A TDLC SIN:

Socially Mediated Learning
and/or
Learning to be Social

Deborah Forster
MP lab, INC, UCSD
Aug 7, 2012
Where is the science in TDLC?

- Trainees are the pathfinders, not the PIs...
- Collaboration = willing to learn each other’s methods. This is the opportunity at this summer ‘camp’
- Behavioral researchers have a lot to gain from being in a research network with computational and brain researchers - why?
  - Dynamical approaches to complex systems
  - Confront multiple data streams on a variety of spatio-temporal scale
  - Multiple perspectives on the same phenomena
Terry Senjowski & Pat Churchland (modified from 1990)

Structural Levels of Investigation - a place to start
...which structures really constitute a level of organization in the nervous system is an empirical, not an a priori matter. We cannot tell in advance of studying the nervous system how many levels there are nor what is the nature of the structural and functional features of any given level.

Further research may lead do the subdivision of some categories, such as “systems” into finer-grained categories, and some categories may be profoundly misdrawn and may need to be completely reconfigured. As we come to understand more about the brain and how it works, new levels of organization may be postulated.

(Senjowski & Churchland, 1990:305)
Levels...

- Of description
- Of analysis
- Of investigation
- Of organization

- Senjowski & Churchland - ‘structural levels’
  - Temporal structure
  - Spatial structure
  - Hierarchical structure

smoke and mirrors?
What happens in this 2-way information traffic?

Qualitative Concepts:

Reduction

*Emergence* (retrieval)

*Submergence* (indexing)

Interdefinition of Structure and Causality

No ‘noise’, just deterministic relations

No ‘reward’, just macroscopic constraints

Matter as a ‘dynamic forest’

Key idea:

Elementary operation is the combination of the external macroscopic and the internal microscopic to create the mesoscopic state.

Can we extend the kind of maths developed in unsupervised learning theory and statistical physics to build a quantitative theory?
But levels do not stop at the surface of the skin...

Levels of Social Complexity in Primate Groups:

1983 Primate Social Relationships

Robert A. Hinde

1997 Relationships: A Dialectical Approach
<table>
<thead>
<tr>
<th>Data Streams:</th>
</tr>
</thead>
<tbody>
<tr>
<td>meaning</td>
</tr>
<tr>
<td>behavior - Micro &amp; Macro</td>
</tr>
<tr>
<td>brain</td>
</tr>
<tr>
<td>physiology &amp; ANS?</td>
</tr>
<tr>
<td>genetics / genomics</td>
</tr>
</tbody>
</table>
Social Dynamics

Can study:

(1) Individuals in social situations

(2) Social dynamics directly
How does TDLC - SIN study social dynamics?

<table>
<thead>
<tr>
<th>lab</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP Lab, INC, UC San Diego</td>
<td>Marni Bartlett</td>
</tr>
<tr>
<td>Infant development, Cognitive Science, UCSD</td>
<td>Javier Movellan</td>
</tr>
<tr>
<td>Human Development, UCSD</td>
<td>Gwen Littlewort</td>
</tr>
<tr>
<td>SCNN, INC, UCSD</td>
<td>Gedeon Deak</td>
</tr>
<tr>
<td>Developmental Psych, SDSU</td>
<td>Terry Jernigan</td>
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<tr>
<td>Rutgers &amp; UCSD</td>
<td>Scott Makeig</td>
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<tr>
<td>Virginia State University</td>
<td>Judy Reilly</td>
</tr>
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<td></td>
<td>Paula Tallal</td>
</tr>
<tr>
<td></td>
<td>Zewelanji Serpell</td>
</tr>
</tbody>
</table>
High density (133-channel) EEG data were recorded simultaneously from pairs of volunteers working memory game ‘Concentration,’ in which a grid of thirty squares was presented on a single touch-sensitive screen. When touched, each square briefly revealed its hidden value (1-15). Monetary rewards were earned when a pair of matching values is touched in sequence. In competitive games, players competed to find the greater number of matching pairs. In collaborative games, players worked together to find more matches than their computerized competitor. In solo games, one player competed against the computer while the other watched. To characterize brain systems engaged during these three types of games, independent contributions to scalp-recorded EEG were decomposed through independent component analysis (ICA) (Makeig, Bell, Jung, & Sejnowski, 1996)

Preliminary analysis of event-related spectral perturbation (ERSP) transforms of IC activations from somato-motor cortex reveal that aspects of motor planning and execution as players reach toward the touch screen are modulated simply by social context, as indicated by greater levels of mu desynchronization in competitive versus collaborative and solo games.
The Computer Expression Recognition Toolbox

The Computer Expression Recognition Toolbox (CERT)
Bartlett, Movellan, & Littlewort UCSD

1. Basic emotions
2. Individual muscle movements:
   The Facial Action Coding System (Ekman & Friesen 1978)
1. A s square and it's a block.
2. It feels really hard.
3. It's yellow-looking. And I'm not peeking. But I don't know what shape it is. Like it's like a triangle or something.
4. Hmm... I don't know what this is called but it's brown and it's a block.
5. shuh.
6. No. But I could I can feel the shape but I but I don't really know what it's called.
7. Hmm...
8. Oh I know what this is. It feels like a dinosaur toy.
9. It's a toy duckie?
RUBI

Robot Using Bayesian Inference

Round I (2004-2008)
Round II (2010-2013)
Learning to Read People

The Machine Perception Laboratory at the University of California, San Diego, developed a robot that learned from its preschool-class environment. It’s called RUBI – Robot Using Bayesian Inference – defined as observations or incoming data that are the basis for determining statistical probability and action. So, for example, the robot is programmed to recognize whether or not a child is interested in or enjoying an activity. Then the robot can respond accordingly. Here is how it recognizes faces and analyzes facial expressions.

1. RUBI’s nose is a video camera that recognizes and follows faces with the aid of its software.
2. Each frame of incoming video is analyzed in real time.
3. RUBI’s software is then able to recognize basic emotions.
   The lab expounded on and automated the “facial action coding system” developed by sociologist Paul Ekman beginning in the 1970s. It identifies virtually every muscle movement in the face and interprets combinations of them as expressions and emotions.

Here’s how:

4. Recognizing that the child is smiling, RUBI can respond with verbal and physical gestures of encouragement, or simply continue with an activity.

One of RUBI’s primary objectives is to recognize whether a child is smiling (“action unit” 12). Its system to do this was also trained using a database of 70,000 faces:

The presence of a neutral face is recognized by the software. Three “action units” – 6 (cheek raise), 12 (lip corner pull) and 25 (lip part) will be measured in this example.

The increasing intensity of the action units is measured as the woman’s expression changes.

It ultimately recognizes the emotion “joy,” using other analyzes too, like changing the orientation of the image.

Source: Machine Perception Laboratory, University of California, San Diego
AIMS:

Explore the use of low-cost social robots as teaching tools for early childhood education

Stage II:

• Develop a social network to connect children, teachers, and educational robots across the nation and the world
• Provide an alternative to current self-directed screen-based learning
• Accelerate research on early education – RUBI platform can facilitate scientific data collection and mining on a massive scale at a rich level of detail
RUBI Hardware:

- 2 Microphones for sound source localization
- Speaker
- Tablet PC for interactive games
- Laser scanner
- IGS2-GM DC motors
- iPad for face and expressions
- 3 DOF Head
- IR & RFID
- 4DOF Arm

RUBI Program Modules:

- High-level Behavior
  - RUBIFace
  - Face Finder
  - Head Controller
  - Arm Controller
  - Motor control
  - Sensors driver
  - Dynamixel driver
  - Motor driver
Research Questions:
• Temporal dynamics of social engagement
• What makes RUBI an effective teacher?
• What sort of agency is necessary, sufficient or desirable in a robot teacher aid
• Attribution of intentionality in early childhood
• Learning-to-learn: can RUBI model learning strategies that transfer to other situations?
• How can RUBI mediate between children, parents & teachers?

More RUBIs
How can networked robots facilitate long-distance and cross-cultural learning?
Integrate network-wide activities of children, parents, teachers, researchers and social robots in early education
**Summary**

In this project we are putting together a first of its kind database of mother-infant interaction. The database is unique in that it incorporates dense motion tracking of mother, infant, and toys as well as five different camera angles to record the interaction. We chose to study the period around the onset of infant reaching (2.5 – 6 months). By recording at a high-level of detail of both the movements and affective signals involved in this transition we hope to shed light on how the physical and social capabilities of infant emerge during this crucial period.

This project is embedded within the larger framework of Project One which attempts to understand human development through the building of a complex humanoid robot that will face many of the same challenges as the infant in her first year of life. In the poster I discuss some possible connections between the recording of data of human infants and our studies in developmental robotics.

**Analyzing Mother and Infant Gaze**

Mother and infant gaze patterns during interaction key indicators of the focus and activities of the current interaction. With the motion capture setup we have very high spatial and temporal resolution orientation data. This data will be key for understanding the development of shared attention while infants are completing their first successful reaches.

**Eliciting Infant Reaches**

**Camera Angles**

- Baby View 1
- Mom Face Closeup
- Baby View 2
- Mom Head Mounted Cam

**Diego San**

Diego San is a 44 degree of freedom humanoid robot. A new face is being constructed by Hason Robotics to allow Diego San to display a full range of facial expressions.

**Motion Capture**

- Coming Soon: Baby Head Cam!
The Gamelan Project

Alexander Khalil-1, Victor H. Minces-2, Deborah Forster-3, Scott Makeig-4, Paula Tallal-5, Judy Reilly-6, Tzvy-Ping Jung-7, Grainne McLoughlin-8, Andrea Chiba-9

Summary and Background:

Of all the world's musical cultures, that of the Balinese—featuring a variety of pitched percussion orchestras known as "gamelan"—seems to value and emphasize ensemble synchrony most highly. Teaching this music to American elementary school children for ten years, ethnomusicologist Alexander Khalil observed that ability to synchronize in an ensemble setting—regardless of other musical abilities—seemed to correlate strongly with ability to "pay attention" or maintain focus not only in music class but in other areas as well.

The present study was conducted with children between the ages of 7 and 12. 150 children were recorded playing specially designed pitched-percussion instruments in like-aged groups of 10-12. Each child's ability to maintain synchrony with his/her group was measured and compared against their performance on computerized psychometric tests of attention and their teacher-assigned rating on the Swanson Scale of attention.

The goal of this effort was to ascertain whether a correlation exists between poor ability to synchronize and these attentional measures. Presented below are the results and analysis of results only for the elementary-age subjects.

Methods:

Participants were 150 children from grades 1-8 at the Mount School, San Diego, California. All children were asked to engage, and were asked to engage, in a 30-minute Gamelan performance. The children were divided into groups of 20, with each group containing 5 children of each sex and grade level. All children were asked to play at the same speed and to play the same notes, as specified by the teacher. A metronome was used to help maintain the tempo. After the performance, each child was given a line rating of attention.

Results:

Individualized Simultaneous Sound Recordings

Examples of Good and Poor Synchronizers:

Conclusions:

This study demonstrates that the ability of a child to synchronize with an external source in a group setting is strongly correlated with established measures of attention performance.

This result is consistent with the idea that some evolutionary advantage may be derived from synchrony. The performance of a single child in this study was associated with significant improvement in measured attention performance.

References:

Acknowledgments:

This work is supported by the Temporal Dynamics of Learning Center through NSF Science of Learning Center grant #ECS-0645113.
Socio-Cognitive Behavior in Baboons

Kenya - Uaso Ngiro Baboon Project - Dr. Shirley Strum
Why study nonhuman primates? The comparative urge...
Baboons as Friends....don’t go to bars...

It is what my Dissertation is NOT:

- Not that simple
- Not about making inferences re ‘in-the-head-cognition’
- Not about human comparison

But it is about
- Baboons
- Sex, Politics, and Cognition

What really happens out there?
Baboon Sexual Consorts:

- 1 week prior to female ovulation
- Male monopolizes access to a sexually active female: consort pair
- Male followers
- Sub adult male peripheral participation - situated learning (LPP)
- Others:
  - infants of female
  - infant friends of male(s)
  - juveniles harassing copulations
- IT’S A PARTY!
- inevitably leads to a switch in male partners: Consort Turnover
- CTO video example…CTO#3
day-in-the-life

Olive baboons in Laikipia, Kenya
Baboon Daily Travel, Idealized Trajectory
Baboon Daily Travel, Socio-Ecological Clusters
SE Clusters - Social Configurations
SE Clusters - ‘Yanking’ out social interaction data
## Consort male performance scores

<table>
<thead>
<tr>
<th>Male</th>
<th>Win</th>
<th>Lose</th>
<th>Challenge</th>
<th>Follow</th>
<th>Total</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
<th>Age</th>
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<tbody>
<tr>
<td>HW</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>23</td>
<td>2.33</td>
<td>1.40</td>
<td>0.30</td>
<td>very old</td>
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<tr>
<td>ND</td>
<td>34</td>
<td>31</td>
<td>24</td>
<td>9</td>
<td>98</td>
<td>1.10</td>
<td>1.42</td>
<td>0.35</td>
<td>old</td>
</tr>
<tr>
<td>RL</td>
<td>29</td>
<td>25</td>
<td>25</td>
<td>5</td>
<td>84</td>
<td>1.16</td>
<td>1.16</td>
<td>0.35</td>
<td>mature</td>
</tr>
<tr>
<td>HK</td>
<td>41</td>
<td>36</td>
<td>39</td>
<td>10</td>
<td>126</td>
<td>1.14</td>
<td>1.05</td>
<td>0.33</td>
<td>young</td>
</tr>
<tr>
<td>CB</td>
<td>22</td>
<td>26</td>
<td>6</td>
<td>7</td>
<td>61</td>
<td>0.85</td>
<td>3.67</td>
<td>0.36</td>
<td></td>
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<tr>
<td>PH</td>
<td>21</td>
<td>24</td>
<td>16</td>
<td>4</td>
<td>65</td>
<td>0.88</td>
<td>1.31</td>
<td>0.32</td>
<td></td>
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<tr>
<td>RT</td>
<td>25</td>
<td>34</td>
<td>10</td>
<td>2</td>
<td>71</td>
<td>0.74</td>
<td>2.50</td>
<td>0.35</td>
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<tr>
<td>SQ</td>
<td>0.5*</td>
<td>0.5*</td>
<td>3</td>
<td>16</td>
<td>20</td>
<td>1.00</td>
<td>0.17</td>
<td>0.03</td>
<td>sub-adult</td>
</tr>
<tr>
<td>GR</td>
<td>0.5*</td>
<td>0.5*</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1.00</td>
<td>0.50</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

**Score 1 = win / loss**

**Score 2 = win / challenge**

**Score 3 = win / total participated**
<table>
<thead>
<tr>
<th>Label</th>
<th>CTO State</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>STA</td>
<td>Stable Configuration</td>
<td>Steady pace and stable coordination and / or synchrony in activity between the consort partners, as well as among the male followers and the rest of the consort party</td>
</tr>
<tr>
<td>DIS</td>
<td>Disruption</td>
<td>Any change in distance, movement patterns, visual attention, or activity that reduces the stability of association and / or coordination between the consort male and female. The state may be initiated by either consort partner or by a third party, and is marked in uncoordinated activity of the consort partners. May or may not reverberate through the rest of the consort party.</td>
</tr>
<tr>
<td>NEG</td>
<td>Negotiation</td>
<td>Unstable and heterogeneous movement or interactions patterns that extend beyond the consort pair (asynchronous at the system level, i.e., not all consort party members are doing the same thing.) Relatively faster pace than STA</td>
</tr>
<tr>
<td>NEW</td>
<td>New Configuration</td>
<td>A new male in contact with the consort female and / or in considerably closer and more coordinated proximity to her than the male who was in consort until that point. NEW does not require the stability and synchrony of STA, which may take some time to achieve, if at all.</td>
</tr>
<tr>
<td>FROM</td>
<td>TO</td>
<td>Counts</td>
</tr>
<tr>
<td>------</td>
<td>----</td>
<td>--------</td>
</tr>
<tr>
<td>STA</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>DIS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>NEG</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>NEW</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FROM</td>
<td>TO</td>
<td>Proportions</td>
</tr>
<tr>
<td>STA</td>
<td></td>
<td>0.00</td>
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<tr>
<td>DIS</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>NEG</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>NEW</td>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

Diagram:

- STA to STA: 0.70
- STA to DIS: 0.50
- STA to NEG: 0.25
- STA to NEW: 0.10
- DIS to DIS: 0.70
- DIS to NEG: 0.50
- DIS to NEW: 0.25
- NEG to NEG: 0.70
- NEG to NEW: 0.50
- END to END: 0.70
- END to NEW: 0.50
- NEW to NEW: 0.70
<table>
<thead>
<tr>
<th>Initiated By</th>
<th>Examples of DIS – Disruptions in CTO events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consort Male</td>
<td>• Side-trip to greet a male follower</td>
</tr>
<tr>
<td></td>
<td>• Hyper vigilance of followers to distraction from grooming and copulating with consort female</td>
</tr>
<tr>
<td></td>
<td>• Divergent foraging choices</td>
</tr>
<tr>
<td></td>
<td>• Monitoring social dynamics outside the consort party</td>
</tr>
<tr>
<td></td>
<td>• Responding to out-of-sight relevant vocalizations</td>
</tr>
<tr>
<td>Consort Female</td>
<td>• Wanders away - divergent foraging</td>
</tr>
<tr>
<td></td>
<td>• Distal greeting and soliciting of follower male(s)</td>
</tr>
<tr>
<td></td>
<td>• Responding to grooming solicitation from female friend / offspring</td>
</tr>
<tr>
<td></td>
<td>• Responds to being threatened by a higher-ranking female</td>
</tr>
<tr>
<td></td>
<td>• Exaggerated run-away at the end of copulation</td>
</tr>
<tr>
<td></td>
<td>• Refuses copulation attempts.</td>
</tr>
<tr>
<td>Follower Male</td>
<td>• Wanders in between consort male and female</td>
</tr>
<tr>
<td></td>
<td>• Distal greeting of consort female</td>
</tr>
<tr>
<td></td>
<td>• Solo challenge of consort male</td>
</tr>
<tr>
<td></td>
<td>• Incite other follower males</td>
</tr>
<tr>
<td></td>
<td>• Allies with other males for coordinated challenge</td>
</tr>
<tr>
<td></td>
<td>• Harasses copulation</td>
</tr>
<tr>
<td>Other Troop Members</td>
<td>• Juvenile (kin or non-kin) harassing copulations</td>
</tr>
<tr>
<td></td>
<td>• Female grooming partner</td>
</tr>
<tr>
<td></td>
<td>• High-ranking female aggression</td>
</tr>
<tr>
<td></td>
<td>• Infant and / or other offspring come to engage</td>
</tr>
<tr>
<td></td>
<td>• Consort male’s infant friend</td>
</tr>
</tbody>
</table>
Profiles of Participation:

1. ALL participants included: All the characters from CTO
2. Like the transitions in the previous chapter: Multiway Contingency Tables
3. Track lifecycle transitions: development, residency
<table>
<thead>
<tr>
<th>Category</th>
<th>Example Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MOVEMENT</td>
<td>Walk; Run; Climb</td>
</tr>
<tr>
<td>2 STATIONARY</td>
<td>Stand; Bipedal; Sit; Lay</td>
</tr>
<tr>
<td>3 SOLITARY</td>
<td>Feed; Self-groom; Self-Sex</td>
</tr>
<tr>
<td>4 RELATIONAL</td>
<td>Groomer/Groomee; Sex; Aggression; Play; Greeting</td>
</tr>
<tr>
<td>5 VISUAL ATTN</td>
<td>Look at; Look away; Glance; Track; Watch; ‘Eyes in back of head’</td>
</tr>
<tr>
<td>6 prefix for trajectory</td>
<td>b=Begin; c=Continue; e=End</td>
</tr>
<tr>
<td>7 visibility</td>
<td>Not visible; Obstructed; Off screen</td>
</tr>
<tr>
<td>8 Body Parts</td>
<td>Face; Lower/Upper Limbs (L/R); Tail; Genitals</td>
</tr>
</tbody>
</table>
Table 6.4 HMBO delineation

|     | HA
<table>
<thead>
<tr>
<th></th>
<th>Head Ahead</th>
</tr>
</thead>
</table>
| 315-360° | HAL
|         | Ahead-Left |
| 270-315° | HLA
|         | Left-Ahead |
| 225-270° | HLB
|         | Left-Back |
| 180-225° | HBL
|         | Back-Left |
| 90-135° | HRA
|         | Right-Back |
| 135-180° | HBR
|         | Back-Right |
| 0-45°  | HAR
|         | Ahead-Right |
| 45-90° | HRA
|         | Right-Ahead |
| 90-135° | HRA
|         | Right-Back |
| 135-180° | HRA
|         | Back-Right |

Fig 6.1 HMBO “Compass Rose”
<table>
<thead>
<tr>
<th>time/frame</th>
<th>vhs frame</th>
<th>HMBO timestep</th>
<th>HMBO Value</th>
<th>HEAD MOVEMENTS</th>
<th>BODY MOVEMENTS</th>
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<tr>
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<td></td>
<td>344</td>
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<td></td>
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<tr>
<td>27</td>
<td></td>
<td>346</td>
<td>0</td>
<td>b HA-L</td>
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<td>12</td>
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<td>361</td>
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<td>HLA</td>
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</table>

Fig 6.1 HMBO - From Coding to Timeseires
a. Head Motion:

b. System States:

NEW

NEG

DIS

STA

Relational multi-tasking
CTO analysis:

- Task space / Relational space -
- Cognition leaks out of the skull: into the environment
- Cognition spreads to the body: embodied attention
- Same device State-Space works on multiple scales
**Socio-Cognitive** Phenomena Gestalt

Polyadic Interactions

- Group structure
- Here-and-now
- Relationships
- Relational contingencies

Social dimensions

Cognitive dimensions
On Levels - multiple spatio-temporal scales

Figure 8.1 Structural levels of organization in the nervous system. The spatial scale at which anatomical organization can be identified varies over many orders of magnitude. Schematic diagrams to the right illustrate an articulatory system that produces speech sounds, a small network model for receptive fields of simple cells in visual cortex (Hubel and Wiesel 1962), and the structure of a chemical synapse (Kandel and Schwartz 1984). Relatively little is known about the properties at the network level in comparison with the detailed knowledge of synapses and the general organization of pathways in sensory and motor systems.
Hinde (1987) interactions, relationships and groups

Socio-cultural Structure

Nervous Endocrine etc. Systems

A

Interactions A–B

Relationship A–B

Social Group

B

Environment

Nervous Endocrine etc. Systems
Neuro-Endocrine
etc. Systems

Nervous Endocrine etc. Systems

Socio-cultural Structure

A

Interactions
A–B

B

Relationship
A–B

Social Group

Environment

Individual behavior

Interactions

Relationships

Group Structure
Neuroendocrine

Individuals

Interactions

Relationships

Group
Levels of Social Complexity
(Hinde, 1987)

Levels of (brain) Investigation
(Senjowski & Churchland, 1990)
Levels of Social Complexity
(Hinde, 1987)

Levels of (brain) Investigation
(Senjowskí & Churchland, 1990)
Conclusions

1. It’s levels, all the way down...
when look at social behavior, the relational dynamics of elements form a continuum with intra-
somatic inquiry, with the familiar tools of dynamical systems, state-space descriptions, etc.

2. Extra-somatic behavior can be layered

3. Tracking behavior dynamically, can bring it into the same analytic frame of reference as other
data streams.

4. We’re now in a world where sensor technology is allowing us to collect, in realtime, multiple
data streams within a single research setting, both inside the lab and out in the world.

5. It means we have to become proficient enough to converse in multiple languages. A good
place to start - data streams synchronized in time.