

Motricity and Social Synchronization in ASD

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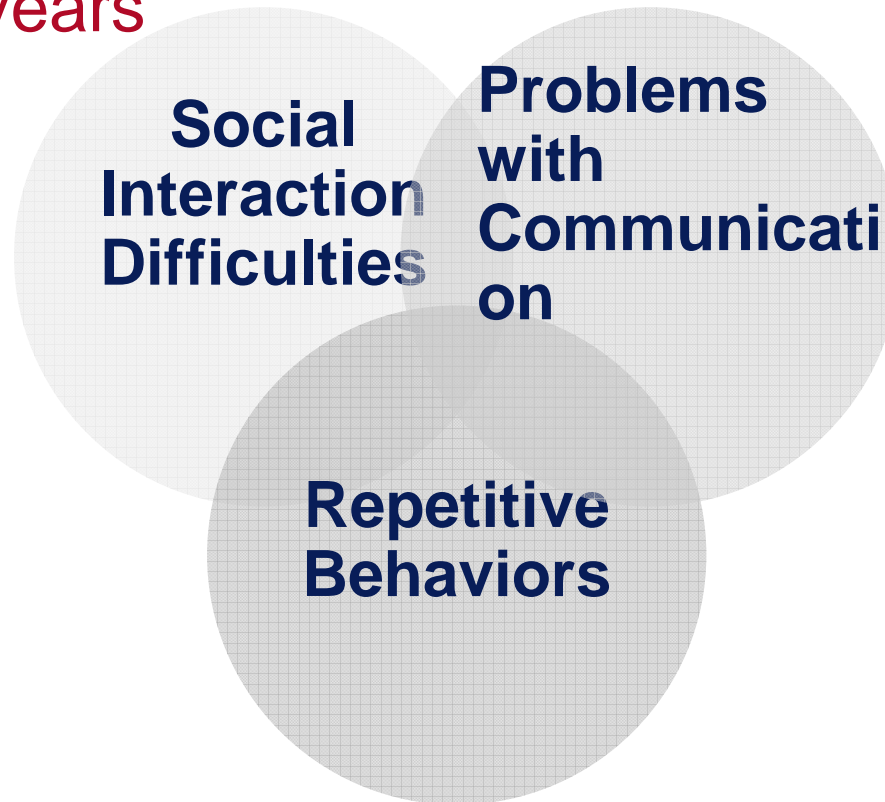
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Autism Spectrum Disorder

(APA DSM V, 2013)

- Early-onset neurodevelopmental disorder (prior to age 3)
- Receiving increased scrutiny: Diagnoses increased in recent years



Motor Deficits in Autism Spectrum Disorder

Though not a core feature, increasing acknowledgment that motor deficits are highly prevalent in ASD (Gowen & Hamilton, 2013; Lai et al, 2014)

Fournier et al (2010): meta-analysis of 83 ASD studies

- “Large effect indicated substantial motor coordination deficits in the ASD groups across a wide range of behaviors”
- “Motor coordination deficits [are] pervasive across diagnoses, thus, a cardinal feature of ASD.”

Motor deficits may be a prodrome to ASD in at-risk infants

May et al (2016): Motor impairment holds promise as an early diagnostic sign, a behavioral marker, and a means by which to improve identification of ASD

Harris (2017): Tests of motor coordination may be important predictors of ASD and delay a diagnosis in early diagnosis

Motor Deficits in Autism Spectrum Disorder

Motor deficits may be the precursor of ASD social and communication difficulties

Gernsbacher et al (2008): Oral and manual motor deficits in infants and toddlers with ASD

- These correlated with each other and predicted later speech-fluency
- Motor deficits could also affect social cognitive processes:
 - initiating and responding to joint attention (Mundy et al, 1995)
 - proto-declarative pointing associated with Theory of Mind (Baron-Cohen et al, 1996)

Are ASD social interaction difficulties rooted in their *social motor coordination* processes?

Social Competence

A person's ability to get along with others

To be able to establish a 'rapport'

Multidimensional Concept (Tickle-Degnen & Rosenthal, 1990)

- *Emotional*
 - Affect regulation: positive experience of one another
- *Cognitive*
 - Sustain joint/mutual attention
 - Take another's perspective: "Theory of mind"
- *Behavioral*
 - Interpersonal coordination
 - Immediate and spontaneous mutual responsiveness
 - Being "in sync" rather than "out of sync" with one another

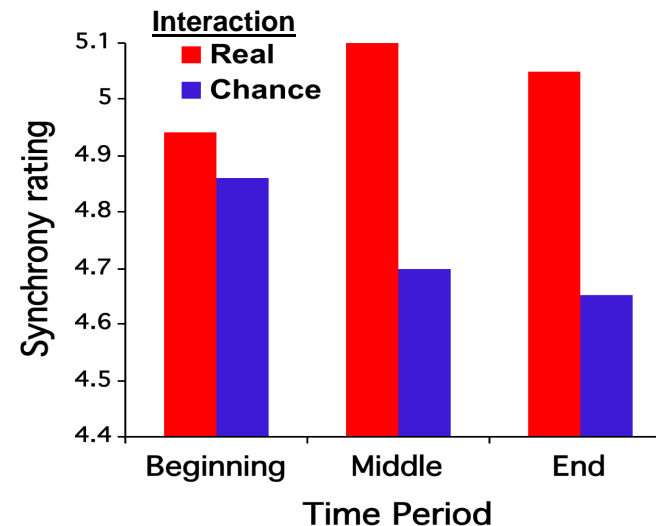
"... analysis revealed harmonious or synchronous organizations of change between body motion and speech in both intra-individual and interactional behavior. Thus the body of the speaker dances in time with his speech. Further, the body of the listener dances in rhythm with that of the speaker (Condon & Ogston, 1966, pg. 338)...."

Interactional Synchrony and Rapport

(Bernieri, 1988)

Task

- Videod students teaching each other imaginary words
- Judges viewed silent video clips and rated the degree of movement synchrony between the interactors
 - First minute, middle minute and final minute



Was the amount of perceived movement synchrony greater than chance?

Was the perceived movement synchrony correlated with perceived social connectedness?

Measured Rapport: “How much of the following did you experience in the interaction?”

enjoyment, liking of partner, satisfaction, excitement, interest, enthusiasm, attentiveness, cooperation and humor

Interpersonal synchrony was positively correlated with participant-rated rapport, $r = .74$.

Infant-mother and -father synchrony in pre-term and full-term infants

(Feldman & Eidelman, 2007)

Social motor coordination correlates with social connectedness and breaks down in pathologies

- ***Behavioral syntax of our sociality***
- ***Seems to index both normal and pathological social competence...***

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Is there a social motor coordination deficit in ASD?

Is it related to social cognitive processes such as joint attention and theory of mind?

Is a social motor deficit dependent or independent of motor deficits?

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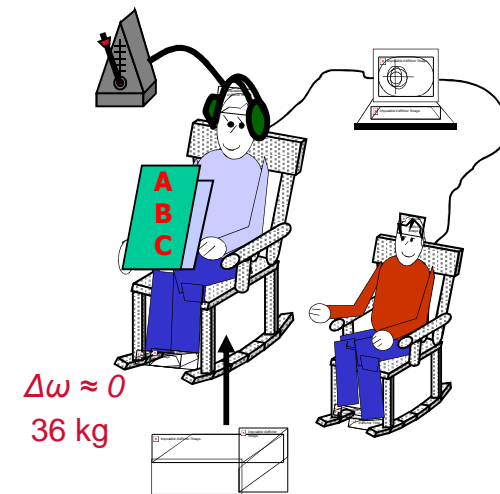
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Do children with autism have a deficit in spontaneous social motor synchrony?

(Marsh, Isenhower, Richardson, Helt, Schmidt, & Fein, 2013)

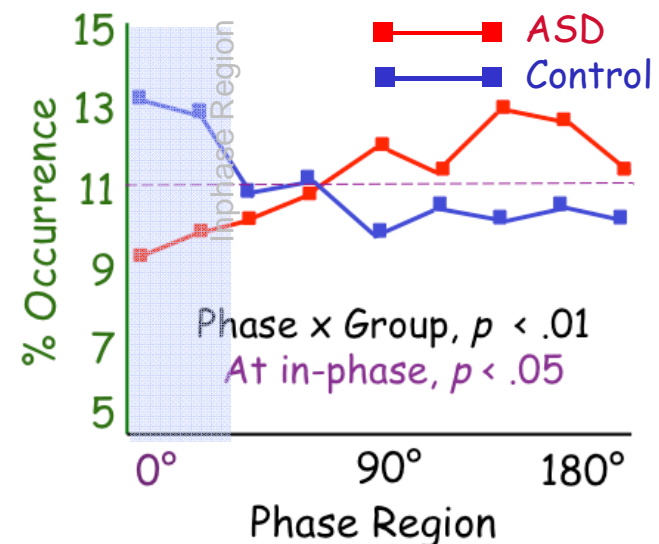
Task

- Children sat in rocking chair and listened to their parent read them a children's story
 - 8 with ASD, 15 control
 - avg age: 3.75 years
- Parents' rocking was paced by a metronome
- The adult rocking chair was weighted to match children's average pretrial natural frequency



Cross-Phase Analysis

- Spontaneous inphase coordination only defined for control pairs



Do children with autism have a deficit in spontaneous social motor synchrony?

(Marsh, Isenhower, Richardson, Helt, Schmidt, & Fein, 2013)

Both analyses suggest that ASD subjects had weaker spontaneous social synchrony

But why?

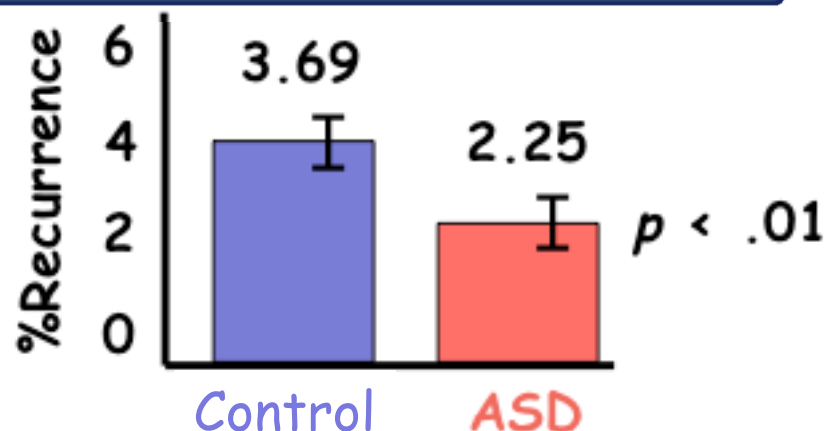
Disrupted Joint Attention Hypothesis

- **Disrupted attention produces weaker dynamical coupling**
- **Less pick up information = weaker coupling (Hajnal et al, 2009)**

average pretrial natural frequency

Cross-Recurrence Analysis

- Controls' rocking behavior had a larger temporal correspondence with parent than children with ASD

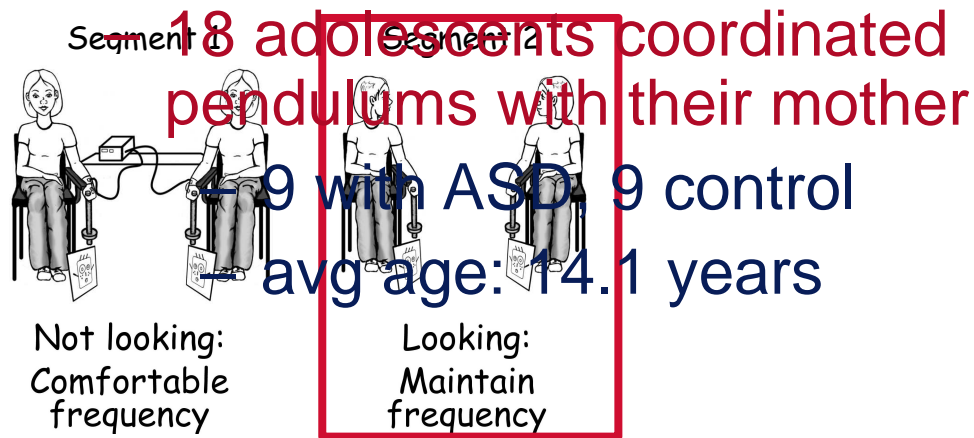


ASD teens have a social synchrony deficit?

(Fitzpatrick, Frazier, Cochran, Mitchell, Coleman, & Schmidt, 2016)

Spontaneous Social Coordination

Task

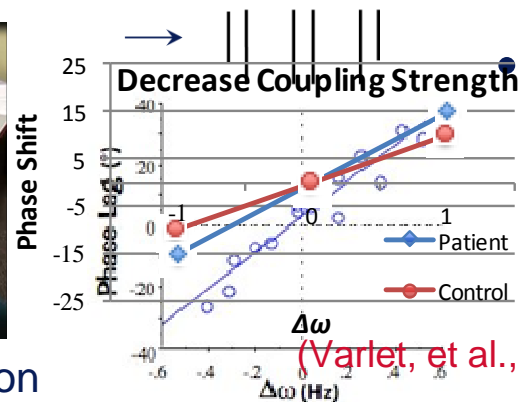


- Expect weak synchronization during looking segment of trial

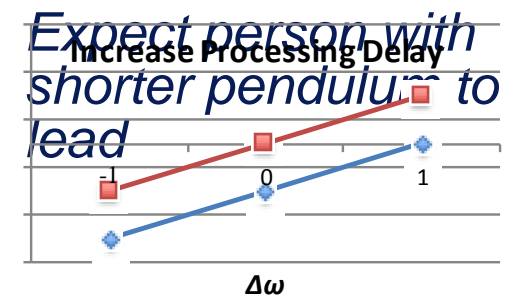
Intentional Social Coordination



In-phase Coordination Anti-phase Coordination



(Varlet, et al., PLoS ONE, 2012)



ASD teens have a social synchrony deficit?

(Fitzpatrick, Frazier, Cochran, Mitchell, Coleman, & Schmidt, 2016)

Spontaneous Social Coordination

Results indicate that ASD subjects had both weaker spontaneous and weaker intentional social synchrony

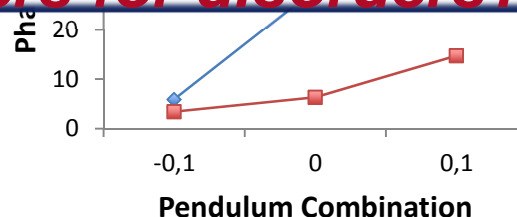
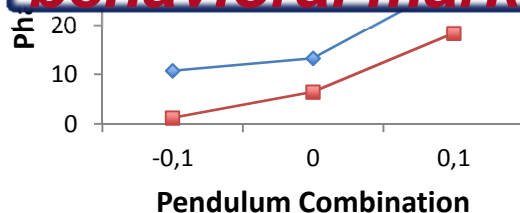
Evidence for a weaker dynamical coupling

- **Support for disrupted joint attention hypothesis: less information pickup => weaker dynamical coupling**

Pattern of results is different from what was seen in adults with schizophrenia (Varlet et al, 2012)

- **Schizophrenia: Only a weaker intentional synchrony...**

Different social synchrony patterns = different bio-behavioral markers for disorders?



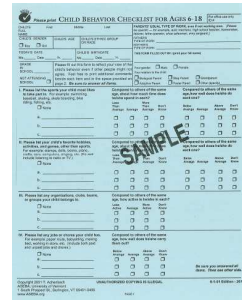
parent (+ lag)
– Phase shift larger for ASD group than controls

Is social synchronization related to clinical and cognitive measures of social competence?

(Fitzpatrick, Schmidt, Cochran, Mitchell, Coleman, & Frazier, in preparation)

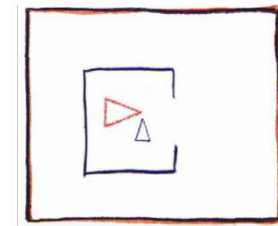
Clinical Assessment of Social Skills

- Autism Diagnostic Observation Schedule (ADOS-2)
- Social Responsiveness Scale (SRS)
- IQ: WAIS Reasoning and Vocabulary Subtests
- Attention Measure
- Child Behavior Checklist (CBCL) ADHD Score

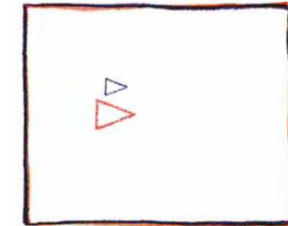


Theory of Mind (ToM)

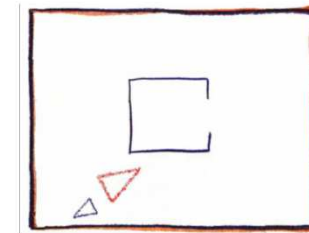
- Ability to attribute mental states to others
- Abell et al. (2000): Participants judged whether they saw a social interaction in displays of animated geometric shapes



Theory of Mind
MCQ Feelings



Goal-Directed



Random

Is social synchronization related to clinical and cognitive measures of social competence?

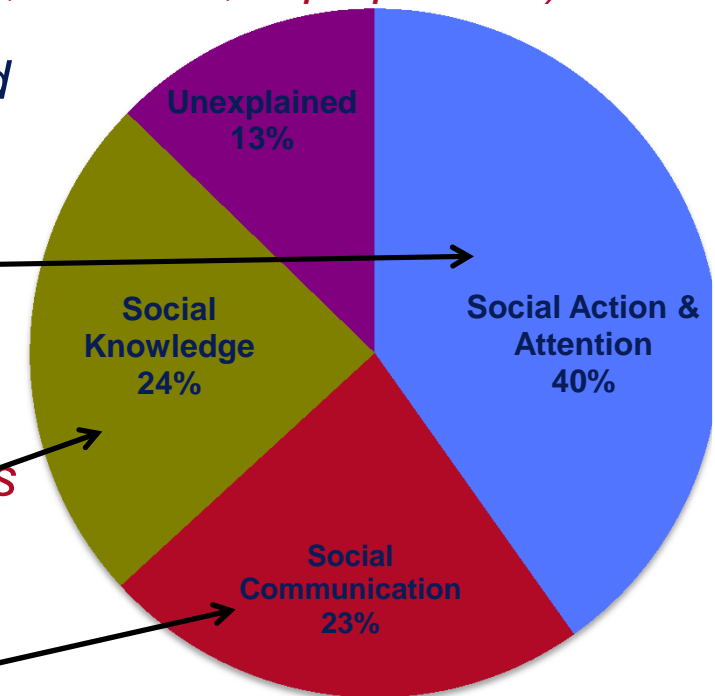
(Fitzpatrick, Schmidt, Cochran, Mitchell, Coleman, & Frazier, in preparation)

PCA explained 87% of the variance and revealed three underlying components

1.) **Social action/attention** factor loaded intentional synchrony (-.92), ADOS (.60), CBCL ADHD (.89), and SRS (.82)

2.) **Social knowledge** factor loaded spontaneous synchrony (.92), and ToM (.76)

3.) **Social communication** factor loaded IQ (-.86), ADOS (.66), and SRS (.44)



Results verify that social competence is a multi-dimensional construct...

... Social synchrony (both intentional and spontaneous) was related to two of the three components

- **Further evidence that social synchrony is an objective bio-behavioral marker for autism**

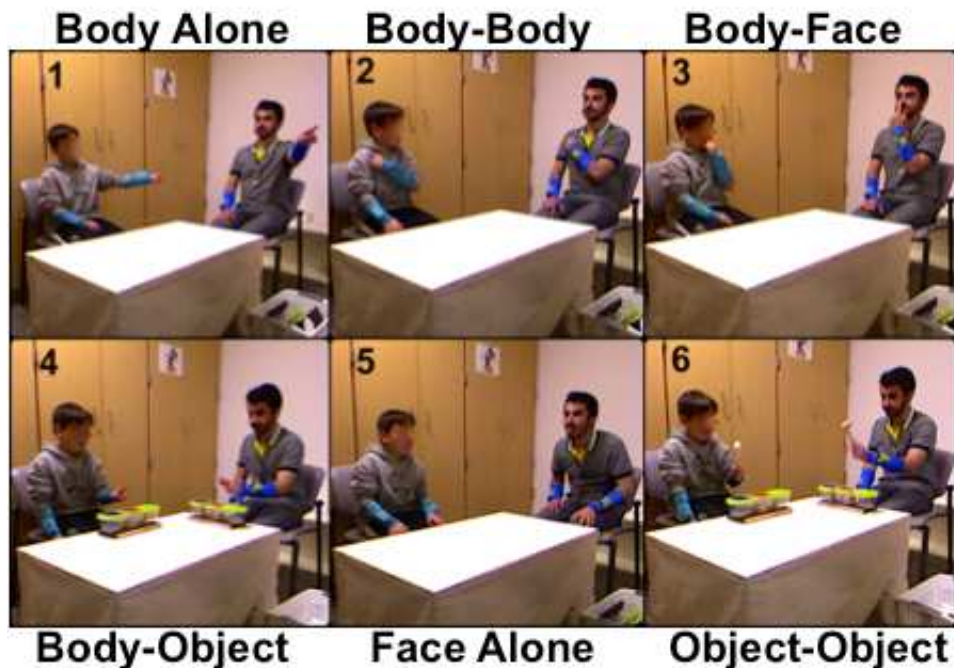
Intentional social synchrony in younger children and its relationship to imitation and motor skills

(Fitzpatrick, Diorio, Richardson & Schmidt, 2013; Fitzpatrick, Romero, Amaral, Thomas, Duncan, Barnard, Richardson & Schmidt, 2017a)

Participants

- **46 with ASD (Mean Age = 8.48 years, 39 M, 7 F)**
- **51 control participants (Mean Age = 8.3 years, 38 M, 13 F)**
- **Mean ADOS score of the ASD group was 11.11 (Range 6 – 20)**
- **Half completed imitation and half the synchrony battery**

inphase and antiphase bimanual drumming tasks



Intentional social synchrony in younger children and its relationship to imitation and motor skills

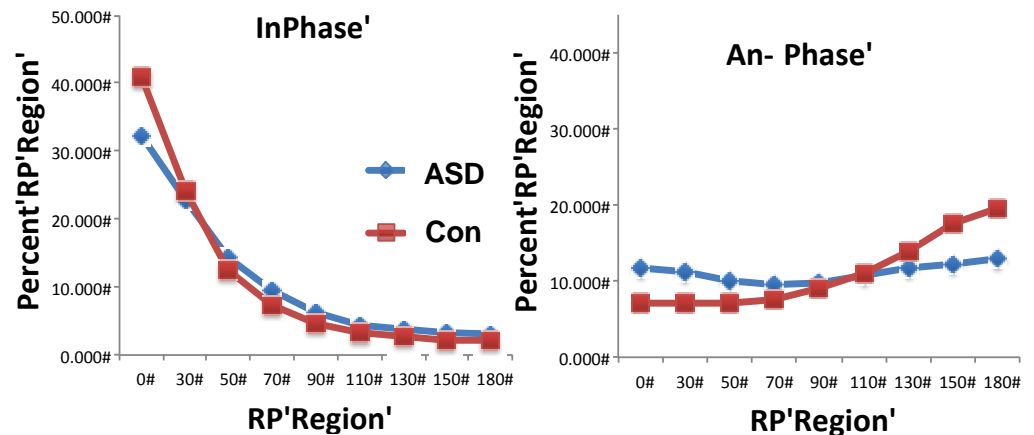
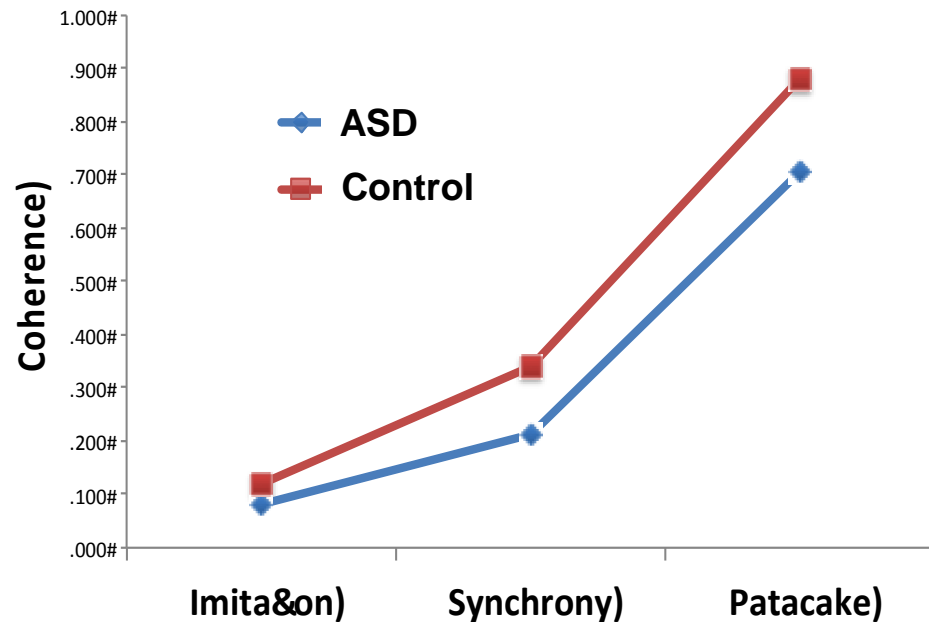
(Fitzpatrick, Diorio, Richardson & Schmidt, 2013;
Fitzpatrick, Romero, Amaral, Thomas, Duncan, Barnard, Richardson & Schmidt, submitted)

Does imitation and social synchrony differentiate children with ASD?

- Control subjects were significantly better for all three tasks
- Imitation was harder than synchrony and patacake
- Larger group difference for synchrony and patacake than imitation

Were there group differences in motor control?

- ASD were worse than control at both drumming tasks
- Anti-phase was harder than in-phase for both groups
- There was a larger difference between the groups for anti-phase drumming



Is social synchronization related to clinical and cognitive measures of social competence?

(Fitzpatrick, Romero, Amaral, Thomas, Duncan, Barnard, Richardson & Schmidt, 2017b)

Theory of Mind (ToM) Tasks

- **Sally-Anne False-belief Task** (Baron-Cohen et al., 1985)
- **Smarties Task** (Luckett et al., 2002)
- **Contents False Belief** (Wellman & Liu, 2004)
- **Choose Drawing** (Peterson, 2002)
 - Mean composite score for all tasks calculated



Attention Tasks

- **Initiating Joint Attention (IJA) Task** (Warreyn et al., 2005)
- **Gaze monitoring task: Responding to Joint Attention (RJA)** (Leekham et al., 1997; Warreyn et al., 2005)

Intention Perception Tasks

- **Behavioral Re-enactment Task** (Meltzoff, 1995)
- **Visual Perspective Taking Task** (Warreyn et al., 2005)



Cooperative Games

Double-tube Task
(Gräfenhain et al., 2009)



Turn-Table Turn-Taking
(Fitzpatrick et al., 2013)



Clinical Assessments of Social Skills

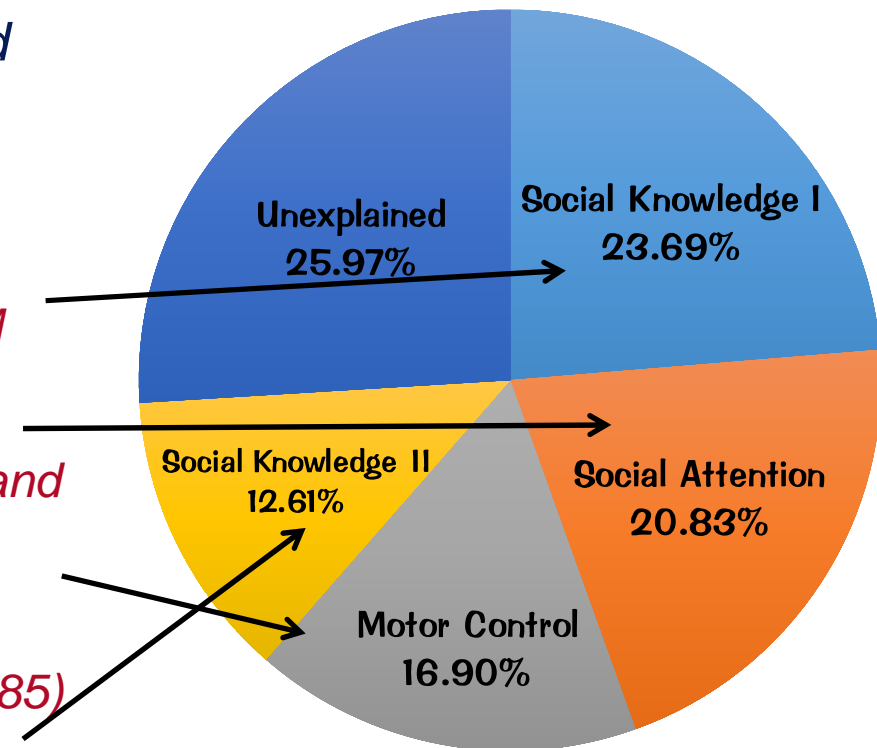
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Is social synchronization related to clinical and cognitive measures of social competence?

(Fitzpatrick, Romero, Amaral, Thomas, Duncan, Barnard, Richardson & Schmidt, 2017b)

A principal components analysis explained 74% of the variance and revealed four underlying components

- 1.) **Social knowledge** factor loaded *Patacake* (.82), *Cooperation* (.77), *ADOS* (-.69), and *ToM* (.63)
- 2.) **Social attention** factor loaded *ADHD* (.90) and *SRS* (.89)
- 3.) **Motor control** factor loaded *Inphase Drumming* (.85) and *Respond Joint Attention* (.85)
- 4.) Another **Social knowledge** factor loaded *Social motor battery* (.88) and *ToM* (.85)



Intentional social synchrony loaded on social knowledge dimensions but not social attention

Motor control is a separate factor from social motor

- **Suggests that social motor deficit is not a motor but a social deficit**

Is natural spontaneous social synchrony related to ASD social competence?

(Romero, Fitzpatrick, Roulier, Duncan, Richardson, & Schmidt, under review)

Past research as found spontaneous social synchrony...

- in both structured (Shockley et al, 2003, 2009) and free (Paxton & Dale, 2013) conversation interactions
- is associated quality of therapeutic outcome in schizophrenia (Ramseyer & Tschachter, 2011)

Evaluated bodily movements of an ASD child and therapist in clinical interviews....

ADOS Conversation and reporting subtask

- 28 videos of child-therapist were used
- Conversation about task outcome or vacation
- Lasted on average 3.5 minutes
- Activity time series of child and therapist were created using video-based motion capture



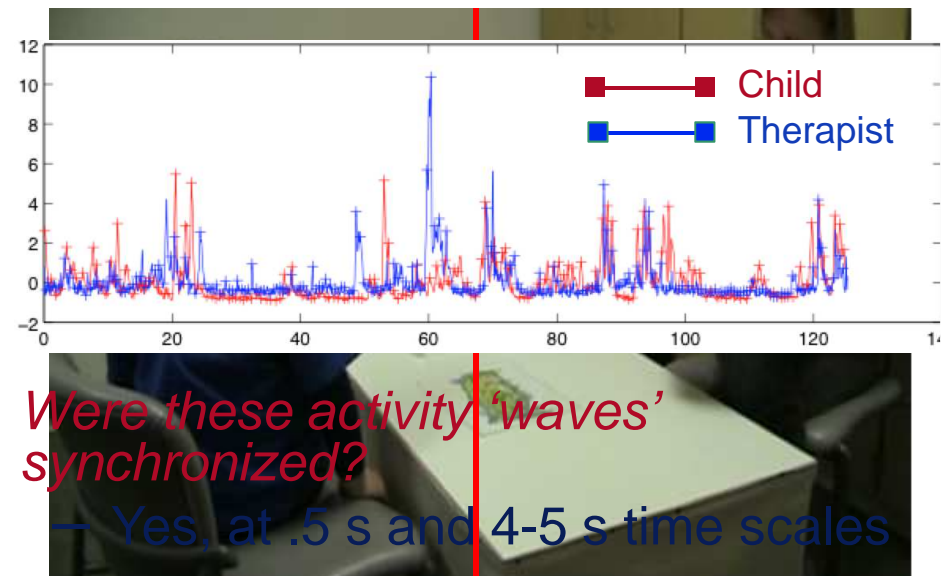
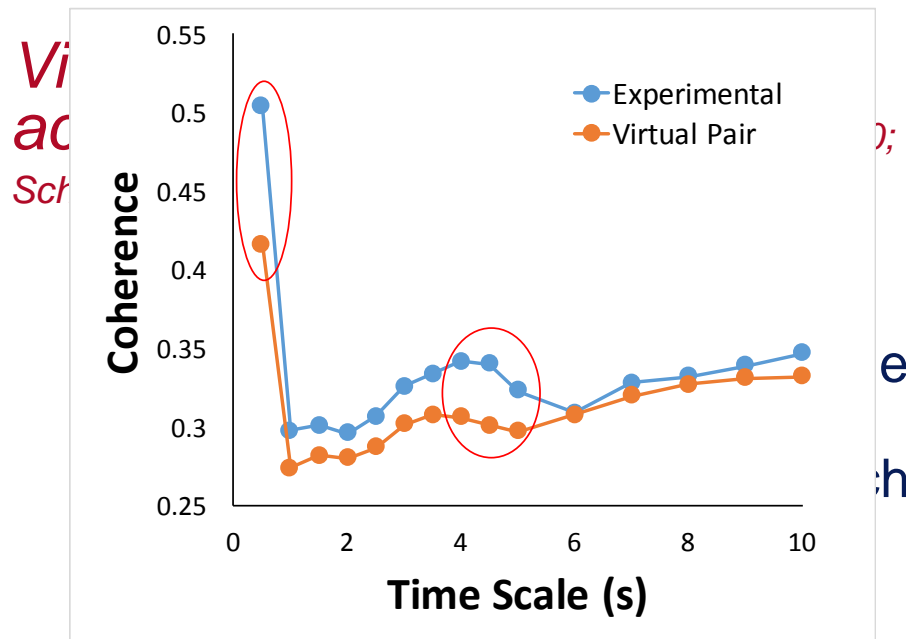
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Fractal/multifractal 'motor signature' of activity

Indicative of metastability and 'health' of the system (Peng et al, 1995)

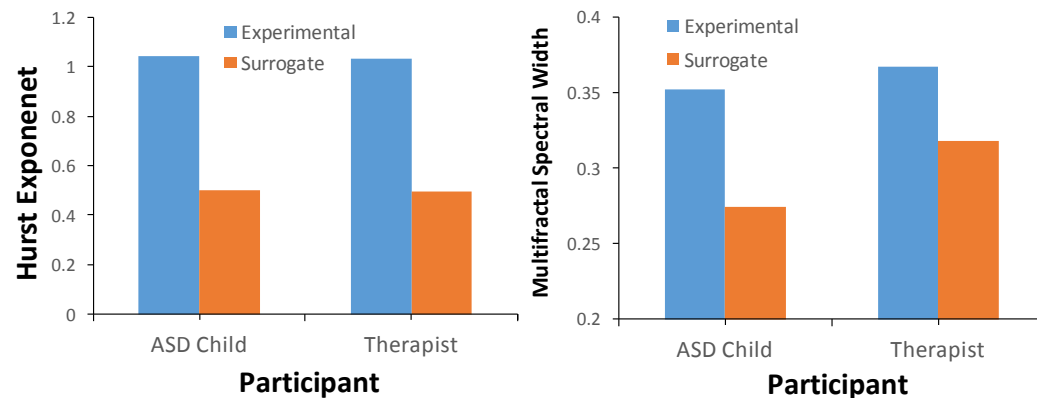
Fractal structure: Long-range correlations in the structure of the noise across time scales

- *Detrended fluctuation analysis (DFA): Hurst exponent*

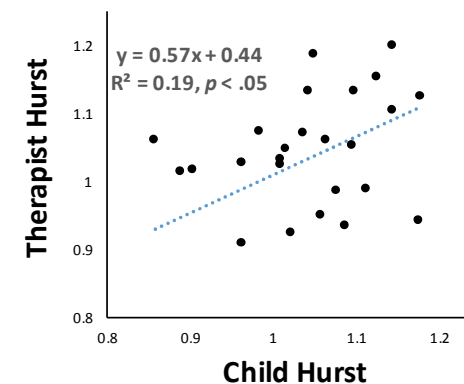
Multifractal structure: measurement of variability in the scaling exponent in systems with intermittent dynamics

- *Multifractal spectral width (Ihlen, 2013)*

Significant fractal and multifractal structure to activity



Fractal structure of therapist is related fractal structure of child!



Did spontaneous social synchrony and fractal motor signature predict ASD social competence?

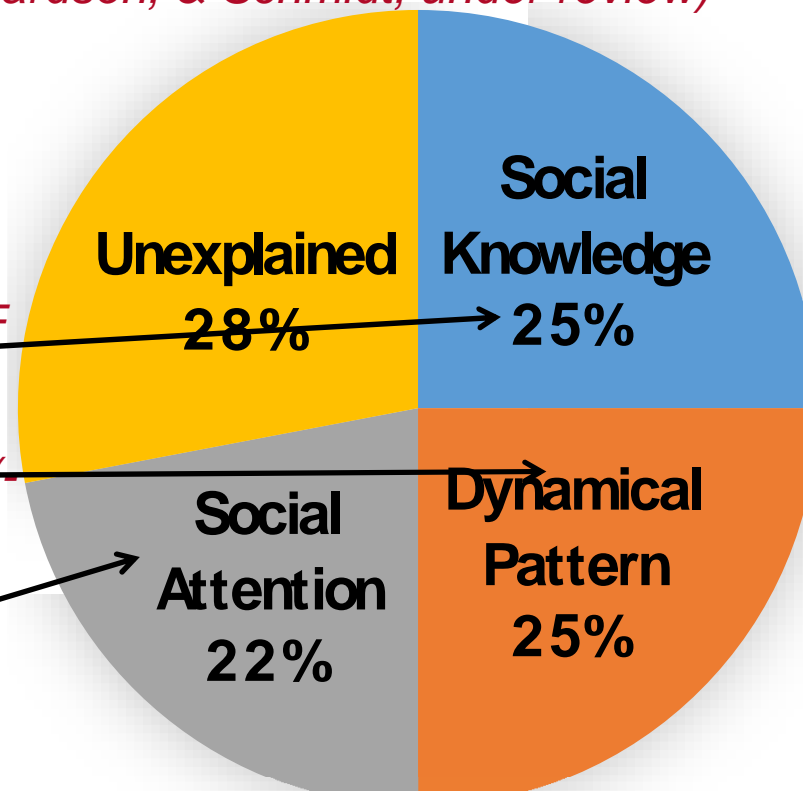
(Romero, Fitzpatrick, Roulier, Duncan, Richardson, & Schmidt, under review)

A principal components analysis explained 72% of the variance and revealed three underlying components

1.) Social knowledge factor loaded ToM (-.80), MF Width Child (.84), and Synchrony at 1 s (.57)

2.) Dynamical pattern factor loaded Fractal Child (-.92) and Synchrony at .5 s (.91)

3.) Social attention factor loaded Respond Joint Attention (.84), ADOS (.64) and Synchrony at 1 s (-.41)



Spontaneous social synchrony is related to both social knowledge and social attention measures

Fractal/multifractal motor signature of activity is related to social synchrony as well as social knowledge

- Suggests that such motor measures of natural activity might provide an objective bio-behavioral marker for autism (Mirman et al. 2012)**

Is there social motor deficit in ASD?

Social motor synchrony differentiated ASD groups from controls across three experiments

- Across tasks (rocking chairs, pendulums, social motor battery)
- Across age groups (3, 8 and 14 year olds)

Social motor synchrony was associated with the severity of ASD as measured by the ADOS

- Across three tasks: intentional pendulum swinging, patacake task, spontaneous synchrony during conversation

Evidence that social synchrony is perhaps a bio-behavioral marker for autism...

Is this social motor deficit related to motor and social cognitive deficits in ASD?

Seems not to be solely dependent on a motor deficit...

- Rhythmic drumming deficit was independent of social motor deficit in PCA

Social motor synchrony was associated with a social attention deficit

- Intentional pendulum swinging, spontaneous synchrony during conversation

Social motor synchrony was associated with a social knowledge (ToM) deficit

- Spontaneous pendulum swinging, patacake task, social motor battery, spontaneous synchrony during conversation

Social motor synchrony seems to be an embodiment of social cognitive abilities that underlie social connectedness

Social Motor Deficits in ASD

Implications

Early diagnosis of ASD in at-risk infants

- May be a prodrome to ASD
- Method: Use videos of natural mother-child play interactions
- To be used in concert with other motor measures

Therapy for recently diagnosed infants and toddlers

- Making people synchronize increases affiliation (Hove & Risen, 2009; Wiltermuth & Heath, 2009)
- Improvisational music therapy (Kim et al, 2008)
- Dance therapy (Hildebrandt et al, 2016; Srinivasan et al, 2015)

Thank you!

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📖 David Cochran, MD

Our social competence is embodied, dynamic, and emergent

- Our sociality emerges from our dynamic interactions with others in our social world
 - dynamic interactions multiple, nested time scales
- Our social competence, our ability to get along, is measured by the stability of this emergent social dynamic
 - This “social” stability rests upon our social cognitive skills
 - This “social” stability is embodied and can be evaluated in the stability of social motor movements in interactions

