# *Shared Information and Virtual Surfaces*

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# *Long Term Goals*

- Investigate performance of self-synchronizing teams
- Understand how teams collaborate on a shared surface in situations characterized by high stakes, uncertainty and time pressure


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# *Project Objective*

- Validate Model:

  **Team Recognition Primed Decision-Making**

- Empirical investigation for validity of:
  - **Pattern Sharing of Cognitive Chunks**
  - **Negotiated Interrupts**


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# *Research Plan*

- Validate Model
  - **Do teams recognize patterns?**
- Intention Sharing
  - **Is real-time telepointing (gesturing) effective?**
- Sharing Representation
  - **Items vs. Chunks**
  - **Time Pressure**


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# *Impact*

- Attention Management
  - **Telepointing (gesturing) was found to be "distracting" for collaboration**
- Perception and Sharing of Patterns
  - Discrete "item" sharing gives higher performance
  - Cognitive "chunk" sharing yielded higher task performance, **even under time pressure**


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# *Applications*

- Potential transition to Dr. Jeff Morrison's Knowledge Desk Program at SSC.
- Findings applicable to the DARPA ITO Augmented Cognition program (BAA #01-38)
- DARPA Cognitive Information Processing Technology (BAA #02-21)


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# Cognitive Limitations

- **Perception**
- **Attention**
- **Memory**

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Norman, D. A., and D. G. Bobrow (1975). On the data-limited and resources-limited processes. Cognitive Psychology, 7, 44-64.

Morrison J. G., R. T. Kelly, R. A. Moore, and S. G. Hutchins (2000). "Implications of Decision-Making Research for Decision Support and Displays" In Janis A. Cannon-Bowers and Eduardo Salas (eds.), Making Decisions Under Stress: Implications for Individual and Team Training. APA Books

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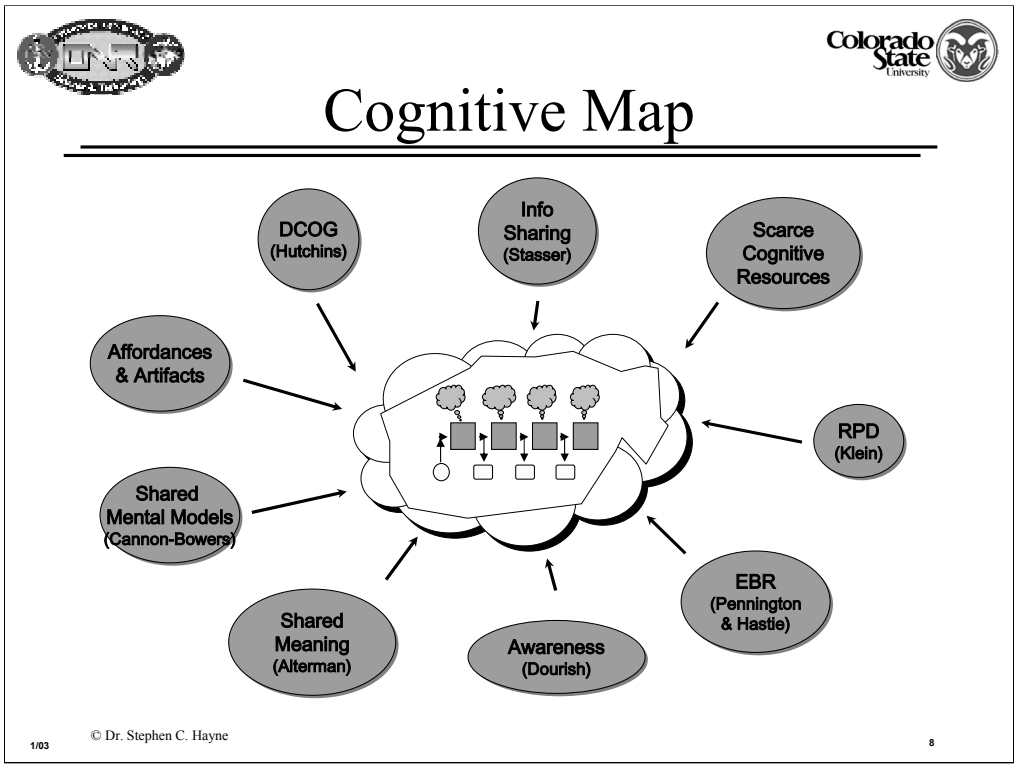


RPD: Klein, G. A. (1993). A recognition-primed decision (RPD) model of rapid decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), Decision making in action: Models and methods. Norwood, NJ: Ablex.

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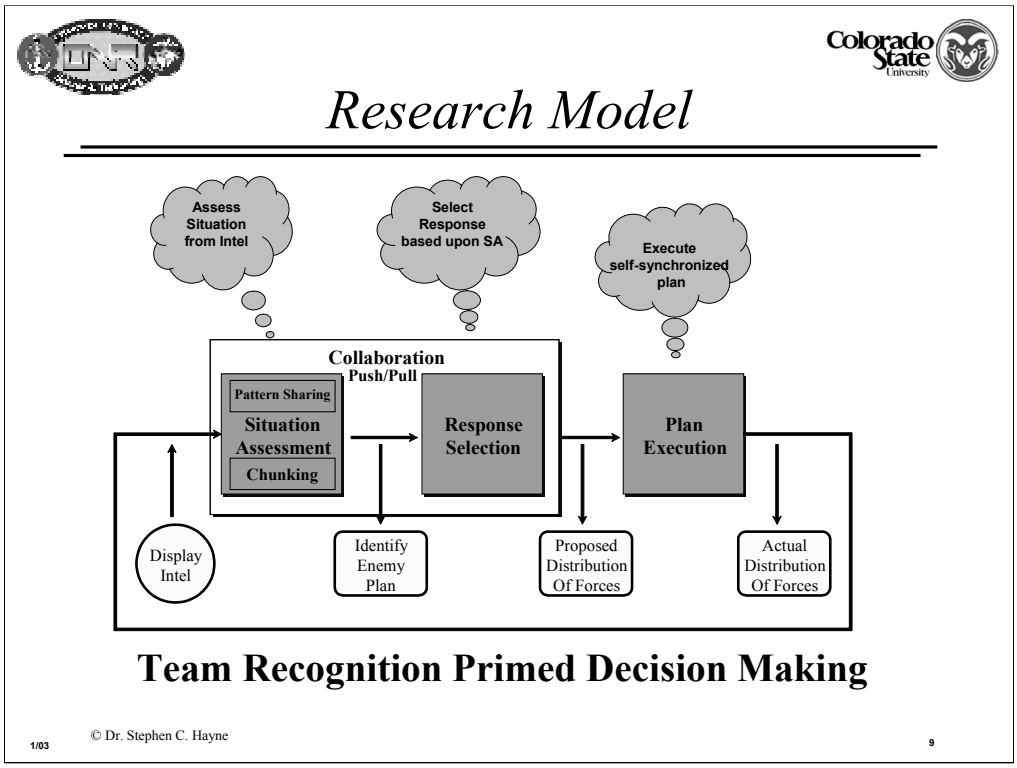


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# *Hypotheses (3 year)*

- **Teams using a compensatory aid for pattern-recognition tasks will outperform teams who do not.**
- Teams using negotiated interrupts with each other for pattern-recognition tasks will outperform teams who do not.
- Teams who learn patterns in the same way will outperform teams who do not.


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# *FY '02 Research Plan*

- Explore sharing of pattern chunks
  - **Labels**
  - Templates (slots)
- Rewards for **speed** and **accuracy**


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# *Team Compensatory Aids*

- **Perception** Tools for
  - ***Pattern Recognition***
  - ***Sharing of Intention***
- **Attention** Tools for
  - ***Telepointing/Gesturing***
  - ***Awareness***
  - Alerting (negotiated)
- **Memory** Aids for
  - Mitigating the Effects of Stress


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# *Research Measures*

- Outcome Measures:
  - *Quality*
  - *Speed*
- Process Measures:
  - *Pattern Recognition (Confidence)*
  - *Pattern Sharing*
  - *Collaboration*
    - *collisions, bumps, leaders, structures*


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Schvaneveldt, R. W. (1990). Proximities, networks, and schemata. In R. Schvaneveldt (Ed.), *Pathfinder associative networks: Studies in knowledge organization.* (pp. 135-148). Norwood, NJ: Ablex.

# *Current Progress*

- Recent Data Collected:
  - Chunking (48 subjects)
  - Chunking Time Pressure (42 subjects)
- Analysis Performed

- International Journal of Human Computer Studies
  - first article from last year's results accepted.


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# *Decision Game*

- Cooperative 3-Player Game
- Each player has 7 Tokens (numbered 1-7)
- Opponent has asymmetric force
  - Patterns: Definitive, Equivocal, Uncertain
- Team places tokens so total >= opponent
- Incentive
  - For total points
  - For time of play
- Play is interactive


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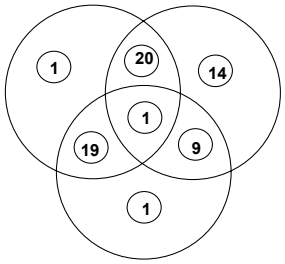
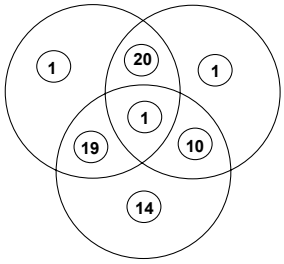
Games is based on: McGunnigle, John, Wayne Hughes, and Tom Lucas, (2000). Human Experiments on the Values of Information and Force Advantage," PHALANX, 33, No. 4, December.

# Patterns




**9**

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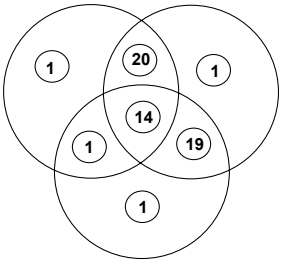


**14**

**Chunk Labels**


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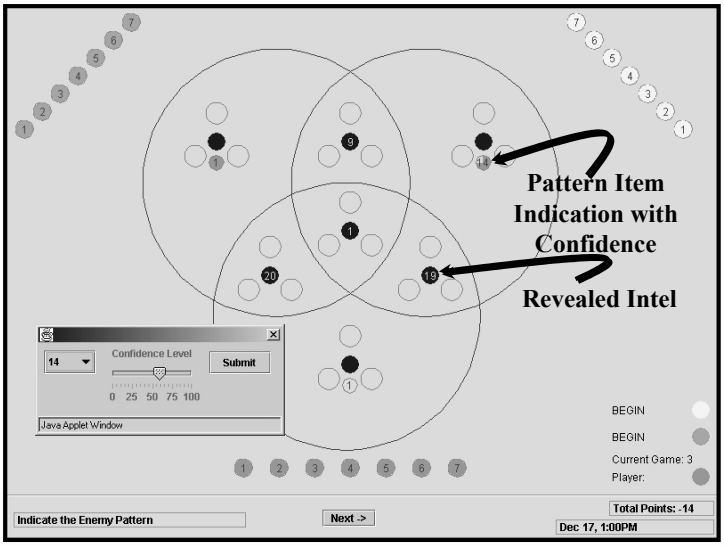
# Pattern Items

Sockets
SQL
RMI
Multicast




Shared
Data
Toolkit

XIS…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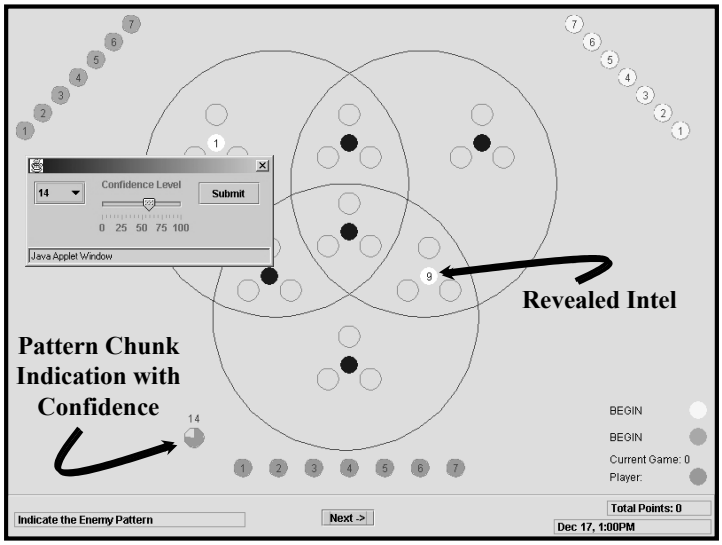
# Pattern Chunks





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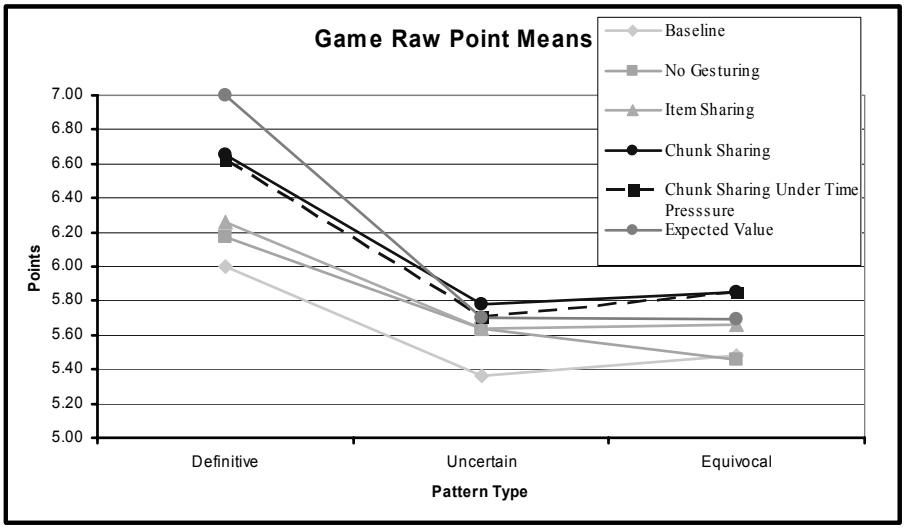
# Raw Scores

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| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Base Line (BL) | 6.00 | 0.87 | 5.36 | 0.89 | 5.48 | 0.81 | 5.59 | 0.88 |
| No Gesturing (NG) | 6.17 | 0.75 | 5.64 | 0.70 | 5.46 | 0.90 | 5.67 | 0.87 |
| Item Sharing (IS) | 6.26 | 0.79 | 5.64 | 0.85 | 5.66 | 0.87 | 5.81 | 0.88 |
| Chunk Sharing (CS) | 6.65 | 0.60 | 5.78 | 0.93 | 5.85 | 0.80 | 6.04 | 0.86 |
| Chunk Sharing Under Time Pressure (CSTP) | 6.62 | 0.78 | 5.71 | 0.79 | 5.85 | 0.88 | 6.01 | 0.91 |
| Total | 6.30 | 0.82 | 5.58 | 0.87 | 5.65 | 0.85 | 5.80 | 0.90 |

**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 19.62 | 0.000 |
| Type | 85.29 | 0.000 |
| Treatment * Type | 1.09 | 0.369 |

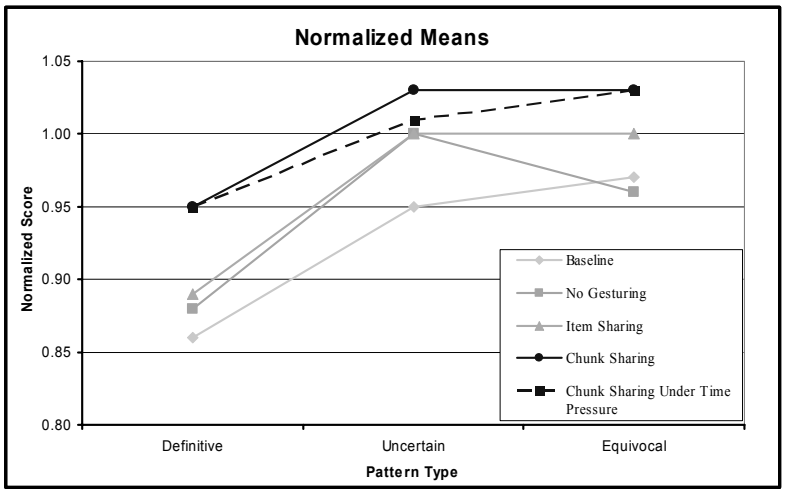
**Pair-wise Comparisons - Pattern Type**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | Definitive vs. | | Uncertain vs. |
| | Uncertain | Equivocal | Equivocal |
| Mean Diff. | 0.71 | 0.64 | -0.07 |
| Sig. | 0.000 | 0.000 | 0.394 |

**Pair-wise Comparisons - Treatment**

| Statistics | Pair-wise Comparisons | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CSTP vs. | | | | CS vs. | | | IS vs. | | NG vs. |
| | BL | NG | IS | CS | BL | NG | IS | BL | NG | BL |
| Mean Diff. | 0.43 | 0.34 | 0.21 | -0.02 | 0.45 | 0.36 | 0.23 | 0.22 | 0.13 | 0.09 |
| Sig. | 0.000 | 0.007 | 0.028 | 0.999 | 0.000 | 0.003 | 0.007 | 0.001 | 0.653 | 0.886 |

# Normalized Scores

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| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Base Line (BL) | 0.86 | 0.12 | 0.95 | 0.18 | 0.97 | 0.14 | 0.94 | 0.15 |
| No Gesturing (NG) | 0.88 | 0.11 | 1.00 | 0.14 | 0.96 | 0.17 | 0.95 | 0.16 |
| Item Sharing (IS) | 0.89 | 0.11 | 1.00 | 0.17 | 1.00 | 0.15 | 0.97 | 0.15 |
| Chunk Sharing (CS) | 0.95 | 0.09 | 1.03 | 0.19 | 1.03 | 0.15 | 1.01 | 0.15 |
| Chunk Sharing Under Time Pressure (CSTP) | 0.94 | 0.11 | 1.01 | 0.15 | 1.03 | 0.17 | 1.01 | 0.16 |
| Total | 0.90 | 0.12 | 0.99 | 0.17 | 1.00 | 0.15 | 0.97 | 0.16 |

**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 16.74 | 0.000 |
| Type | 49.24 | 0.000 |
| Treatment * Type | 0.01 | 0.837 |

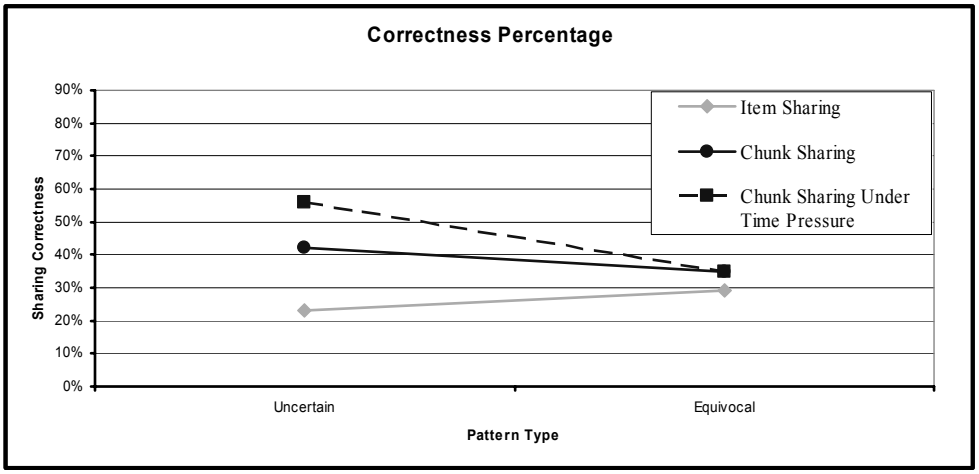
**Pair-wise Comparisons - Pattern Type**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | Definitive vs. | | Uncertain vs. |
| | Uncertain | Equivocal | Equivocal |
| Mean Diff. | -0.09 | -0.10 | -0.01 |
| Sig. | 0.000 | 0.000 | 0.769 |

**Pair-wise Comparisons - Treatment**

| Statistics | Pair-wise Comparisons | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CSTP vs. | | | | CS vs. | | | IS vs. | | NG vs. |
| | BL | NG | IS | CS | BL | NG | IS | BL | NG | BL |
| Mean Diff. | 0.07 | 0.06 | 0.04 | 0.00 | 0.07 | 0.06 | 0.04 | 0.04 | 0.02 | 0.02 |
| Sig. | 0.000 | 0.015 | 0.011 | 1.000 | 0.000 | 0.007 | 0.014 | 0.003 | 0.732 | 0.896 |

# Sharing Correctness

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| Treatment | Pattern Type | | | | | |
|---|---|---|---|---|---|---|
| | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD |
| Item Sharing (IS) | 0.23 | 0.35 | 0.29 | 0.39 | 0.28 | 0.38 |
| Chunk Sharing (CS) | 0.42 | 0.44 | 0.35 | 0.40 | 0.37 | 0.41 |
| Chunk Sharing Under Time Pressure (CSTP) | 0.56 | 0.44 | 0.35 | 0.42 | 0.41 | 0.43 |
| Total | 0.38 | 0.43 | 0.33 | 0.40 | 0.34 | 0.41 |

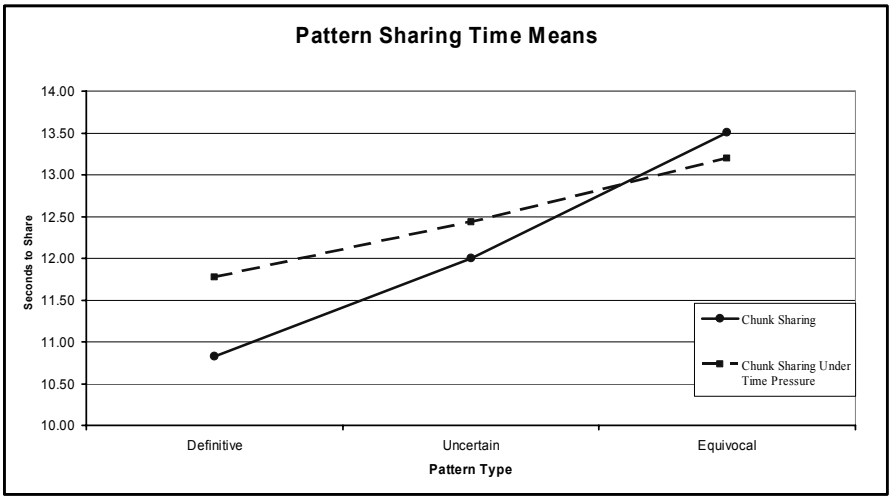
**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 11.53 | 0.000 |
| Type | 4.53 | 0.034 |
| Treatment * Type | 4.84 | 0.008 |

**Pair-wise Comparisons - Treatment**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | CSTP vs. | | CS vs. |
| | IS | CS | IS |
| Mean Diff. | 0.13 | 0.04 | 0.09 |
| Sig. | 0.002 | 0.580 | 0.030 |

# Pattern Sharing Time (Seconds)




No time pressure when sharing…

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| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Chunk Sharing (CS) | 10.82 | 7.68 | 12.00 | 11.68 | 13.51 | 11.34 | 12.52 | 10.66 |
| Chunk Sharing Under Time Pressure (CSTP) | 11.77 | 10.51 | 12.43 | 12.36 | 13.20 | 10.25 | 12.72 | 10.73 |
| Total | 11.22 | 8.96 | 12.18 | 11.91 | 13.37 | 10.83 | 12.60 | 10.68 |

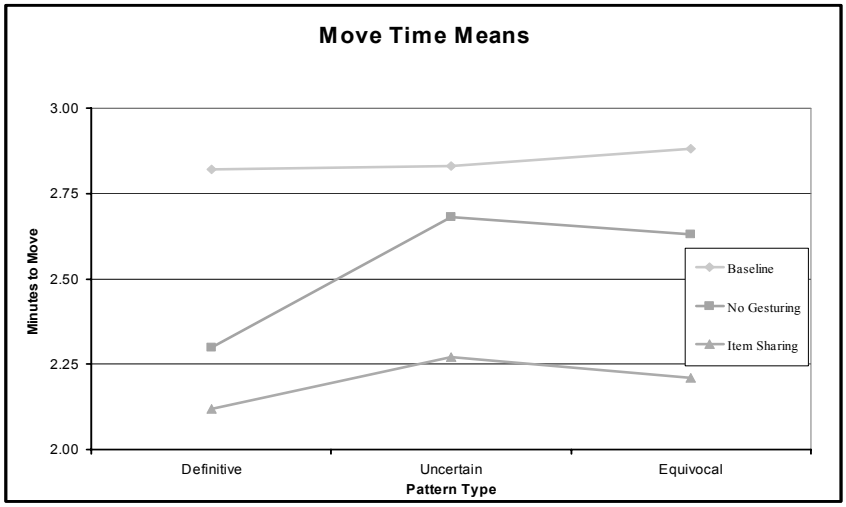
**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 0.11 | 0.741 |
| Type | 1.53 | 0.217 |
| Treatment * Type | 0.15 | 0.864 |

**Pair-wise Comparisons - Pattern Type**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | Definitive vs. | | Uncertain vs. |
| | Uncertain | Equivocal | Equivocal |
| Mean Diff. | -0.96 | -2.15 | -1.19 |
| Sig. | 0.808 | 0.205 | 0.640 |

# Move Time




No time pressure when moving…

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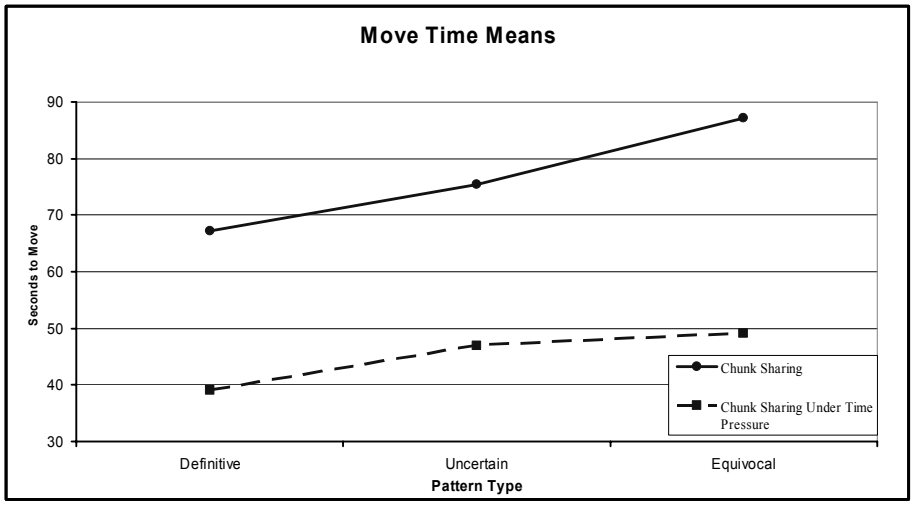
| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Base Line (BL) | 2.82 | 1.42 | 2.83 | 1.54 | 2.88 | 1.39 | 2.86 | 1.43 |
| No Gesturing (NG) | 2.30 | 0.65 | 2.68 | 1.11 | 2.63 | 0.78 | 2.56 | 0.84 |
| Item Sharing (IS) | 2.12 | 0.77 | 2.27 | 0.84 | 2.21 | 0.83 | 2.20 | 0.82 |
| Total | 2.48 | 1.17 | 2.59 | 1.28 | 2.58 | 1.18 | 2.56 | 1.20 |

**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 33.96 | 0.000 |
| Type | 1.45 | 0.235 |
| Treatment * Type | 0.41 | 0.802 |

# Move Time (Seconds)




Time pressure when moving…

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| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Chunk Sharing (CS) | 67.14 | 34.96 | 75.35 | 34.68 | 87.15 | 52.32 | 79.69 | 45.86 |
| Chunk Sharing Under Time Pressure (CSTP) | 39.10 | 25.19 | 46.90 | 37.31 | 49.15 | 29.30 | 46.17 | 30.40 |
| Total | 53.78 | 33.67 | 61.81 | 38.55 | 69.03 | 46.88 | 63.72 | 42.65 |

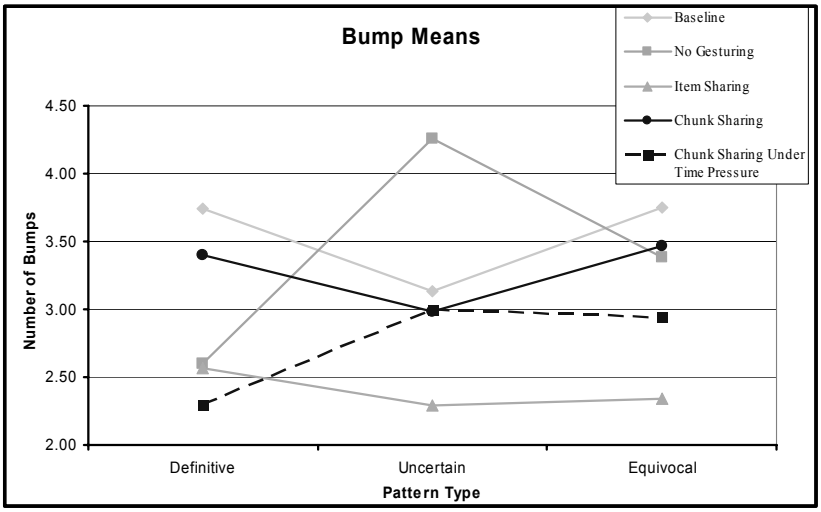
**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 82.86 | 0.000 |
| Type | 7.81 | 0.000 |
| Treatment * Type | 1.17 | 0.310 |

**Pair-wise Comparisons - Pattern Type**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | Definitive vs. | | Uncertain vs. |
| | Uncertain | Equivocal | Equivocal |
| Mean Diff. | -8.04 | -15.26 | -7.22 |
| Sig. | 0.235 | 0.000 | 0.213 |

# Bumps

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1/03

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| Treatment | Pattern Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Definitive | | Uncertain | | Equivocal | | Total | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Base Line (BL) | 3.74 | 3.41 | 3.13 | 3.10 | 3.75 | 3.01 | 3.62 | 3.13 |
| No Gesturing (NG) | 2.60 | 2.12 | 4.26 | 4.40 | 3.38 | 2.37 | 3.35 | 2.84 |
| Item Sharing (IS) | 2.57 | 2.22 | 2.29 | 1.54 | 2.34 | 1.84 | 2.39 | 1.88 |
| Chunk Sharing (CS) | 3.40 | 3.35 | 2.98 | 2.27 | 3.47 | 2.64 | 3.36 | 2.76 |
| Chunk Sharing Under Time Pressure (CSTP) | 2.30 | 2.01 | 3.00 | 2.73 | 2.94 | 2.32 | 2.80 | 2.36 |
| Total | 3.08 | 2.91 | 2.93 | 2.70 | 3.21 | 2.60 | 3.12 | 2.70 |

**ANOVA Results**

| Source | F | Sig. |
|---|---|---|
| Treatment | 9.06 | 0.000 |
| Type | 0.82 | 0.439 |
| Treatment * Type | 1.33 | 0.224 |

**Pair-wise Comparisons - Pattern Type**

| Statistics | Pair-wise Comparisons | | |
|---|---|---|---|
| | Definitive vs. Uncertain | Definitive vs. Equivocal | Uncertain vs. Equivocal |
| Mean Diff. | 0.15 | -0.13 | -0.28 |
| Sig. | 0.778 | 0.768 | 0.320 |

**Pair-wise Comparisons - Treatment**

| Statistics | Pair-wise Comparisons | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CSTP vs. | | | | CS vs. | | | IS vs. | | NG vs. |
| | BL | NG | IS | CS | BL | NG | IS | BL | NG | BL |
| Mean Diff. | -0.82 | -0.55 | 0.41 | -0.56 | -0.26 | 0.00 | 0.97 | -1.23 | -0.96 | -0.27 |
| Sig. | 0.010 | 0.579 | 0.547 | 0.301 | 0.807 | 1.000 | 0.001 | 0.000 | 0.038 | 0.936 |

# *Conclusions*

- Team Recognition Primed Decision Making Model Continues to be Validated
- Sharing of Pattern **Chunks** Improves Performance
  - Cognitive Alignment
  - Ultra Thin tool


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# *Cleanup for FY 2002*

- Protocol Process Analysis
  - Who's doing the bumping?
    - Detailed process analysis is required and ongoing
  - Emergent Leadership under Time Pressure?
    - Consistent leader and followers
  - Stimulating Structures
    - Moves of the 7,6 and 1 chips


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# *FY 2003 Plans and Onward*

- Change task domain (increase complexity)
  - Team Chess (expert chunk sharing)
    - Gobet/Simon (wants to explore CHREST)
    - Geo-Space, Power, Role, Hierarchy
  - Dynamic pattern recognition
  - Open Source Data
- Manipulate the ability of team members to “push” or “pull” pattern information from their teammates (negotiated interrupts)
- Sudden Insight Signal in conjunction with gaze


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