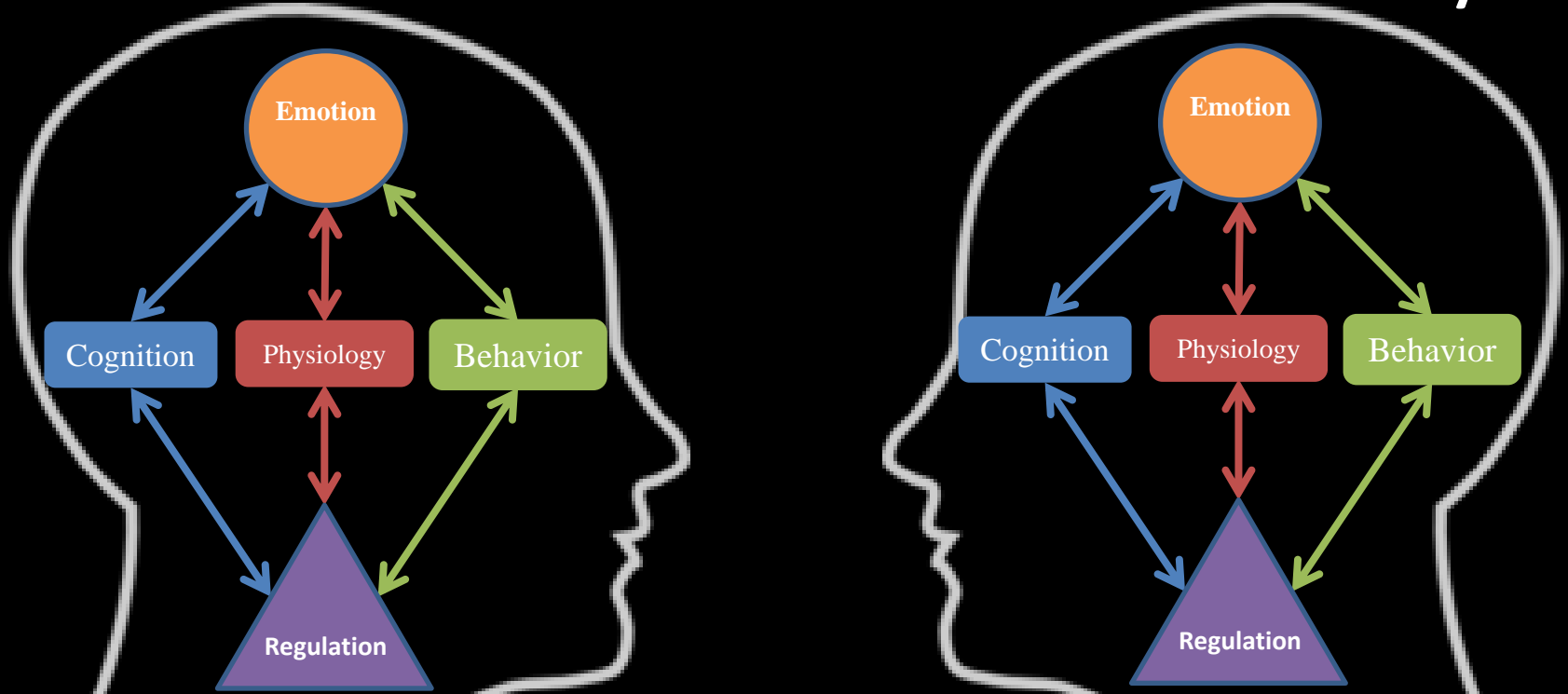
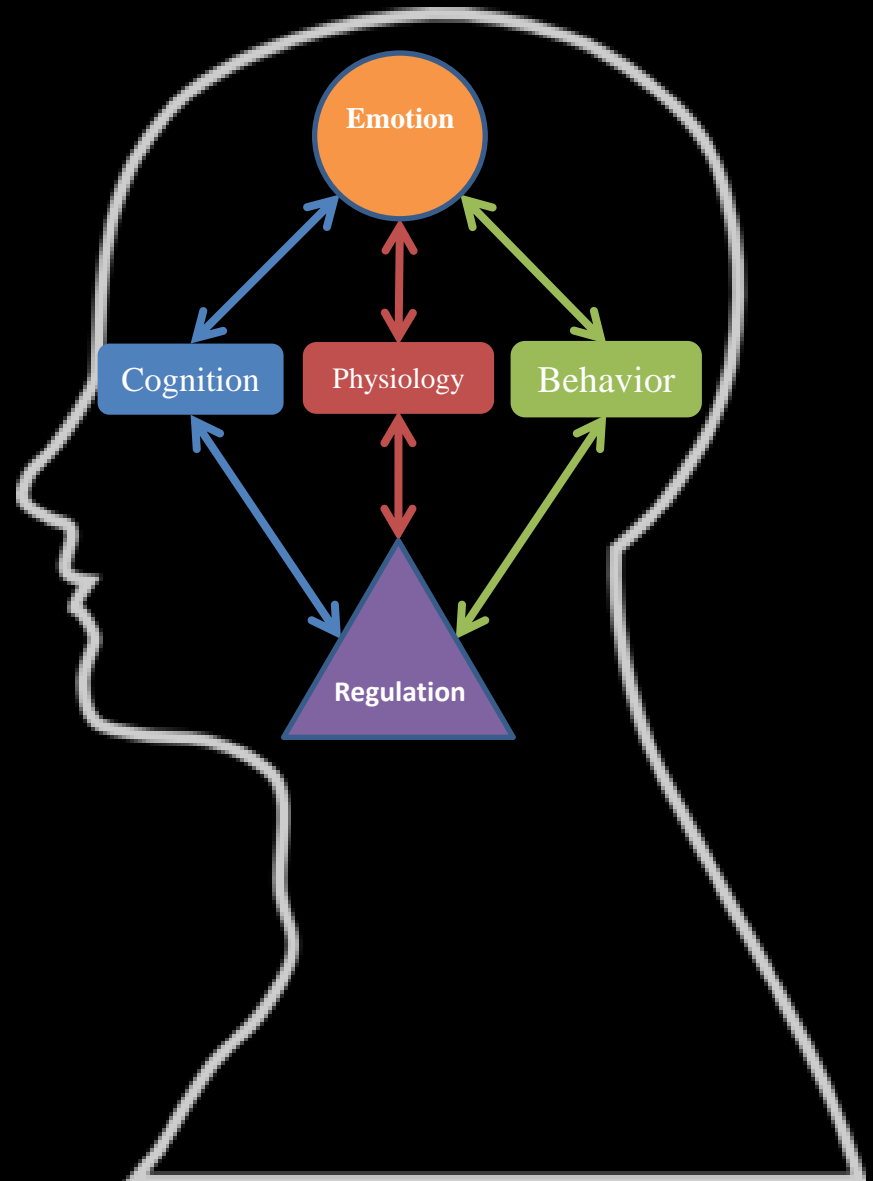
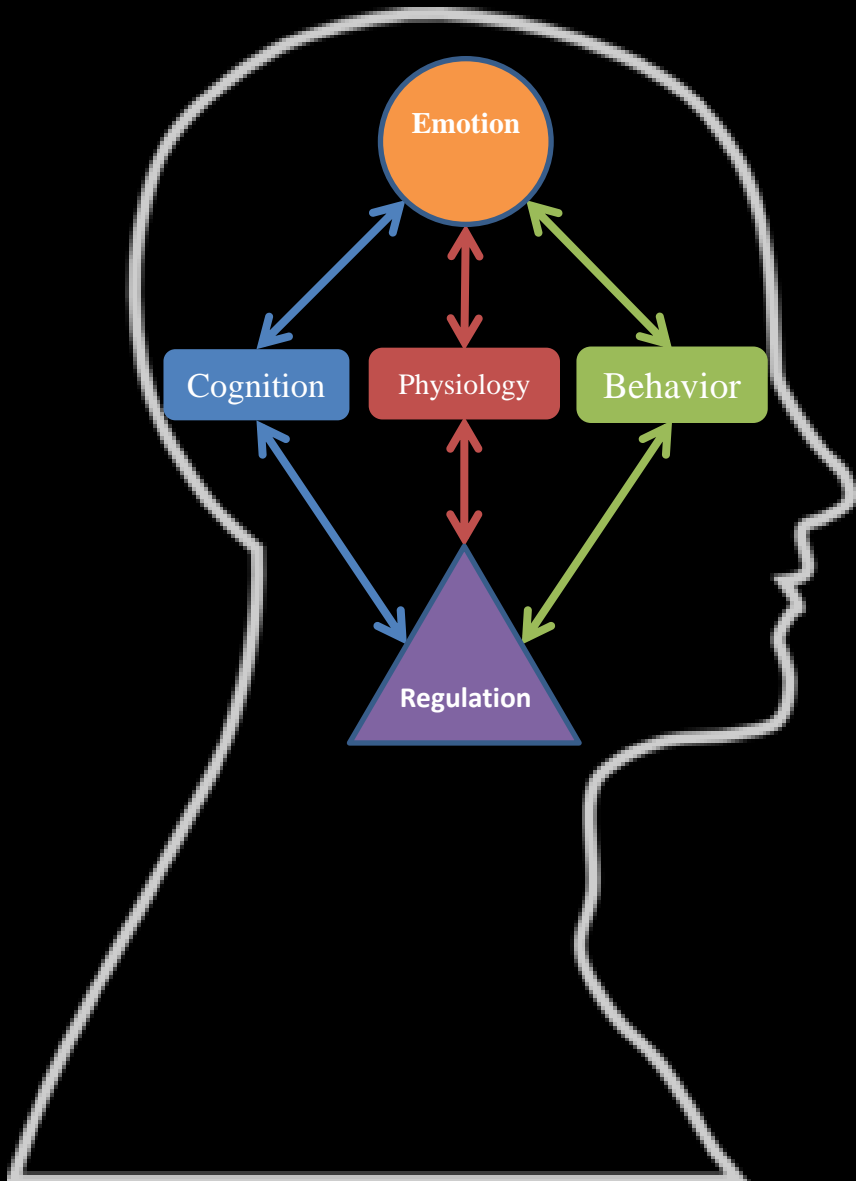
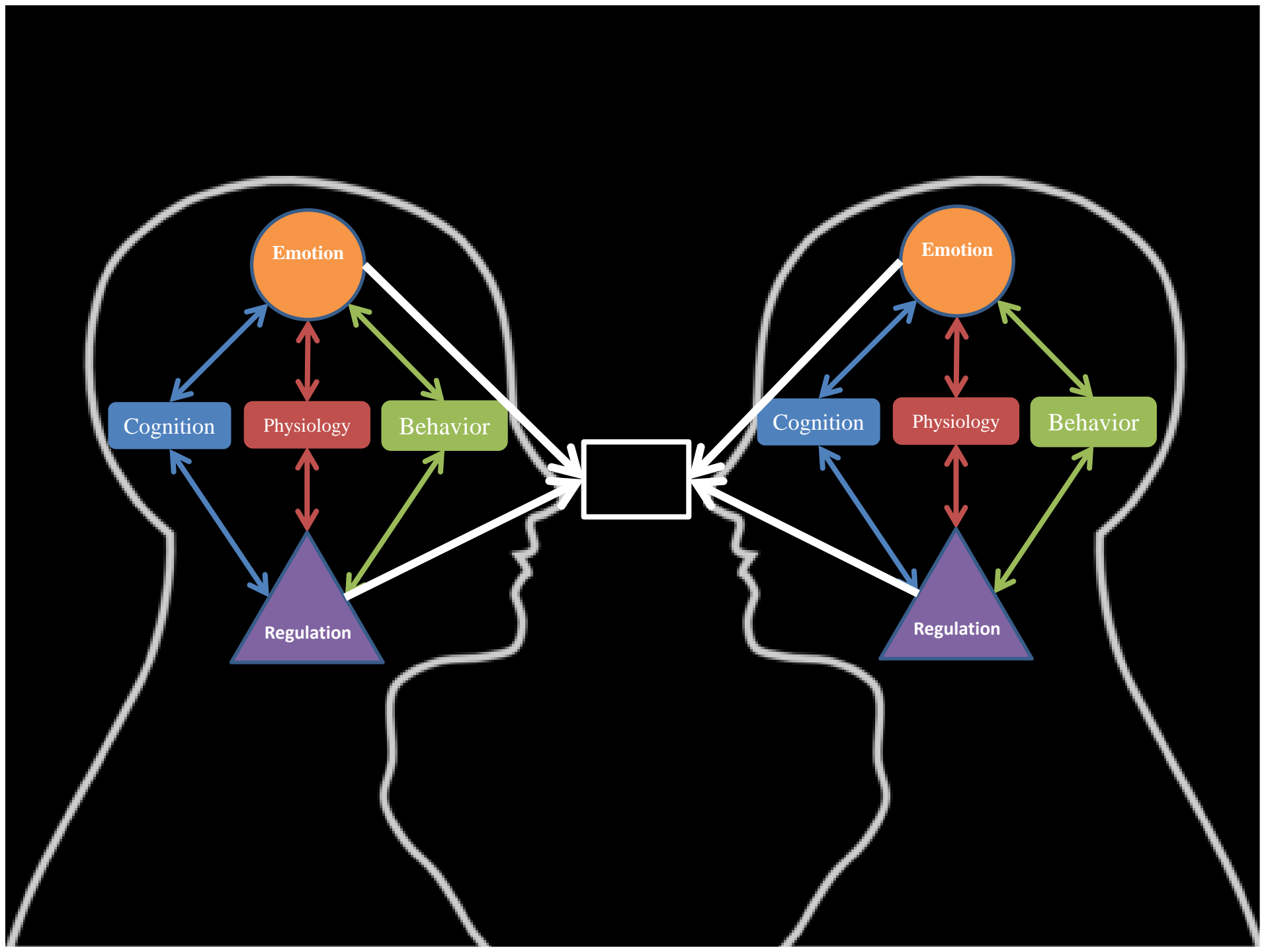


# State Space Grids and Multivariate Multilevel Survival Analysis



Tom Hollenstein  
Queen's University





# Emotion Dynamics

- Rise & Fall of one state
  - Onset, Latency, Rise Time, Intensity, Duration, Offset (Thompson, 1990)
- State-to-state Change (Variability)
  - Flexibility/Rigidity, Diversity, Predictability, Inertia

# State Space Grids

# GridWare

[www.statespacegrids.org](http://www.statespacegrids.org)

**Filters**

family

A1  
B2  
C3

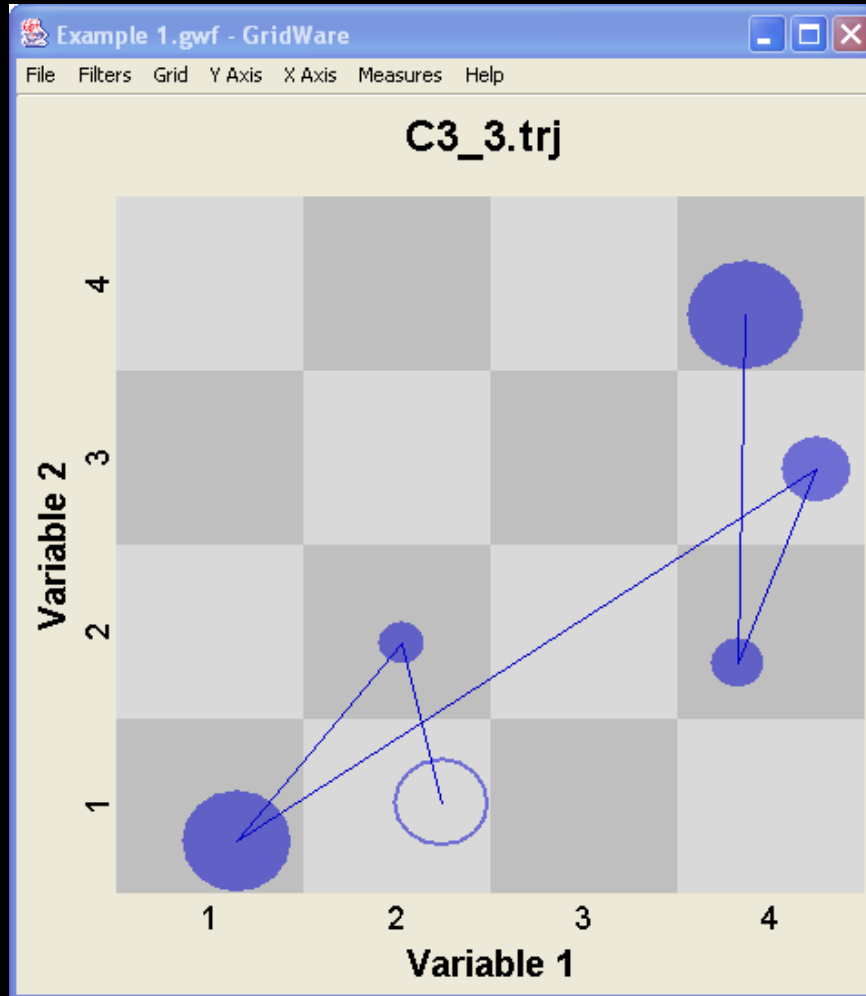
3 ≤ wave ≤ 3

10 ≤ age ≤ 12

gender

male  
female

0 ≤ time ≤ 15



**Measures**

**Grid Measures**

Selected Trajectories <input type="button" value="v"/>	1
Mean Missing Duration <input type="button" value="v"/>	0
Mean Missing Events <input type="button" value="v"/>	0
Mean Duration <input type="button" value="v"/>	15
Mean # of Events <input type="button" value="v"/>	6
Mean # of Visits <input type="button" value="v"/>	6
Mean Cell Range <input type="button" value="v"/>	6
Overall Cell Range <input type="button" value="v"/>	6

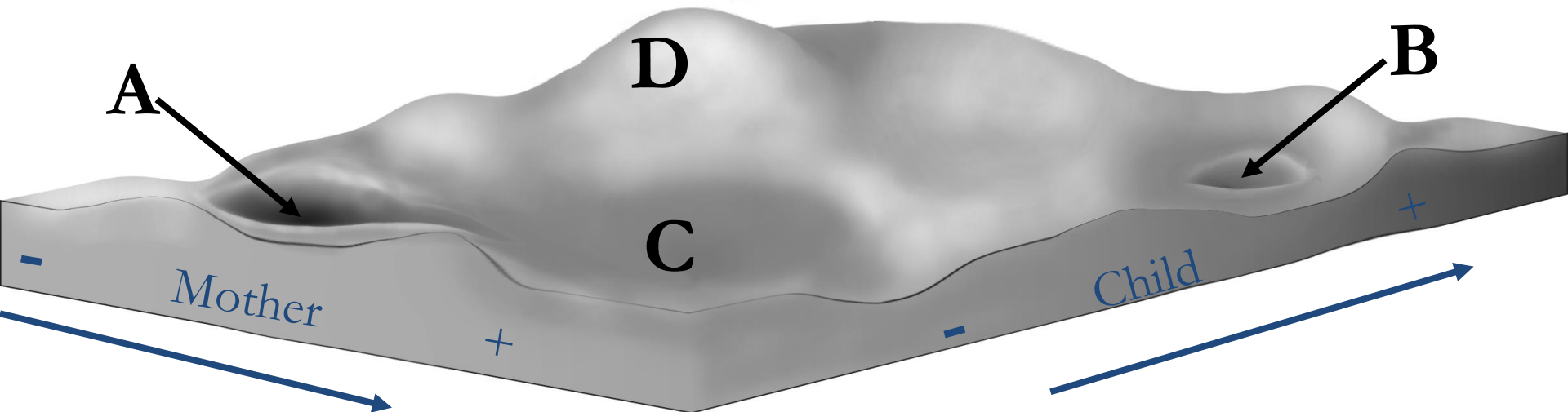
**Region Measures**

Selected Cells <input type="button" value="v"/>	0
Mean Duration <input type="button" value="v"/>	0
Mean # of Events <input type="button" value="v"/>	0
Mean # of Visits <input type="button" value="v"/>	0
Mean Cell Range <input type="button" value="v"/>	0
Overall Cell Range <input type="button" value="v"/>	0

# State Space and Attractors

- State space: “space” of all *possible* states of a system
- Attractors: “absorbing” states that have a high probability of recurrence
- Repellors: states that rarely, if ever, occur.

# Hypothetical State Space



A = Deep (“strong”) attractor

= Mutual Negative

B = Shallow (“weak”) attractor

= Mutual Positive

C = Attractor basin

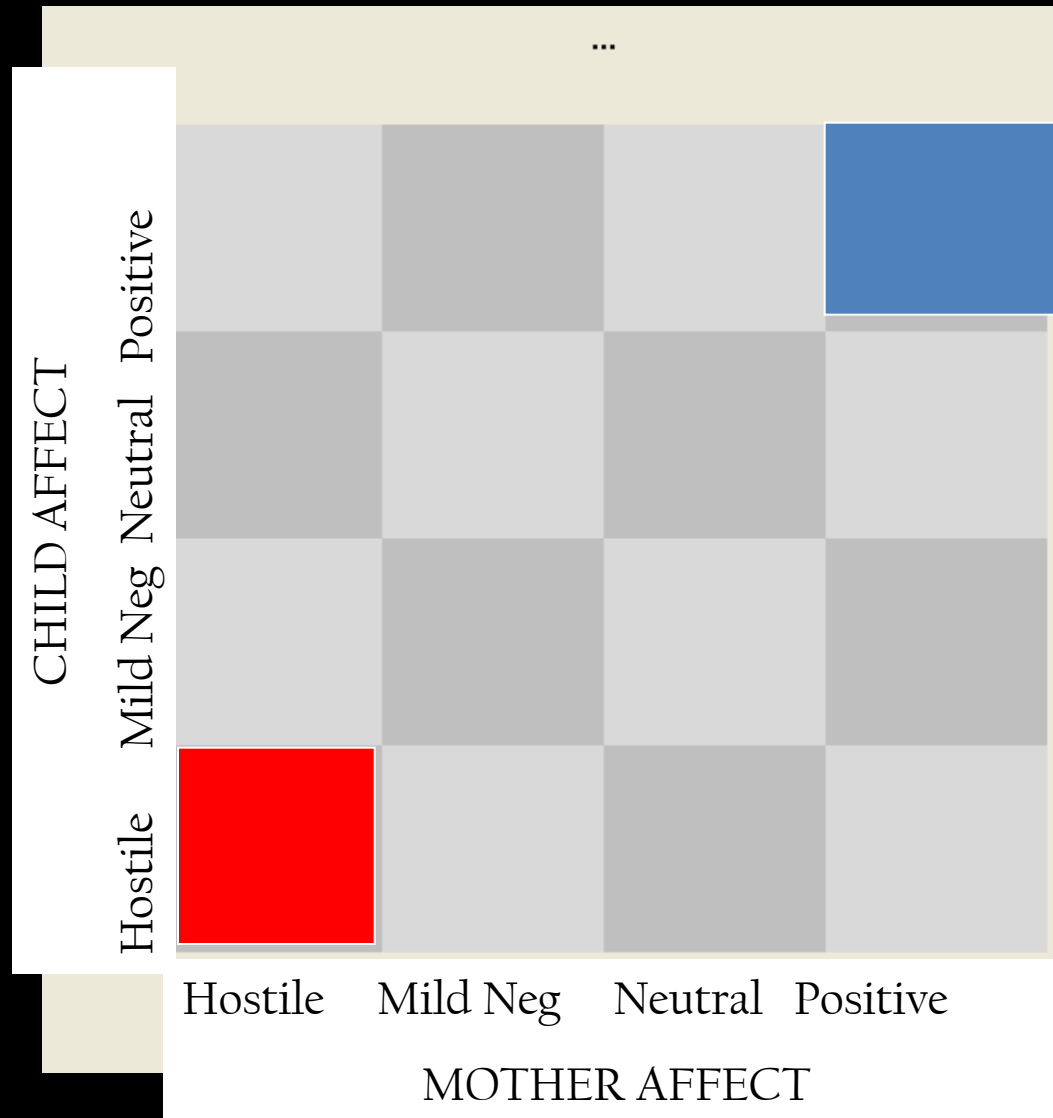
= Permissive

D = Repellor

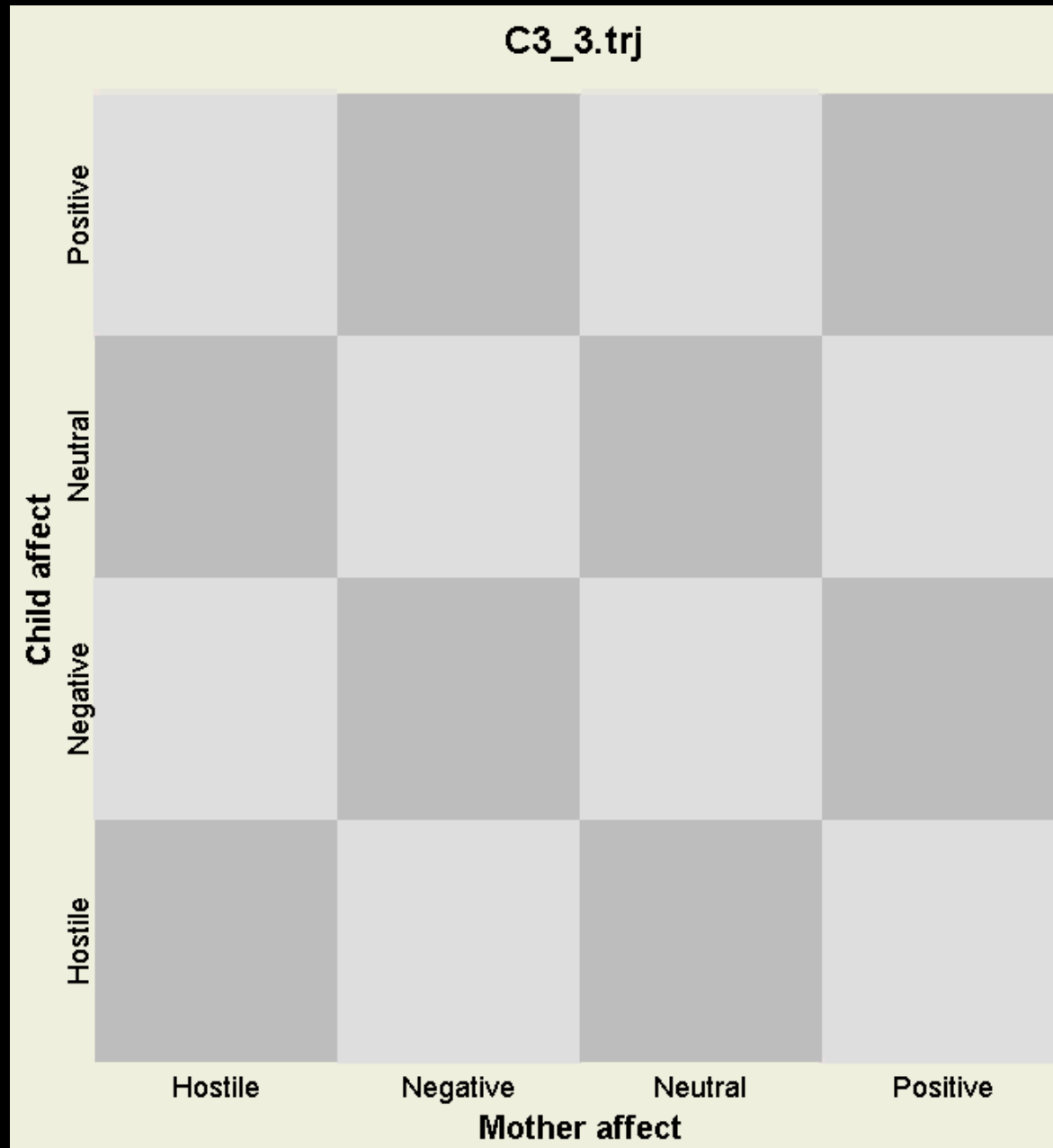
= Harsh



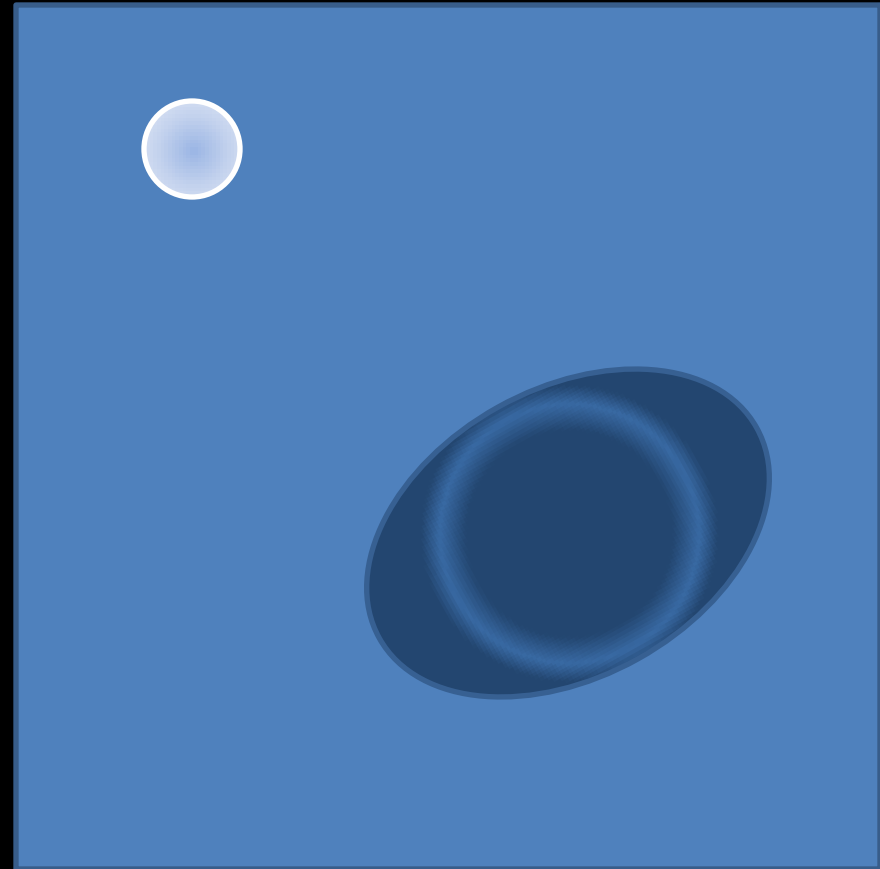
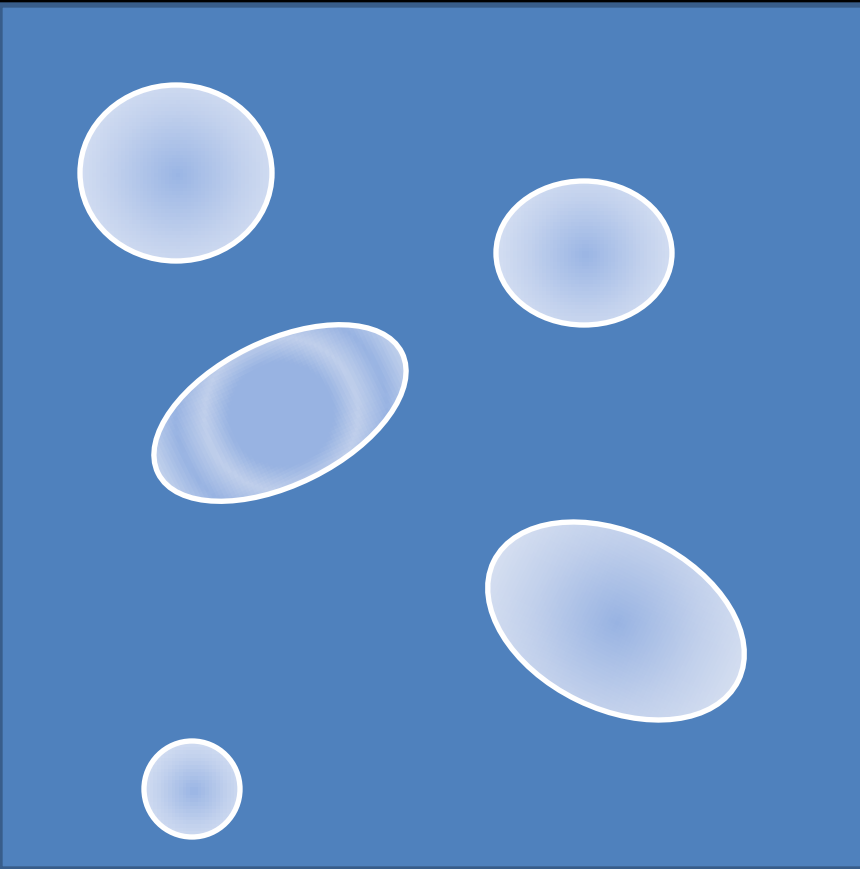
# State Space Grid: Dyad



# Plotting behavior on a State Space Grid



A well-regulated (flexible) system has  
many attractors



# SSG Variability

More Cells → Dispersion

More Transitions

Higher Entropy

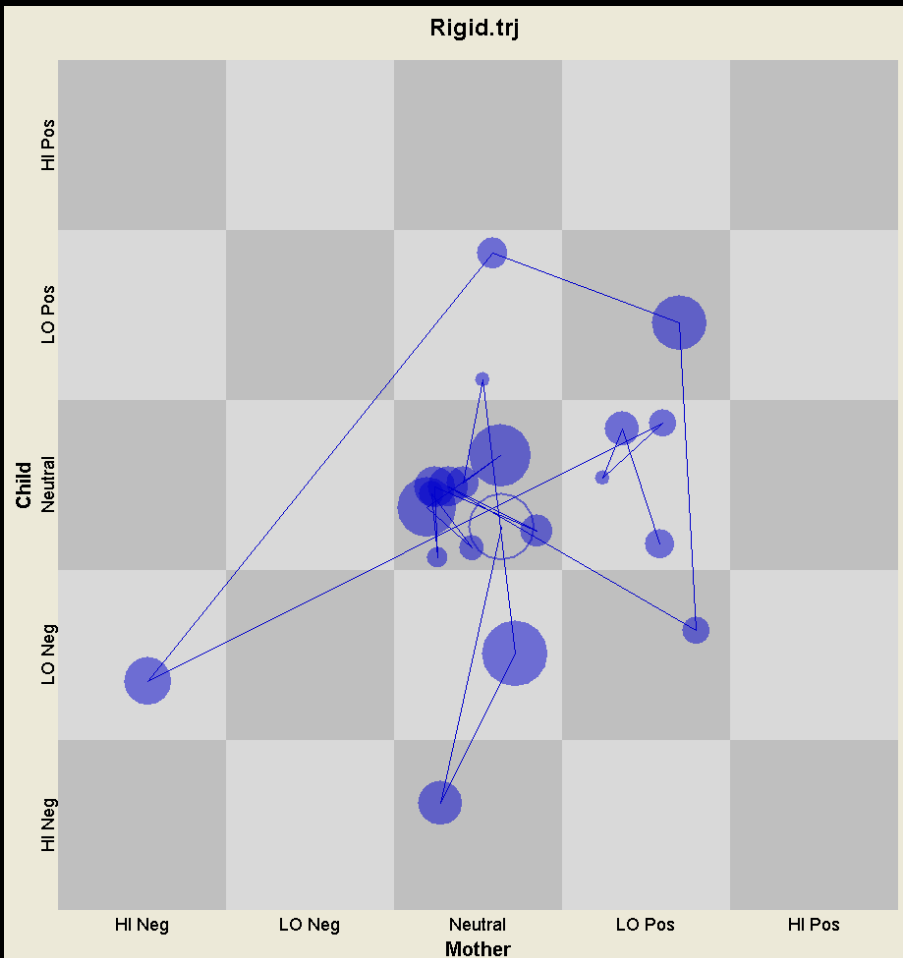
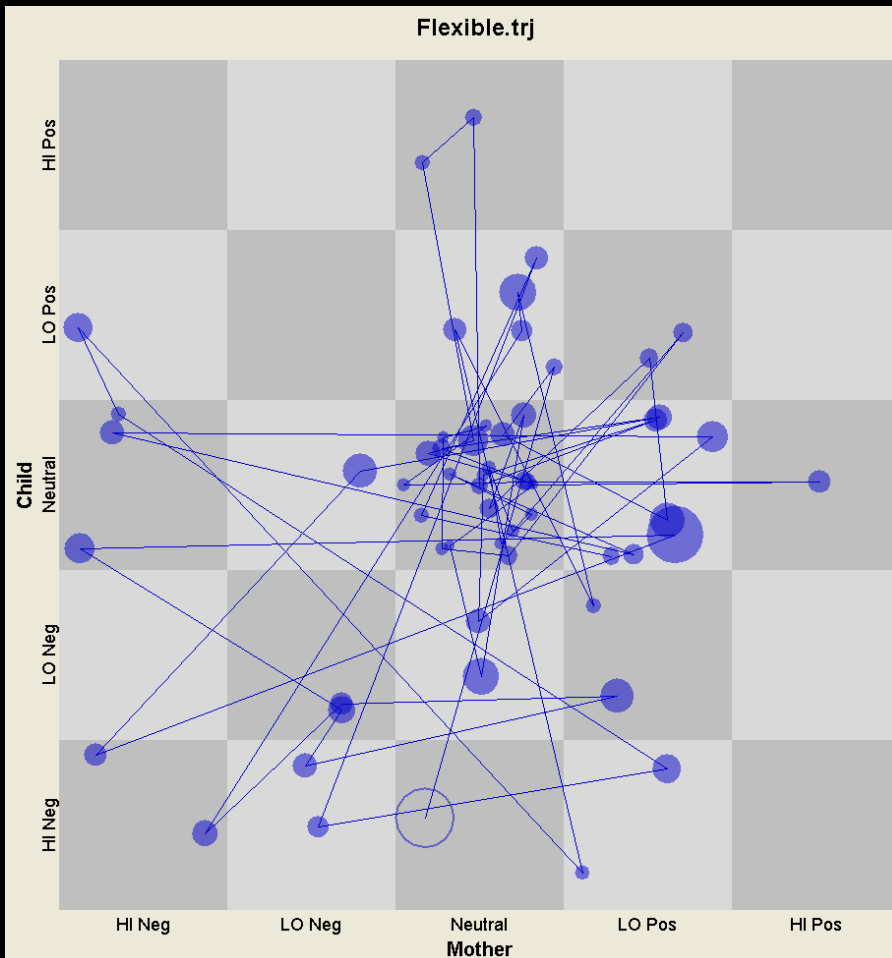
Shorter Average Durations

Fewer Cells → Dispersion

Fewer Transitions

Lower Entropy

Longer Average Durations



# Some Results to Date

- Parent-child rigidity associated with psychopathology and poor outcomes (e.g., Dishion et al., 2004; Hollenstein et al., 2004)
- Dyadic flexibility associated with child's inhibitory N2 amplitude (Lewis et al., 2012) and improvements due to treatment (Granic et al., 2007)
- Dyadic flexibility better predictor than individual flexibility (van der Giessen et al., in press)
- Patterns may be different in infancy and toddlerhood (Lunkenheimer et al., 2011; Sravish et al., 2014)

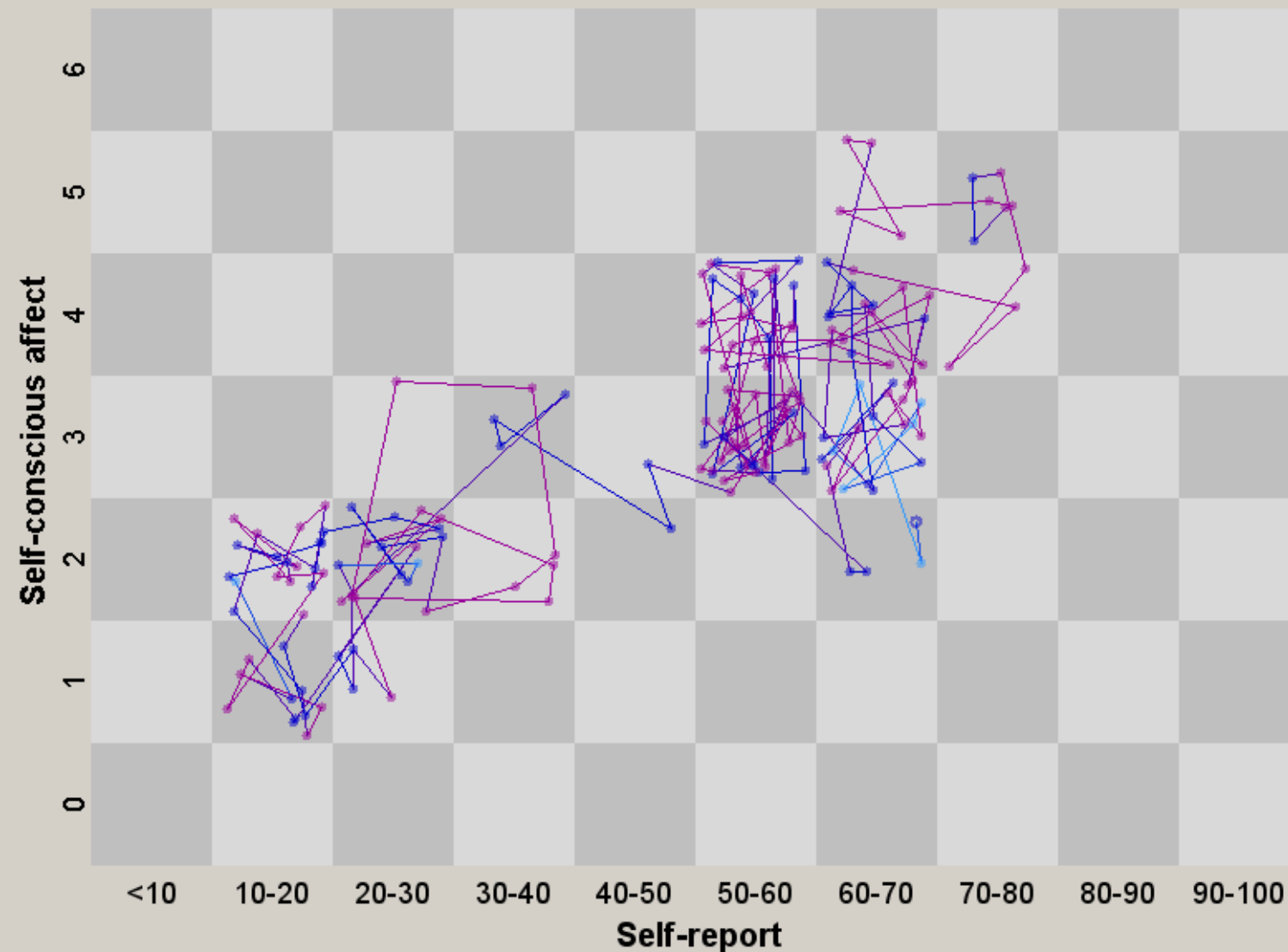
# Types of Analysis

1. Single cell or region (group of cells)
2. Whole-grid indices (e.g., flexibility)
3. Grid-to-grid change
4. 3 or more dimensions
5. Complementary Analyses: Attractor analysis with MMSA

SR-SCA  $r = .80$

(HR-SR =  $-.17$  HR-SCA =  $-.25$ )

VA048\_SCACHRSR.trj



HR %  $\Delta$  from  
Baseline

90 + %

80-90%

70-80%

60-70%

50-60%

40-50%

30-40%

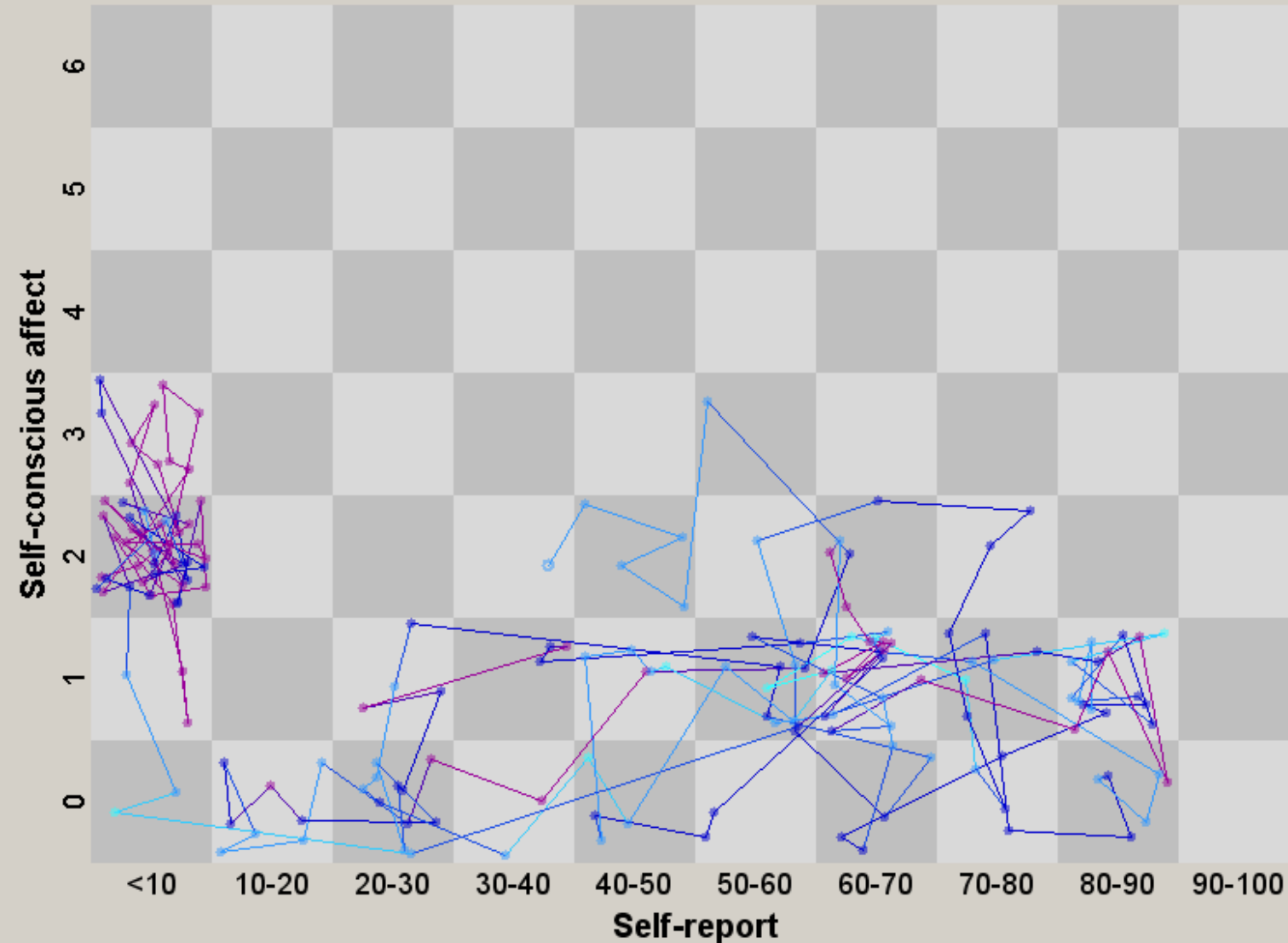
20-30%

10-20%

< 10%

SR-SCA  $r = -.46$   
(HR-SR = .37   HR-SCA = -.42)

VA113\_SCACHRSR.trj



HR % Δ from  
Baseline

90 + %

80-90%

70-80%

60-70%

50-60%

40-50%

30-40%

20-30%

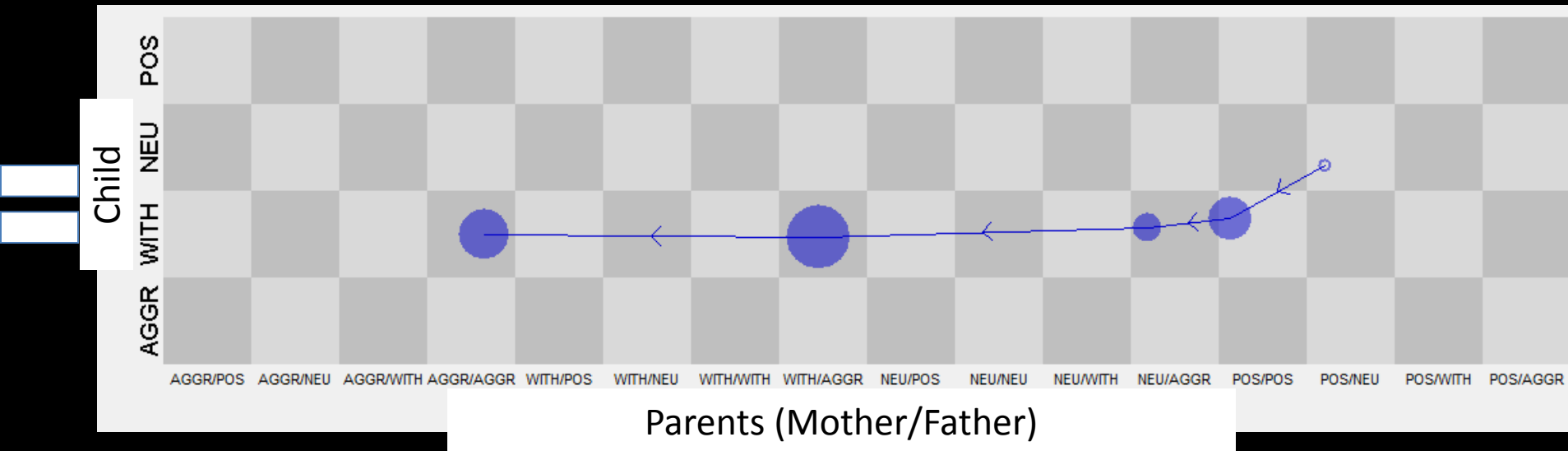
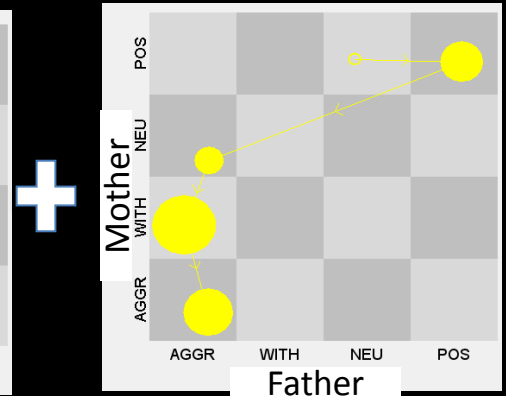
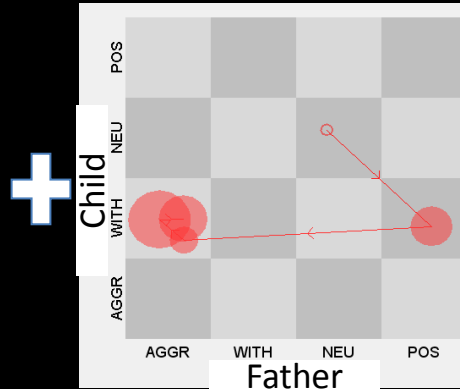
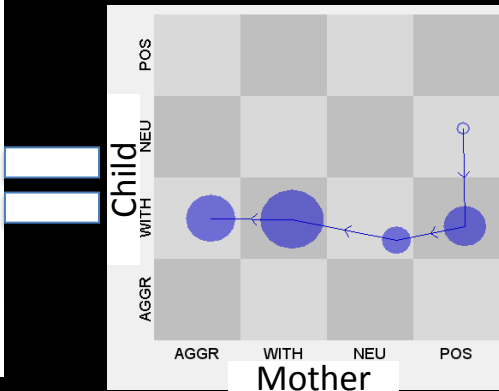
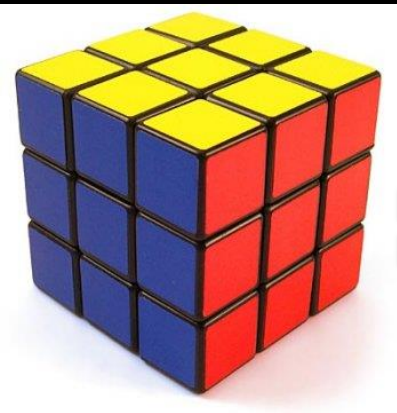
10-20%

< 10%

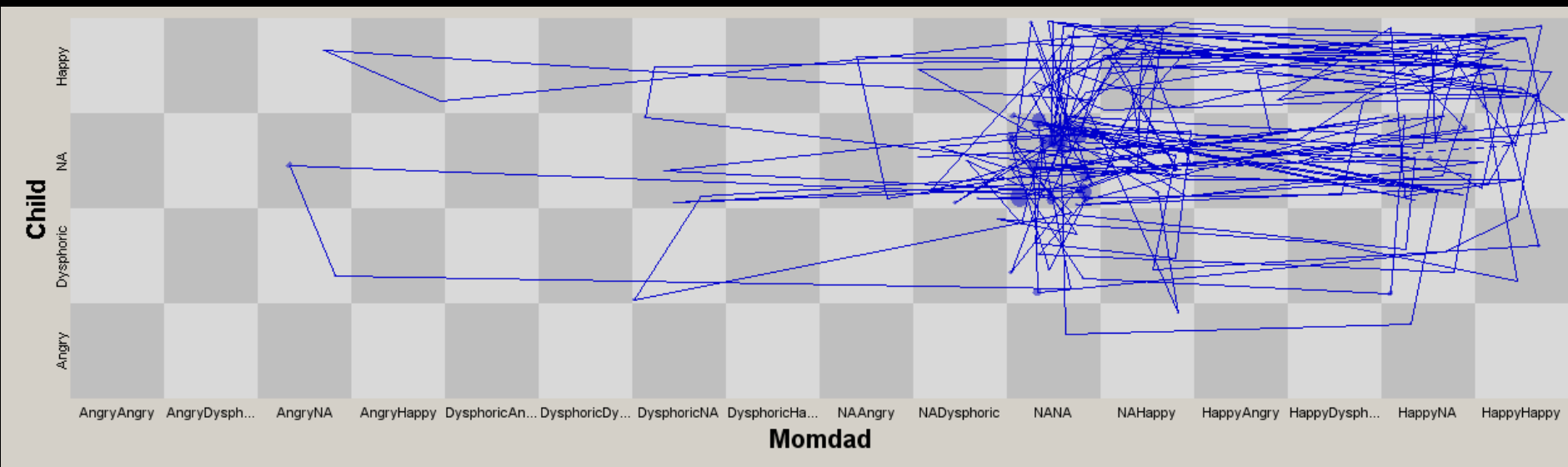
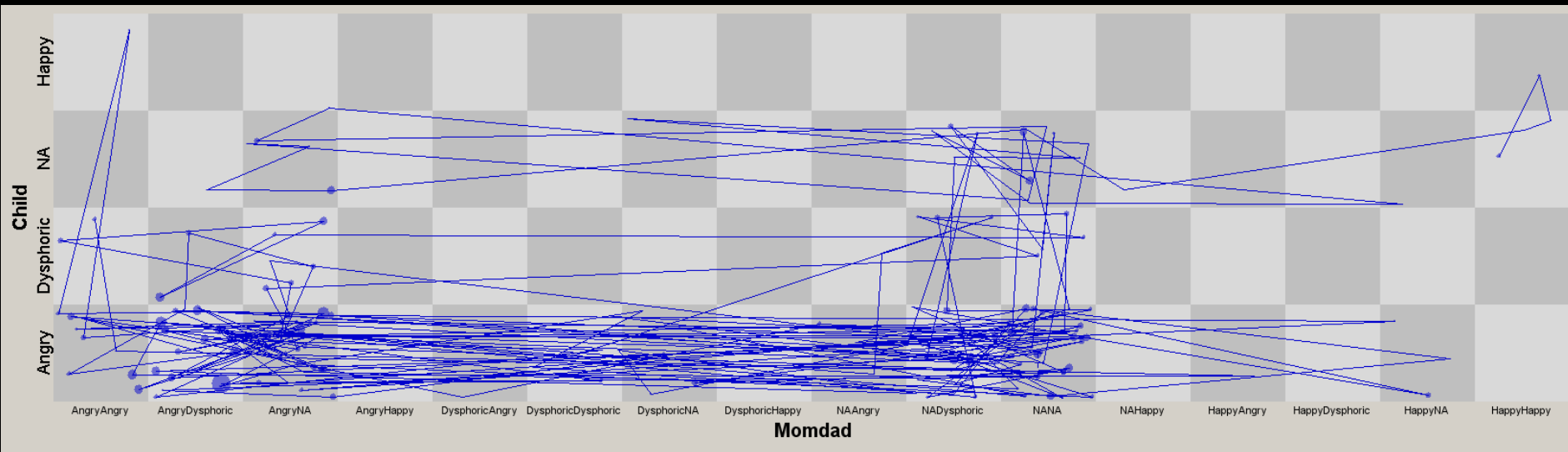


# Three 2D = One 3D

$4 \times 4 \times 4 = 4 \times 16 = 64 \text{ cells}$



# Hollenstein, Allen, & Sheeber (in press)



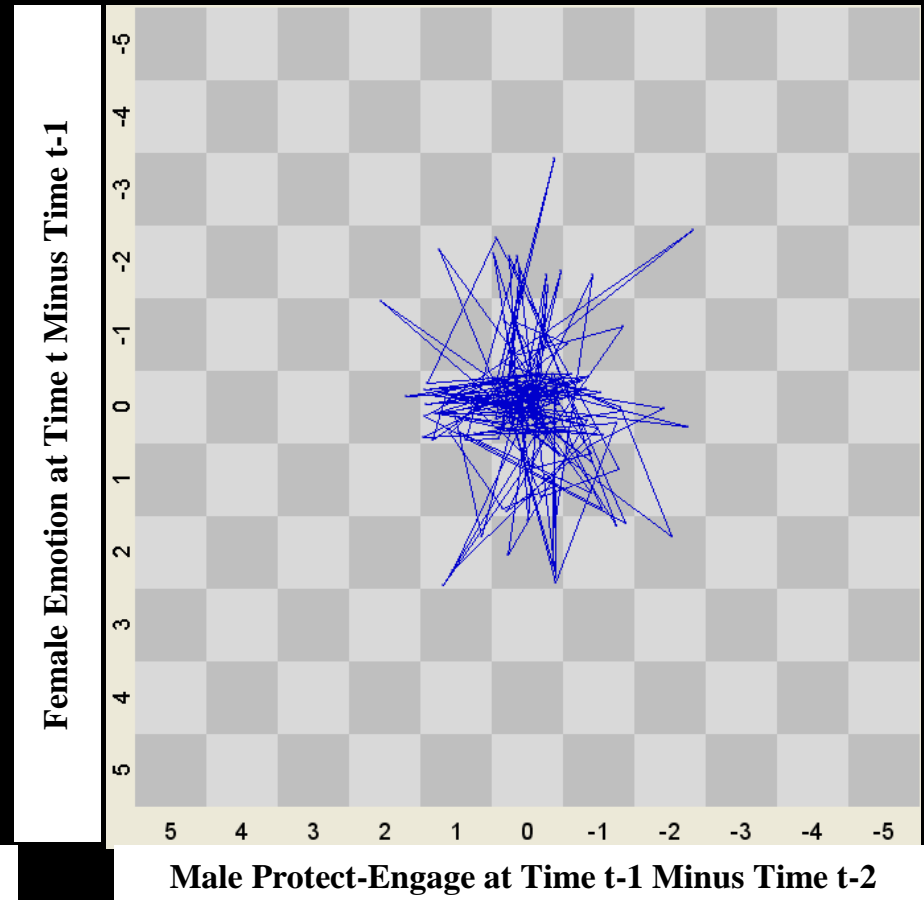
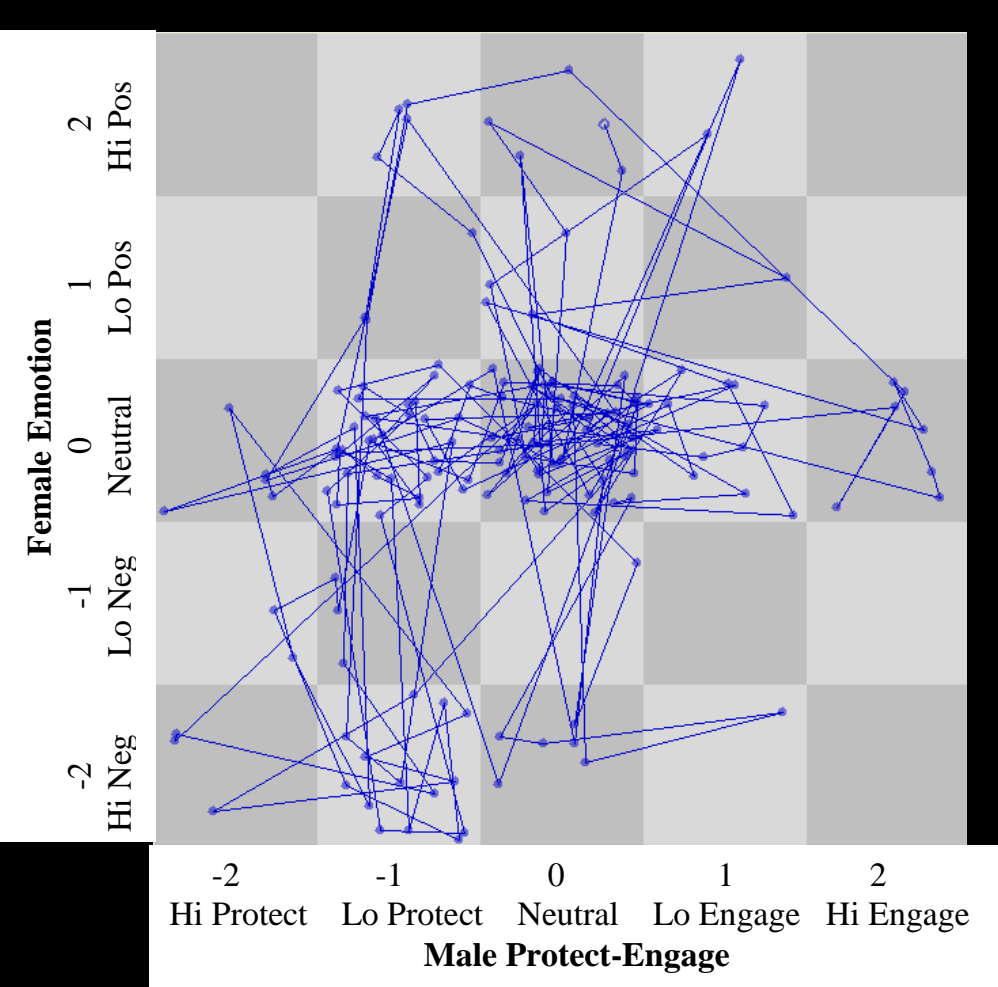
# Triadic Flexibility

(Hollenstein, Allen, & Sheeber, in press)

- Triads with depressed children →  
*more* Dispersion and Entropy  
(no Transition differences)
- Not just more negative affect
- Discriminant function analysis to get attractors
- Depressed triads: less triadic matching

# 3-step changes

$T1-T2\Delta \rightarrow T2-T3\Delta$



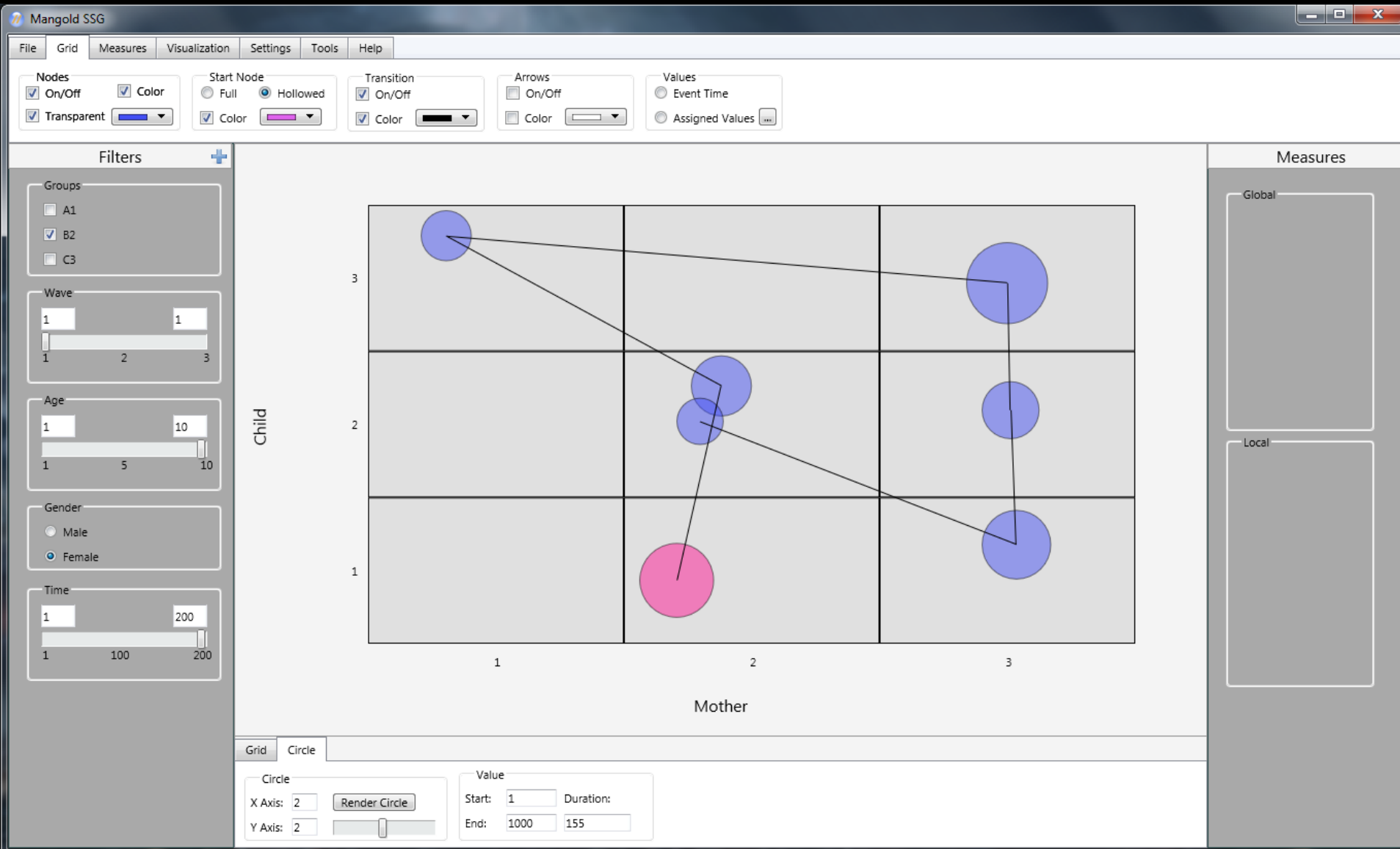
Butler, Hollenstein, Shoham, & Rohrbaugh (2013)

# Butler, Hollenstein, Shoham, & Rohrbaugh (2013)

- As predicted, double smokers successfully used engagement to down regulate partner negative affect
- Use of protective buffering had unintended effect of up-regulating negative affect

# New! State space grids in Mangold

[www.behavior-research.com](http://www.behavior-research.com)



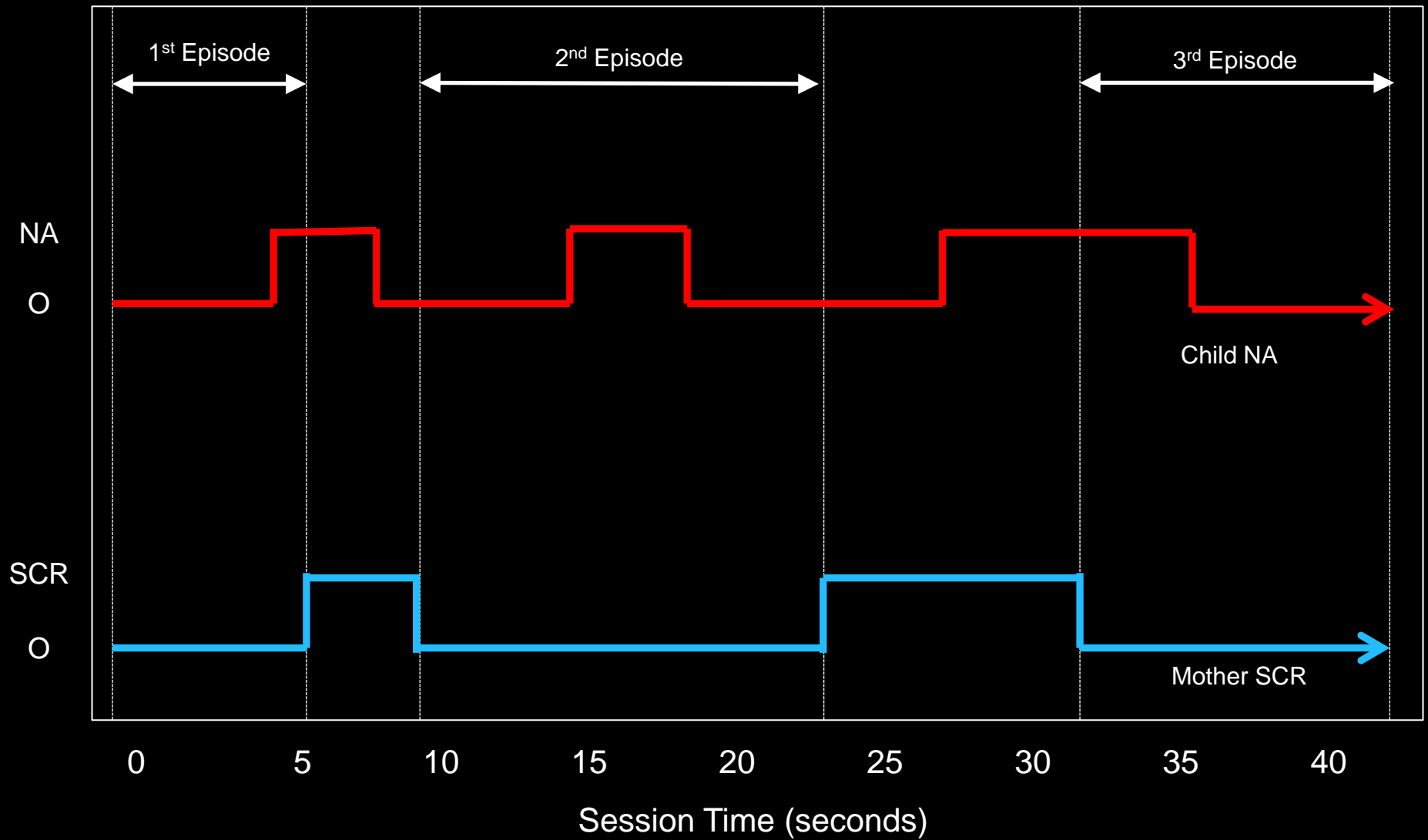
# Multivariate Multilevel Survival Analysis

Courtesy of Jess Lougheed

# Hazard Rate

- The hazard rate is the rate at which behaviors happen given that a person is at risk, that is, capable of experiencing the event.
- $H$  = the likelihood of a person performing the observable target behavior given that they are currently capable of doing so (i.e., they are not currently engaging in the behavior).
- The risk period is referred to as the waiting time or duration.





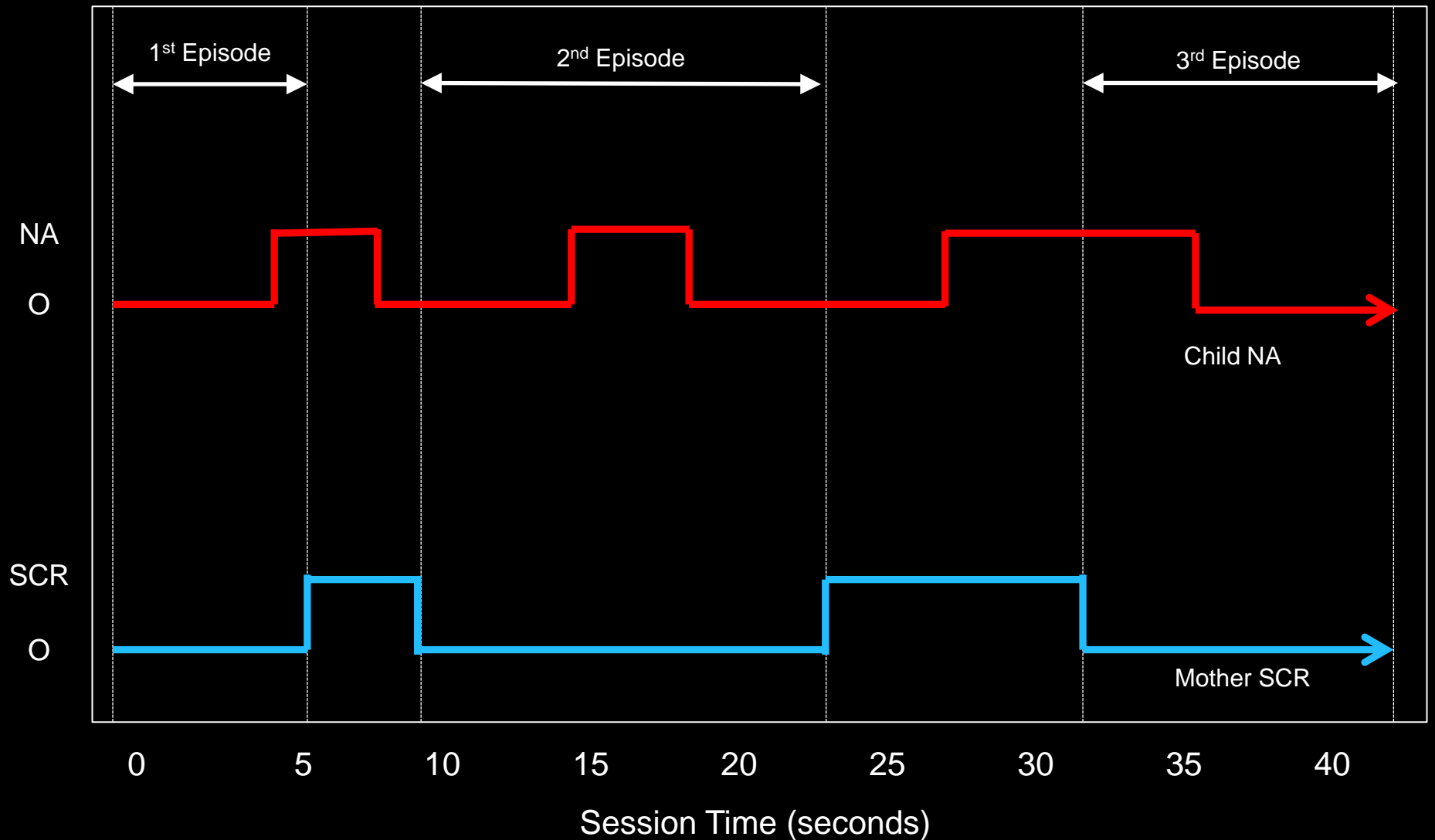
*Note.* Mother states include Supportive CR (SCR) and Other (O). Child states include negative affect (NA) and other (O).

# Mother supportive co-regulation

(Lougheed, Hollenstein, Lichtwarck-Aschoff, & Granic, in press)

- 8-12 y.o. externalizing children (EXT) and controls
- Supportive Co-regulation = validation, reappraisal, positive emotional directives
- Two models:
  - Mom supportive response to Child NA
  - Transitions out of Child NA following Mom support

(Mills, 2010; Stoolmiller & Snyder, 2006)



*Note.* Mother states include Supportive CR (SCR) and Other (O). Child states include negative affect (NA) and other (O).

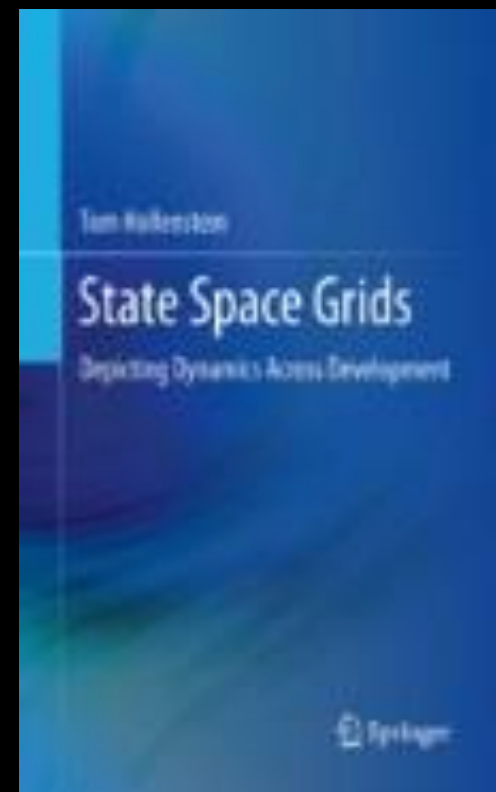
## Results Summary

- Group differences:
  - Not on frequency
  - Not on duration
  - Not on overall probability of Mom Support
  - Model 1: Mom supportive response to NA
    - EXT less likely to respond supportively to NA
  - Model 2: Transitions out of NA following Mom support
    - EXT less likely to transition out of NA when Mom is supportive

# State Space Grids

Hollenstein (2013)

- Well-suited to analyses of interaction data
- Can be used on its own as well as in concert with other analyses
- Just beginning to scratch the surface of possibilities...



# Acknowledgments

- Queen's University
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- Jess Lougheed, Dianna Lanteigne, Marc Lewis, Isabel Granic, Emily Butler, Anna Lichtwarck-Aschoff, Nick Allen, Lisa Sheeber, Mike Stoolmiller, Jim Snyder, Tom Dishion, Jerry Patterson, and many others...

# Thank You

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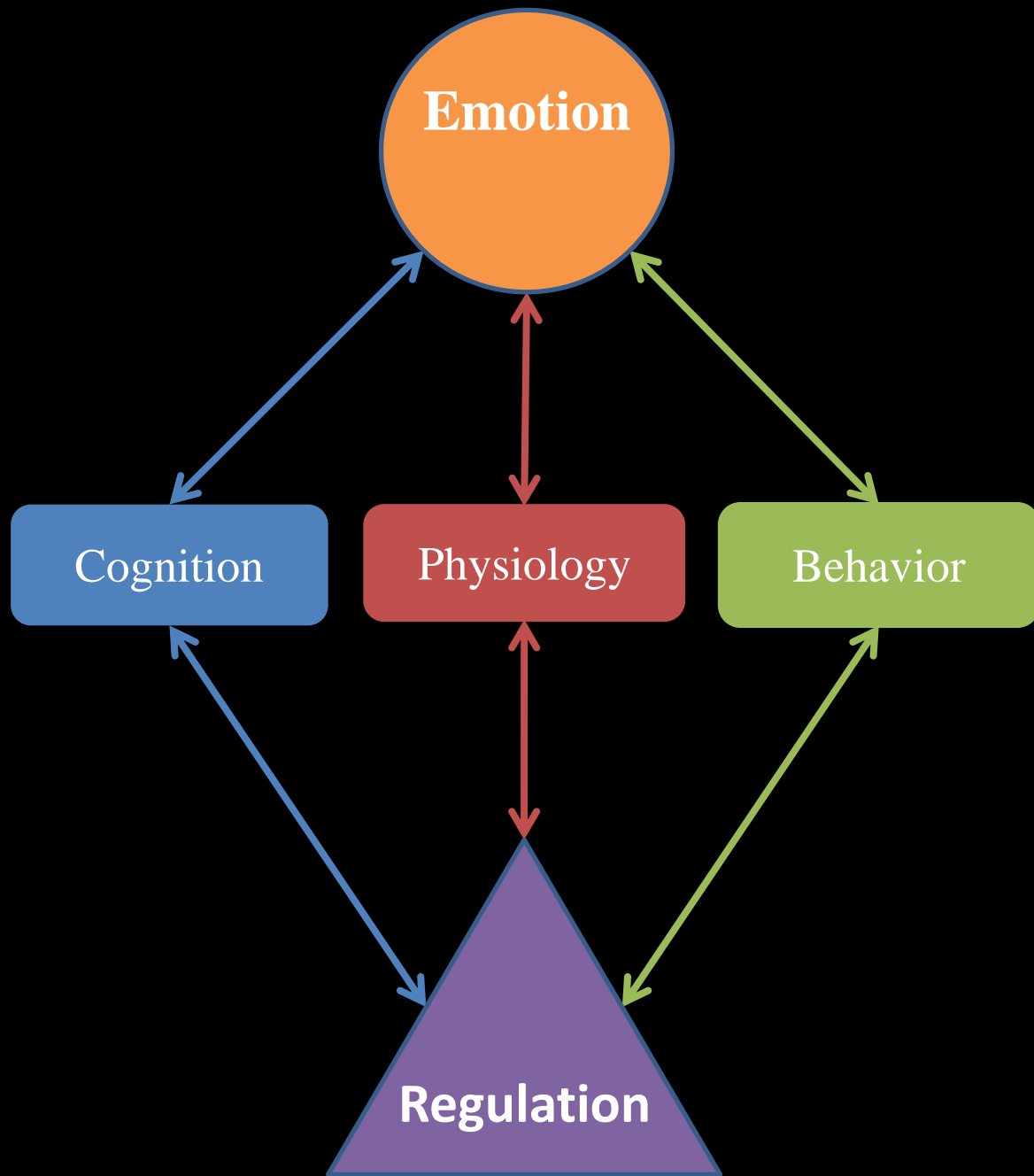
[www.statespacegrids.org](http://www.statespacegrids.org)



# Relations of Hazards To Other Obs Measures

- Anger Incidence or Simple Rate =  $I_A = \frac{h_A h_{NA}}{h_A + h_{NA}}$ . Note that  $I_{NA}$  is the same value.
- Anger Average Duration =  $D_A = 1/h_{NA}$ .
- Anger Prevalence or Duration Proportion =  $P_A = \frac{h_A}{h_A + h_{NA}}$ .
- Entropy =  $-[P_A * \log(P_A) + P_{NA} * \log(P_{NA})]$ .





Emotion Dynamics:

Onset/offset, latency, rise time, intensity, duration, inertia, flexibility

