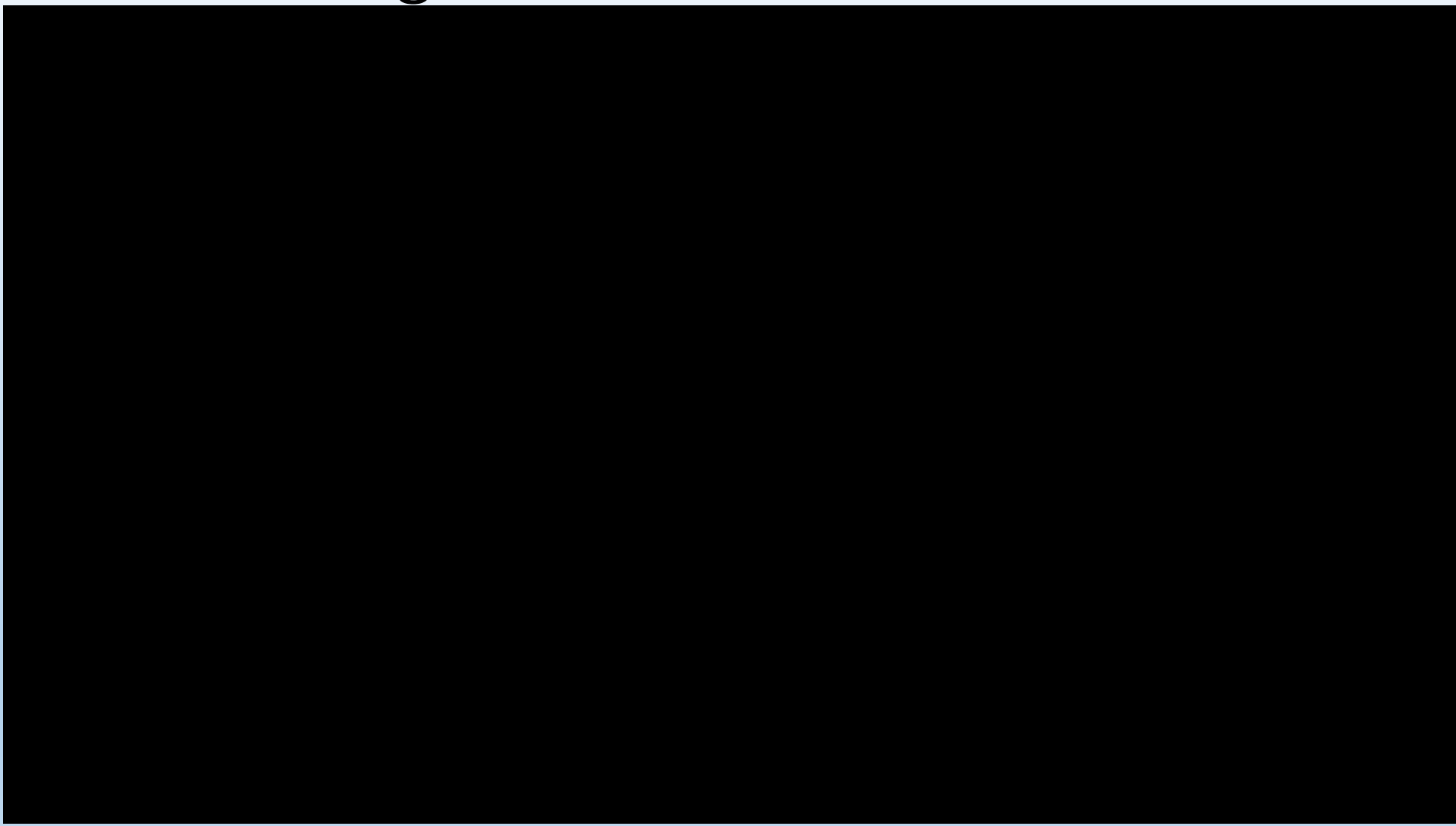
- The brain was built for motion, and bodily action plays a key role in cognitive development.
- Neurocognitive assessments do not engage body movement and Functional Movement assessments do not engage higher cognitive function.
- Rhythmic movement is not assessed by either testing system, even though keeping rhythm demands both EF and body coordination.
- We are creating the first assessment system focused on executive function in motion: Activate Test of Embodied Cognition (ATEC).



Workshop Objectives:

The objective of this workshop is to identify gaps in research related to the science of interoception and its roles in nervous system disorders as well as to develop strategies and recommendations to facilitate the advancement of this area of research. The workshop will bring together expertise from diverse fields in basic neuroscience and clinical research to address two major connections – the connections between brain and body and the connections between basic research and human/clinical research.

ACTIVATE: A Revolution in Measuring Neurocognition.

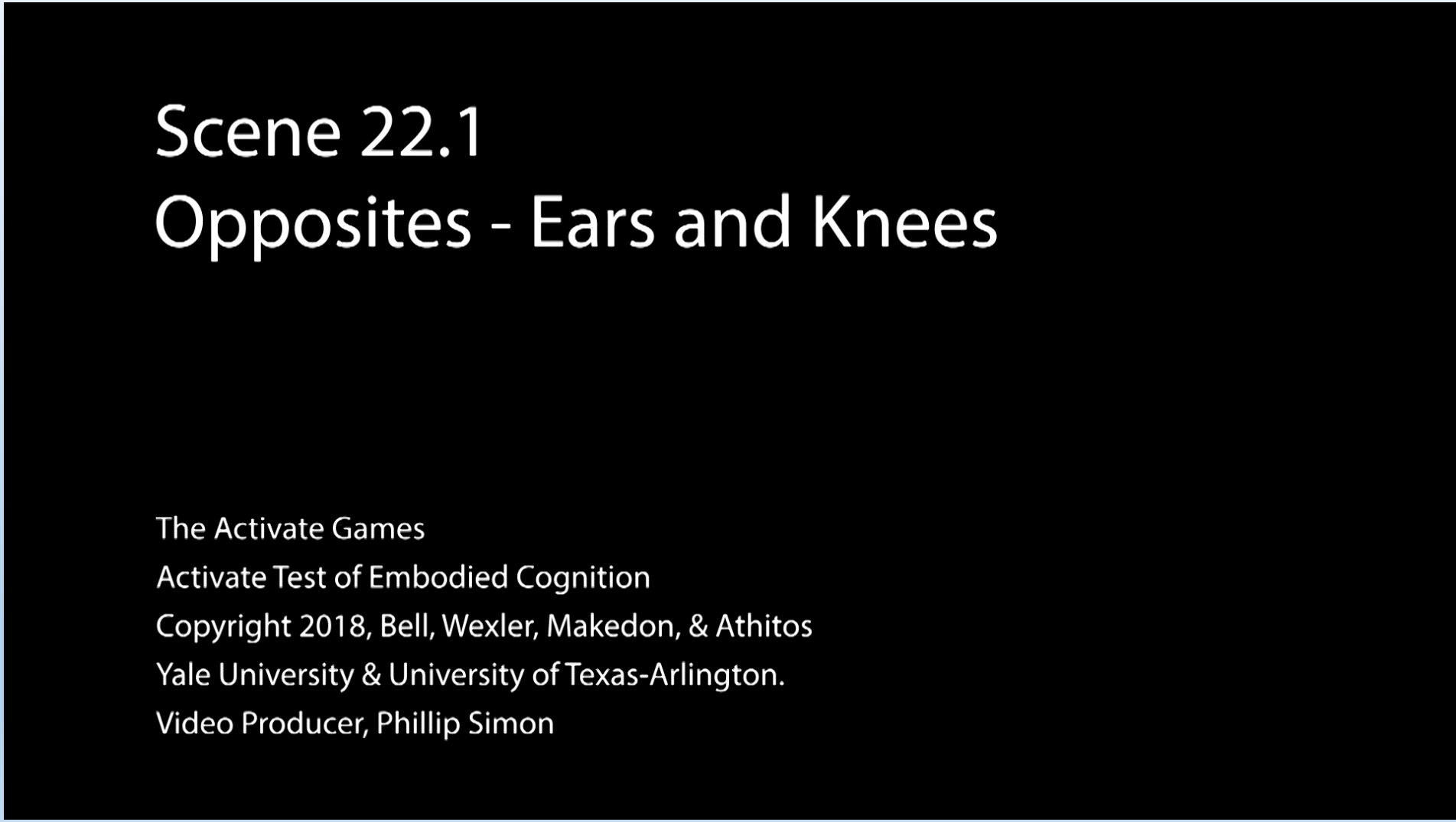


Bilateral Coordination and Self-Regulation
Cross your Body game

- The most demanding game
- There are five levels to the game
- First, the child is asked to cross their body with each hand and touch the body part that is named, three times in rhythm to a song.
- Then, the child must do the opposite motion of what is named:

    - Ears ⇔ Knees

Aliza explains the Opposite Moves



Then the game gets harder…

- Then, new opposite motions are added:
  - Hips ⇔ Shoulders

- Finally, all four motions are put together:
  - Ears ⇔ Knees
  - Hips ⇔ Shoulders

See how a normally developing 7 year-old performs the task

A 9-Year Old with Attention Problems has a lot more trouble.

ATEC Scoring Measures

ATEC TOTAL SCORE

BALANCE CONVERTED SCORE ☐ +

WORKING MEMORY CONVERTED SCORE ☐ +

SELF-REGULATION CONVERTED SCORE ☐ +

SUSTAINED ATTENTION CONVERTED SCORE ☐ +

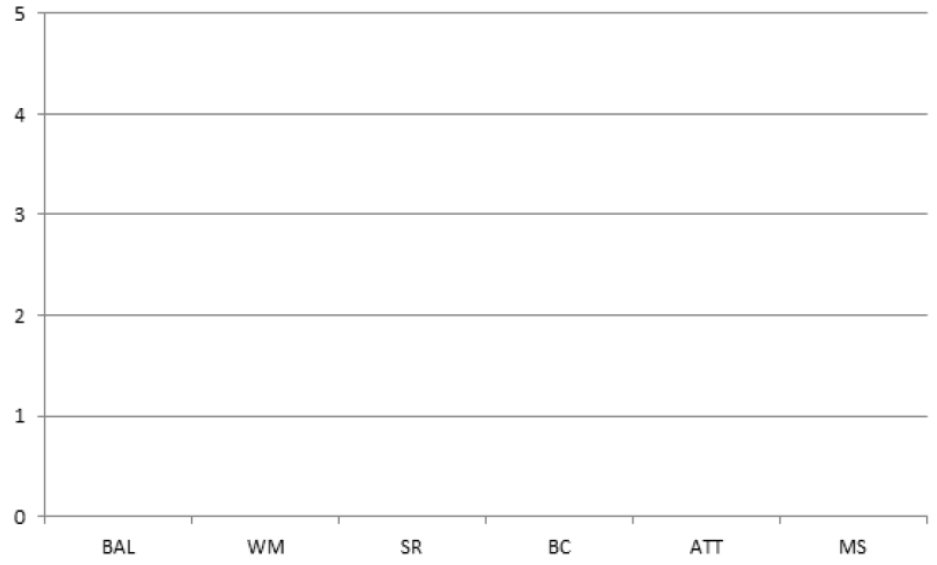
ATTENTION CONVERTED SCORE ☐ +

MOTOR SPEED CONVERTED SCORE ☐ =

ATEC TOTAL SCORE ☐

Performance Categories

Undeveloped	0—12	☐
Very Early Development	13—15	☐
Early Development	16—18	☐
Early to Middle Development	19—21	☐
Middle Development	22—24	☐
Middle to Full Development	25—27	☐
Full Development	28—30	☐



Test-Retest Reliability at 2 Weeks N =28

ATEC Total Time 1 Mean = 28.96 (4.48) N = 28

ATEC Total Time 2 Mean = 30.43 (4.46) N = 28

ICC = .945, df = 27, $p < .000$

Change from Time 1 to Time 2 = 1.47 = Cohen's d' =.33. Small but significant practice effect.

Relationship to age, grade and IQ

Children improve on ATEC with normal development.

- Age X ATEC Total r = .41, p = .024, N = 30
- Grade X ATEC Total r = .45, p = .012

Age correlates with EF Factor r = .37 ($p < .02$) and with Movement Factor r = .30 ($P < .05$).

ATEC scores are independent of IQ.

- PPVT X ATEC Total, Spearman r = .07, p = ns, n = 16

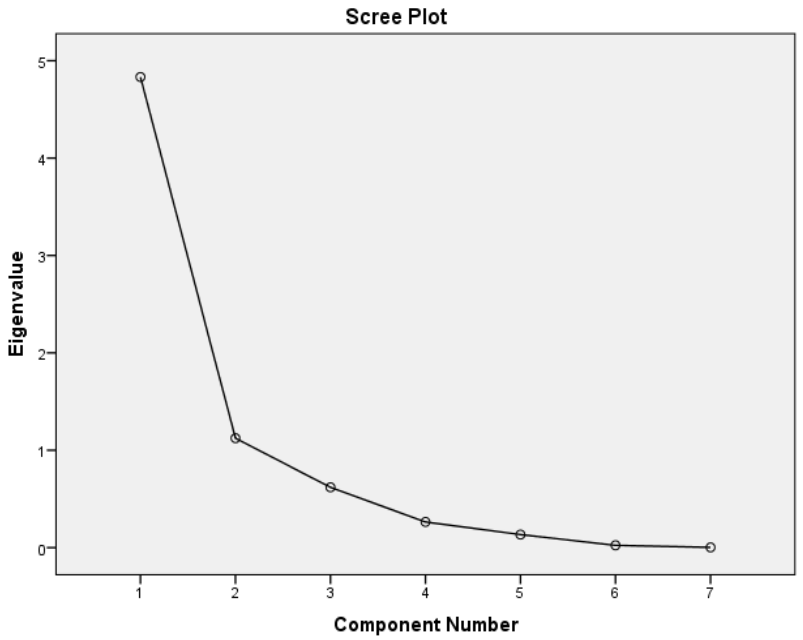
Factor Analysis of ATEC (N =58)

- Because of high intercorrelations among ATEC subtests, PCA with Verimax rotation was used to produce a 2 factor solution, explaining 85% of Variance

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loading		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulat
1	4.833	69.038	69.038	4.833	69.038	69.038	4.045	57.787	5
2	1.124	16.059	85.098	1.124	16.059	85.098	1.912	27.311	8
3	.619	8.846	93.944						
4	.264	3.768	97.712						
5	.134	1.913	99.626						
6	.024	.339	99.965						
7	.002	.035	100.000						

Extraction Method: Principal Component Analysis.



Executive Function (EF)and Motor Movement (Move) Factors

Attention, Working Memory, Self-regulation, Response Inhibition are most heavily weighted on EF factor.

Balance and Motor Speed are most heavily weighted on Motor factor.

Rhythm and Coordination is weighted on both factors.

Component Matrix[a]

	Component	
	1	2
ATEC_S1_ResponseInhibition_Raw	.968	-.003
ATEC_S1_SelfRegulation_Raw	.965	-.100
ATEC_S1_Attention_Raw	.901	-.366
ATEC_S1_RhythmCoordination_Raw	.898	.103
ATEC_S1_WorkingMemory_Raw	.894	-.376
ATEC_S1_Balance_Raw	.539	.687
ATEC_S1_MotorSpeed_Raw	.507	.597

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
ATEC_S1_Attention_Raw	.968	.091
ATEC_S1_WorkingMemory_Raw	.967	.078
ATEC_S1_SelfRegulation_Raw	.902	.356
ATEC_S1_ResponseInhibition_Raw	.860	.443
ATEC_S1_RhythmCoordination_Raw	.750	.505
ATEC_S1_Balance_Raw	.162	.858
ATEC_S1_MotorSpeed_Raw	.175	.764

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Relationships to Validity Criteria

- BRIEF – 2 Behavior Regulation Index
- CBCL Competency Scale
- Executive Function Neurocognitive Testing
- BART-C – Adaptive Risk Taking

BRIEF-2 Index scores and CBCL Competency Scores by ATEC Factors

(controlling for age)

BRIEF-2	BRI	ERI	CRI	GEC
EF Factor	-.44*	-.38*	-.45*	-.47*
Move Factor	.03	.19	.11	.11

CBCL	Activities	School	Social	Total Competency
EF Factor	.21	.28	.43*	.47*
Move Factor	.36*	.24	.05	.22

* p< .01

Executive Function Neurocognitive Testing by ATEC Factors (Controlling for Age)

Tests	Flanker (Attention Task)	Go/No Go (Response Inhibition)	Working Memory Test	BART Total Score (Adaptive Risk Taking)
EF Factor	.38*	.50**	.42*	.17
Move Factor	.19	.01	.13	.31*

*p < .01; ** p< .001

ATEC explains more variance in childhood competency than other measures

Stepwise Linear Regression with Neurocognitive Tests and ATEC factors entered to predict CBCL Competency shows that ATEC EF factor explains most of the variance (Adjusted Rsq = .24) with WMT (Adjusted Rsq = .31) making a small (.07) but significant contribution to explained variance.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.501[a]	.251	.236	8.643	.251	16.724	1	50	.000
2	.580[b]	.337	.310	8.214	.086	6.359	1	49	.015

a. Predictors: (Constant), REGR factor score EF1 for analysis 2

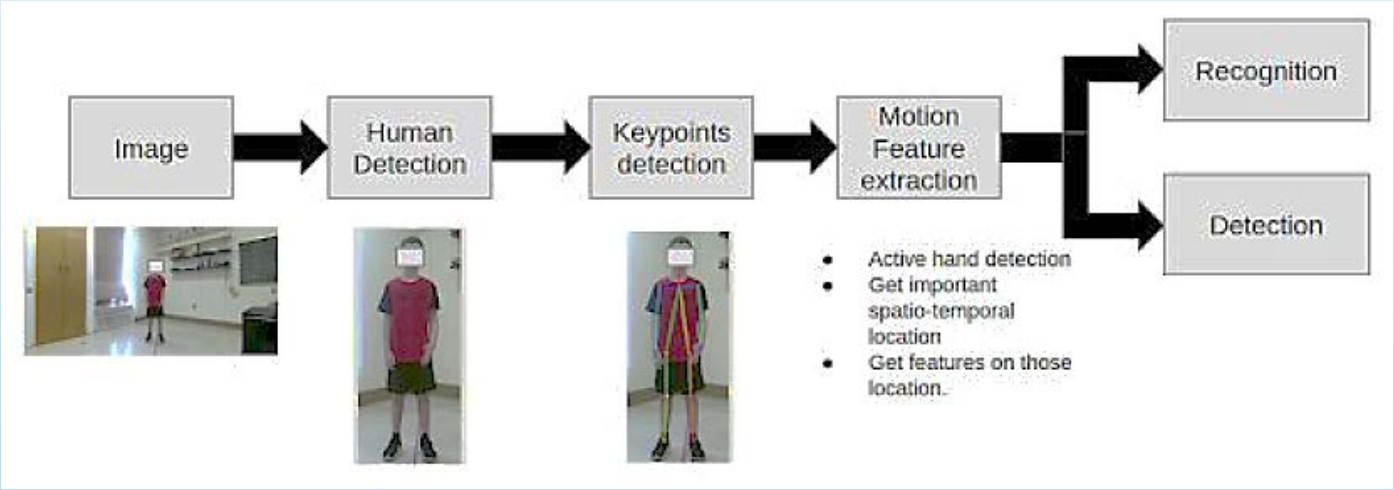
b. Predictors: (Constant), REGR factor score EF1 for analysis 2, NIH_WMT

c. Dependent Variable: CBCL_COMPETENCE

Motion Capture and Analysis Methods for Automated Scoring

Cross your Body

Aim: Detect *keypoints of interest*: ears, knees, shoulders, hips and hand movements
Current results: average accuracy of 87.3% (touch movement detection)



Finger Tapping

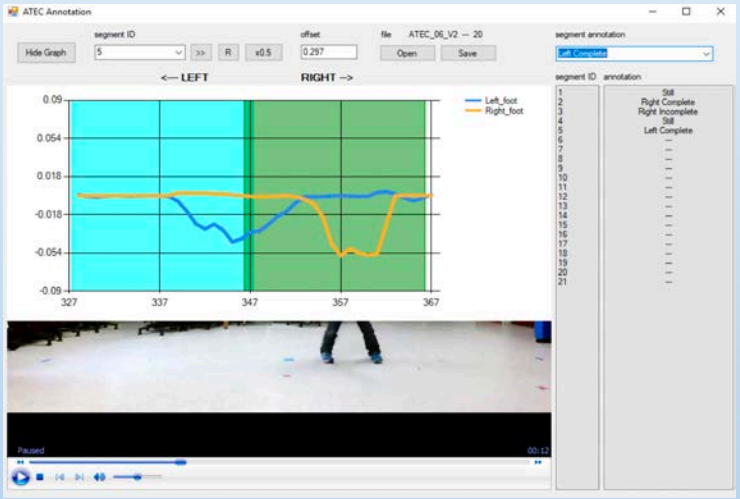
Aim: Hand Keypoint Detection for Rapid Sequential Movements
Current Outcome: The Hand Keypoints (HKD) Dataset and a comparison of state-of the art methods for finger tip detection and wrist detection – average accuracy: 80%

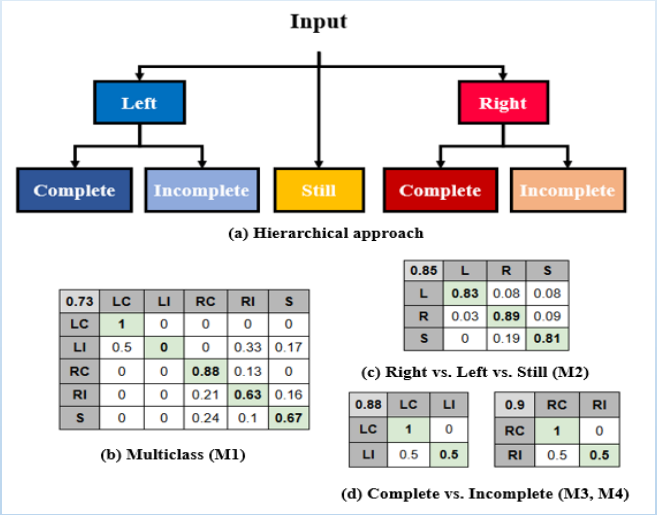
Motion Capture and Analysis Methods for Automated Scoring

Sailor Step

Aim: Detect and analyze lower-body movements – direction and rhythm

Current Outcomes: visualization and scoring interfaces and baseline approaches with accuracy between 73-88%





0.73	LC	LI	RC	RI	S
LC	1	0	0	0	0
LI	0.5	0	0	0.33	0.17
RC	0	0	0.88	0.13	0
RI	0	0	0.21	0.63	0.16
S	0	0	0.24	0.1	0.67

0.85	L	R	S
L	0.83	0.08	0.08
R	0.03	0.89	0.09
S	0	0.19	0.81

0.88	LC	LI
LC	1	0
LI	0.5	0.5

0.9	RC	RI
RC	1	0
RI	0.5	0.5

Ball Drop

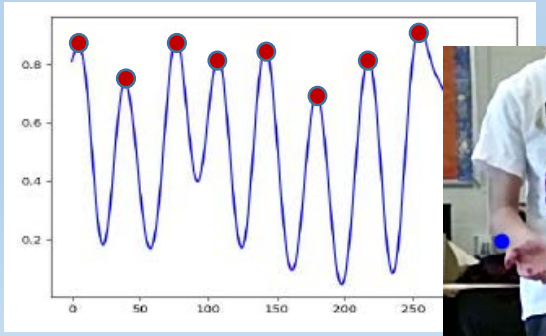
Aim: Detect Ball Passes and Hand Movements

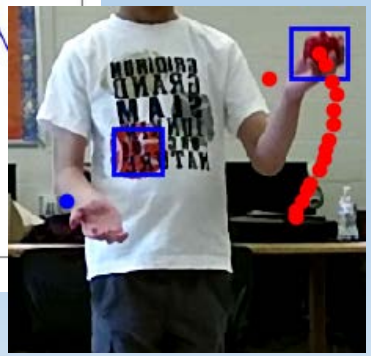
Current Results: Ball Pass – 89% accuracy

No Ball Pass – 77% accuracy

Hand raise – 69% accuracy

Hand Wrist Distance Tracking – Ball Pass Detection





Next Steps for ATEC

- Discriminant validity will be determined comparing community samples with ADHD and ASD samples.
- Pre-post intervention studies to determine ATEC sensitivity to interventions and to study course of illness.
- Development of an adult version for use with mild to moderate TBI, Parkinson's Disease and other movement disorders.

Cross-cultural validity in China

C8 Sciences ACTIVATE Physical Games

ACTIVATE Physical Games with Cognitive Demands


Thank you for your kind attention
ONE WAY
Enjoy New York