# *Passing the Bubble: Cognitive Efficiency of Augmented Video for Collaborative Transfer of Situational Understanding*

## Review of Human Factors Discovery and Invention Projects


Code 342
Cognitive and Neural Sciences
Office of Naval Research

January 11-13, 2005

# Report Documentation Page

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# Research Team

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# Project Summary

## Overview

I. **Project Summary Overview**
   Long term goals
   Expected final product, potential impact, applications
   Project objective, approach

# Long-term Goals

1. Determine how to annotate videos or images to share situational awareness better
    - Strategic conditions,
    - tactical conditions,
    - environmental conditions
    - commander's future plans.
    - distributed team members
2. Guidelines for annotating video and well chosen stills

# Long-term Goals

2. Develop methodology for quantitatively measuring the value of asynchronous briefing
3. Deepen Theoretical Framework
   - Dynamical representations
   - What is shared understanding
   - Distributed  cognition and Annotation
   - Annotation and attention management

# This Year's Goals

4. Slice away at the value of co-presence, gesture, real-time interactivity
   - How good can remote 'over the shoulder' observation of a face to face presentation be?
   - How important is interactivity, even if not face to face? (ie. Asking questions)

# Expected Final Products

1. Guidelines: When and how to use annotation to improve shared understanding. Major factors:
   - Annotating stills vs. annotating video's, cost and benefits
   - Using annotation types (circles, arrows, moving ellipses) for specific information needs
   - Annotation and expertise level – who needs it most and when
   - How to tell good from bad (pointless) annotation
2. Metrics: cognitive efficiency of different annotational techniques
   - Relativized to expertise
   - Relativized to knowledge types
3. Articles & Theoretical models
   - Dynamic Representations
   - Annotation and Sharing Understanding
   - Empirical Findings and relation to Illustration

# II. Technical Plan

- Experimental plan, data collection

# Experimental Plan

- Add new conditions – see factorial table
- Increased orientation on differences between live and taped live presentations
- Analyze if certain graphic objects are more effective at conveying certain knowledge objects
- Analyze relation of gesture in live with annotation in live

# New Conditions

+ 36 controls

| Players | Synchronous | Co-located | Gesture visible | Live questions | # Trials |
|---|---|---|---|---|---|
| Expert - Expert | Y | Y | Y | Y | 12 |
| Expert - Expert | Y | N | Y | Y | 12 |
| Expert - Expert | Y | N | N | Y | 12 |
| Expert - Expert | Y | N | N | N | 12 |
| Expert – Expert | N | N | N | N | 12 |
| Expert – Expert | N | N | Y | N | 12 |
| Intermediate – Intermediate | | | | | 12 |
| | | | | | 12 |
| | | | | | 12 |
| | | | | | 12 |
| | | | | | 12 |
| | | | | | 12 |
| Expert- Intermediate | Same 6 conds | | | | 72 |
| Intermediate - Expert | Same 6 conds | | | | 72 |

# Examples



Experts talking from different venues

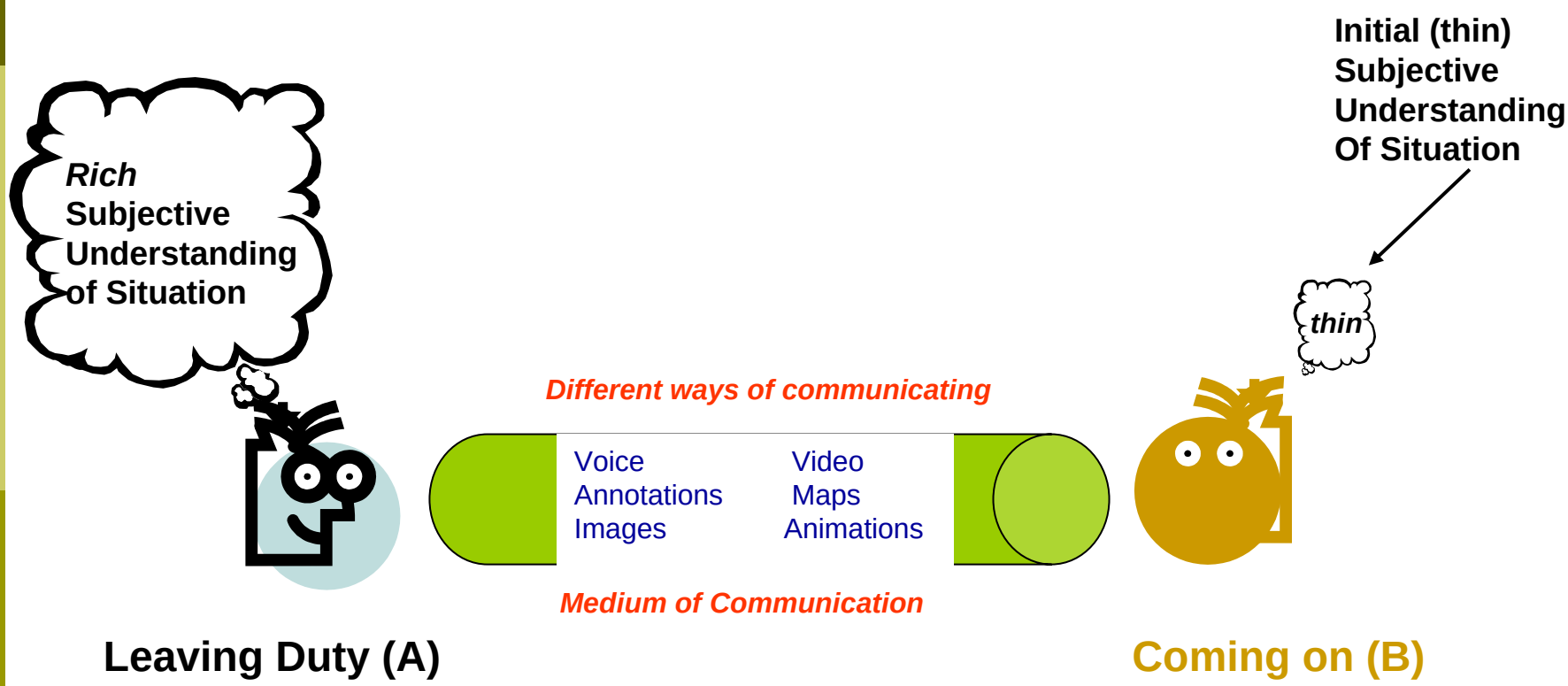
Intermediates Face to face

# New Experiments

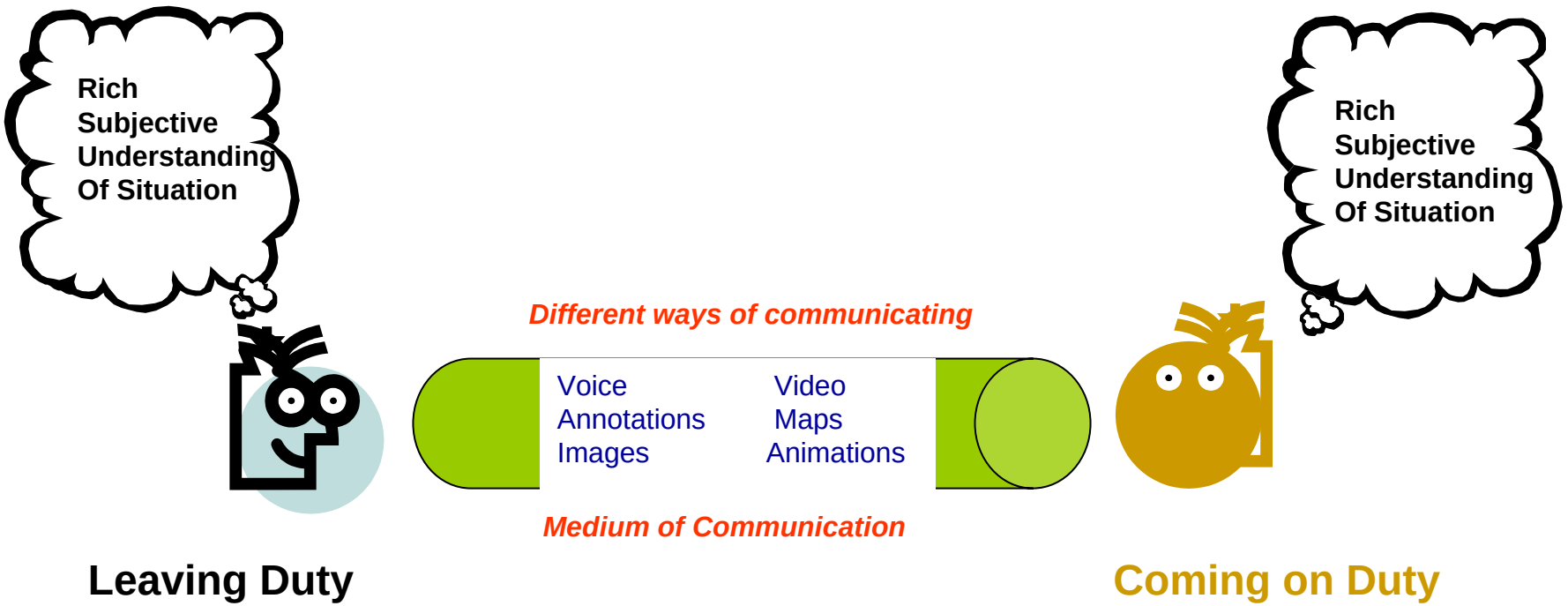
| New Trials | | | | | |
|---|---|---|---|---|---|
| | New Conditions | New Controls | Old Conditions | More Controls | Total |
| Required | 286 | 143 | 120 | 48 | 597 |
| Completed | 108 | 0 | 0 | 14 | 122 |

# Experimental Design

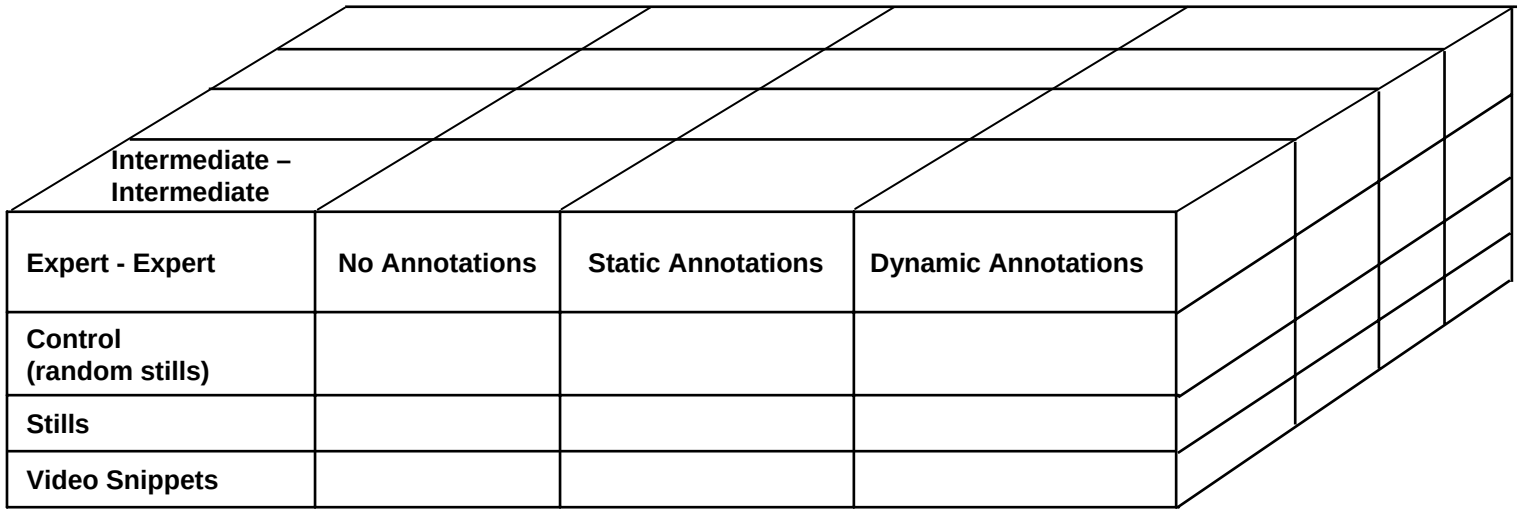
# Opening Context



# Closing Context



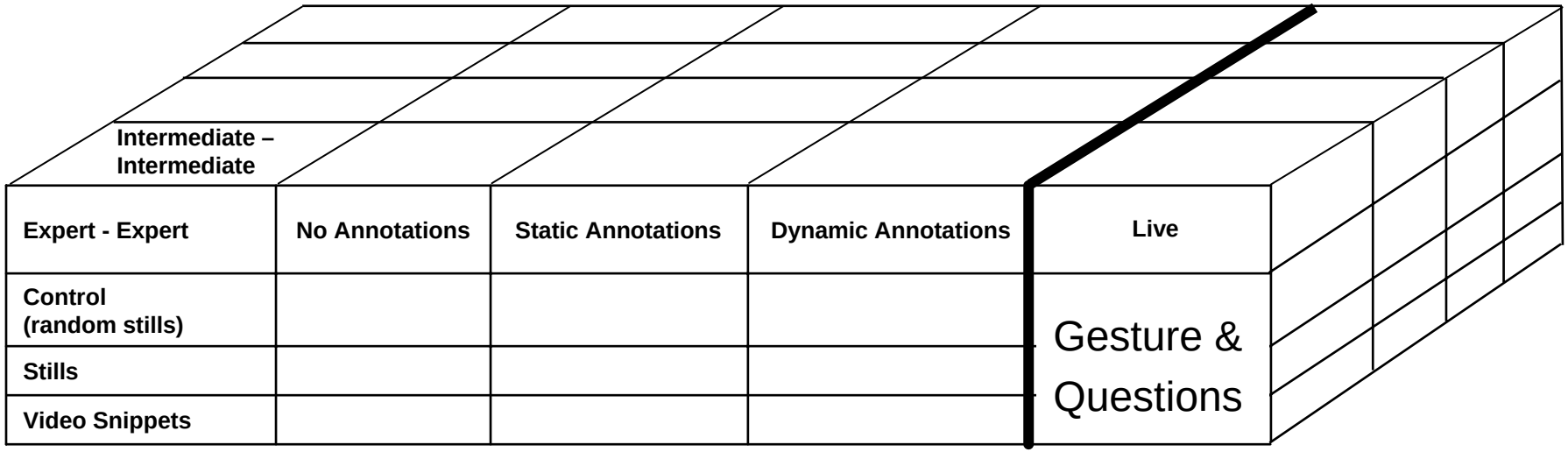
# Original Factorial Design




Annotating video snippets and stills

Takes long time to create presentations

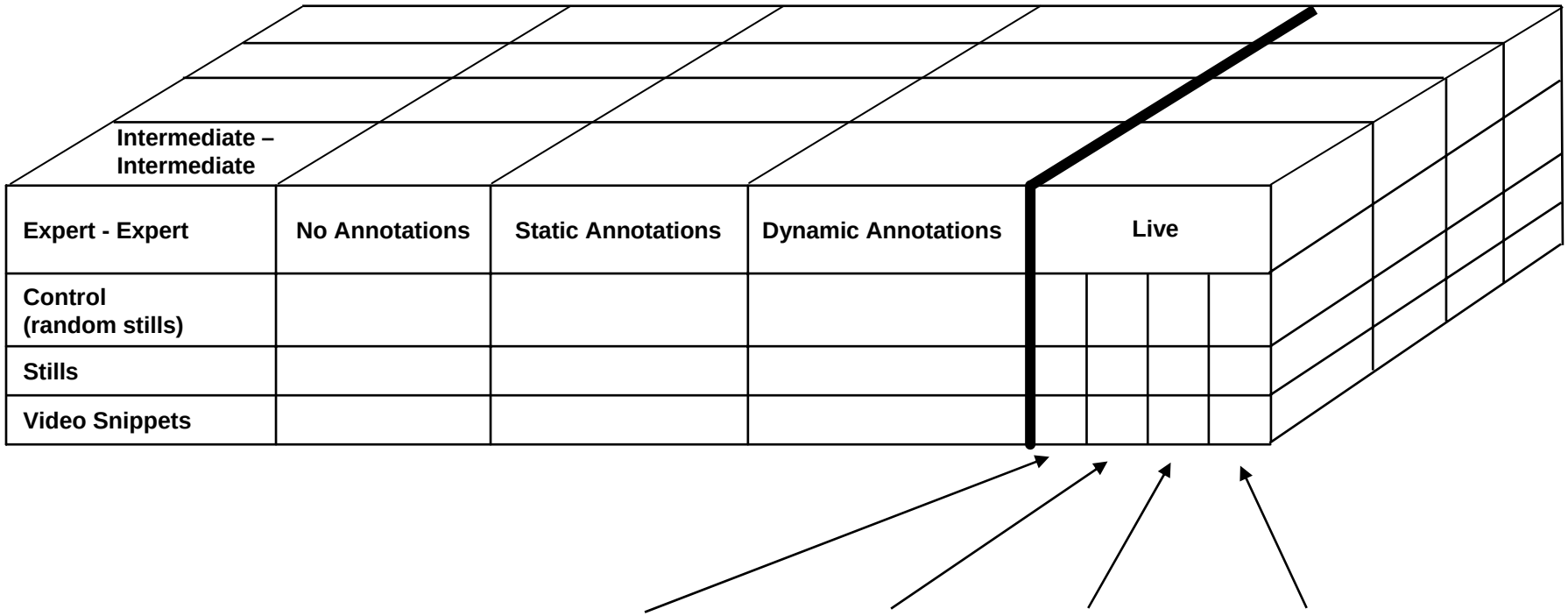
# Added Live Presentation




Live was a new condition to support face to face presentation

And near real-time production

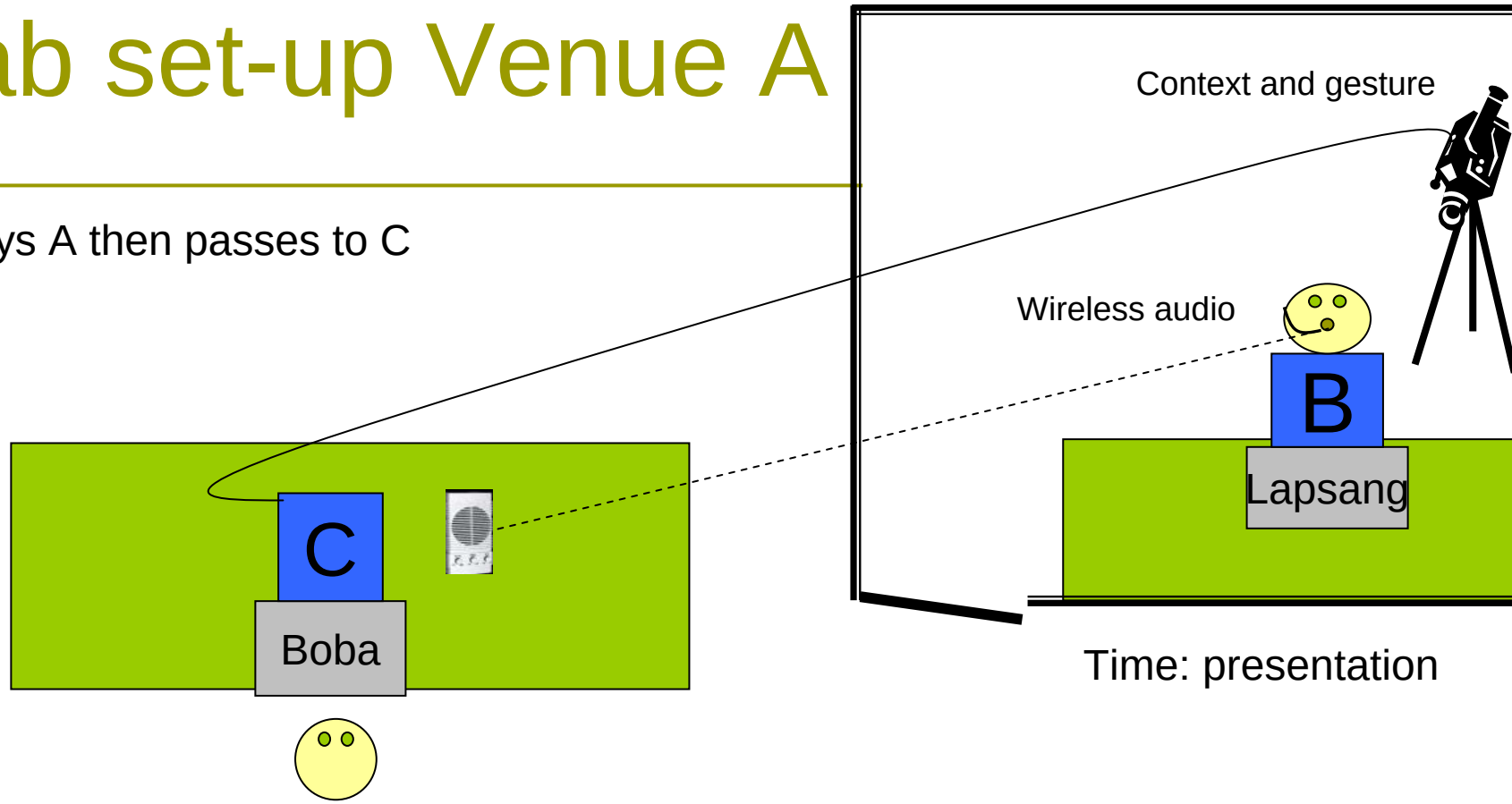
# Separate Live Factors




Face to face = synchronous, co-located, gesture, questioning

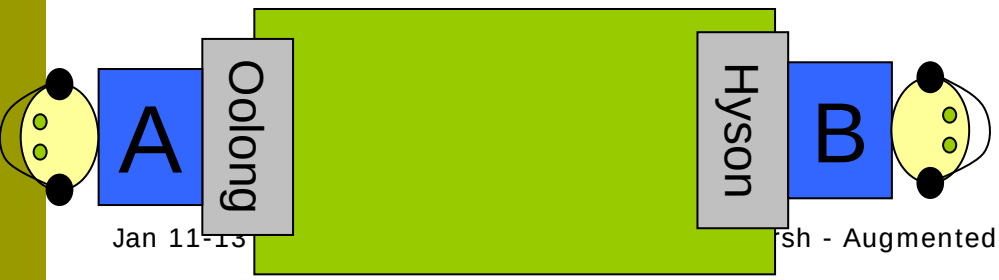
# Lab set-up Venue A

B plays A then passes to C




Time: presentation

Time: Game 0 – 15 min



# Research Hypotheses

1. Graphical annotation adds to performance in presentations made of well chosen stills and well chosen video snippets.
2. Video is better than Stills in conveying situational understanding in strategic contexts
3. Annotation is always helpful because it adds info
4. dynamic annotations are less helpful on video snippets than static graphical annotations are.

# Research Hypotheses

5. Live presentations to the person are no better well designed canned  presentations
6. Good presentations have significantly more knowledge objects than bad presentations.
7. Being didactic with other experts is a bad thing
8. Info about the enemy is more valuable than about our own side

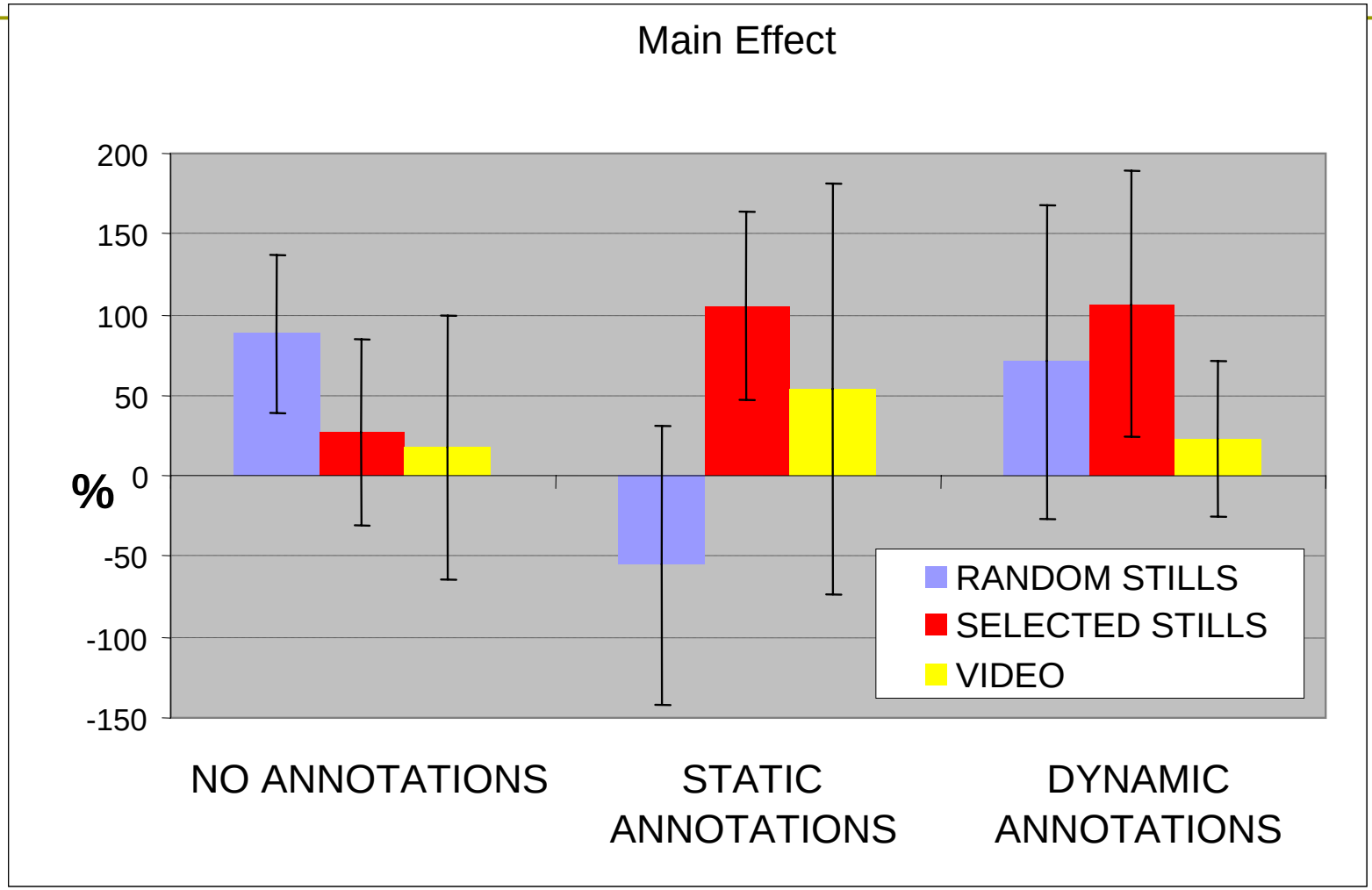
# Project Status

## Main Results

# 1. Graphical annotation is helpful

- As predicted: Graphical annotation adds to performance in presentations made of well chosen stills and well chosen video snippets.

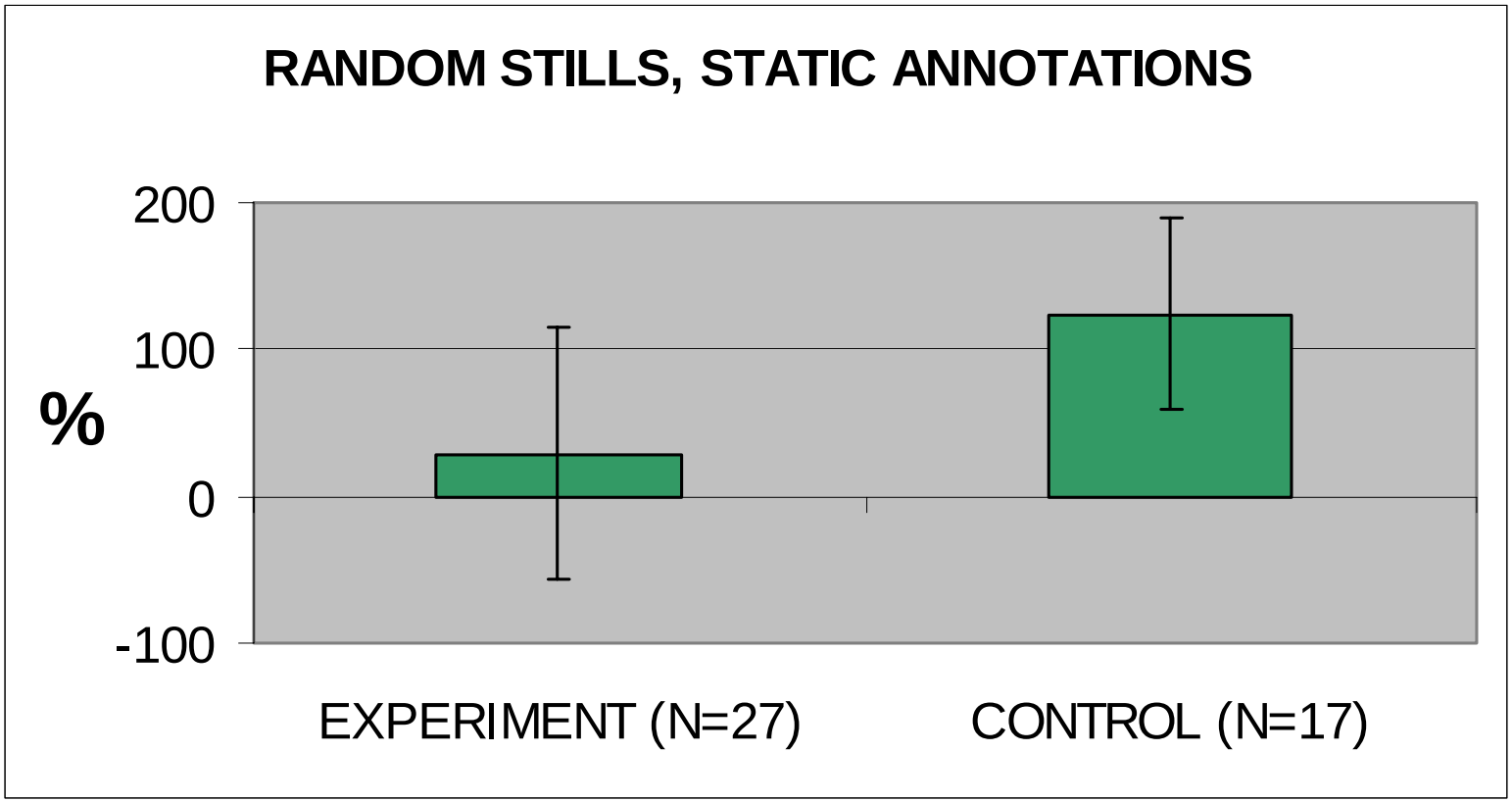
# Graphical annotation is helpful



# 2. Random stills don’t benefit from annotations

- Surprise 1: Graphical annotation may add nothing or even be detrimental for presentations made from machine chosen, i.e. randomly chosen, stills.

# Random stills don't benefit from annotations



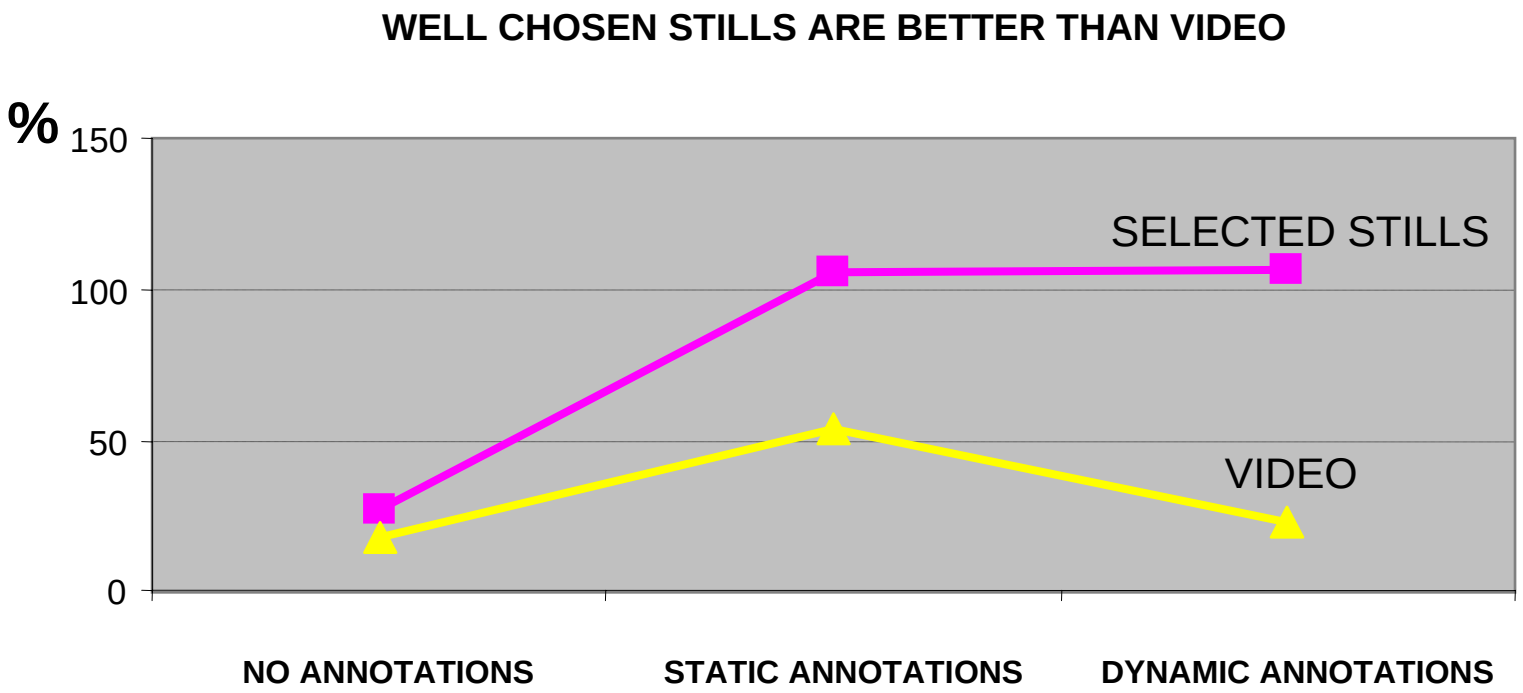

- On the same games, subjects actually seem to be doing worse after viewing presentations made of randomly picked stills with static annotation.
- so far significance is marginal $F(1,42)=2.418$, $p=.127$

# Random stills don't benefit from annotations .. details

- good audio narrative makes sense of randomly chosen stills.
- Conjecture: Graphical annotation lowers performance by distracting listener from making own sense of randomly chosen stills.
  - Stills are in temporal sequence but their story will be fragmented and possibly incomplete. The audio narrative helps but requires substantial inference on the part of listeners. Experts seem able to deal with this fragmentary information and are bothered by the annotations the presenter adds to the scene. This suggests that attending to annotation may carry a bigger cognitive cost than previously assumed.

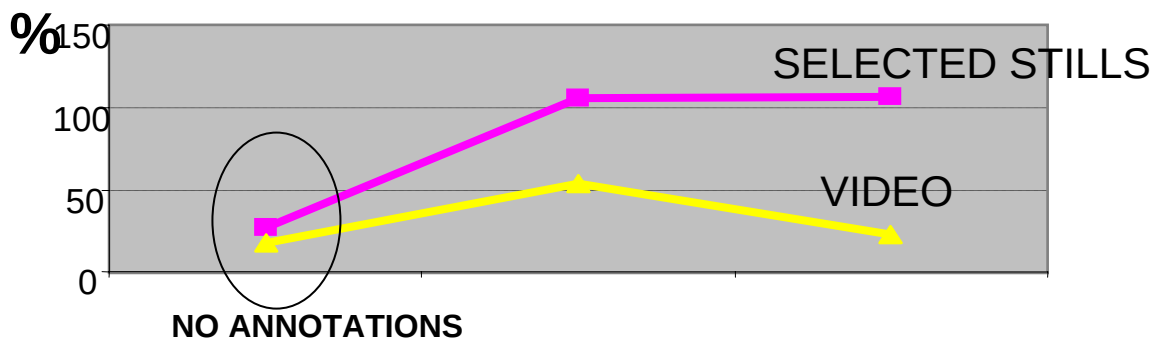
# 3. Well chosen stills best

- Surprise 2: well chosen stills are best.
  - Well chosen stills when annotated (whether with static or dynamic annotations) seem to be better than selected video snippets that are annotated.

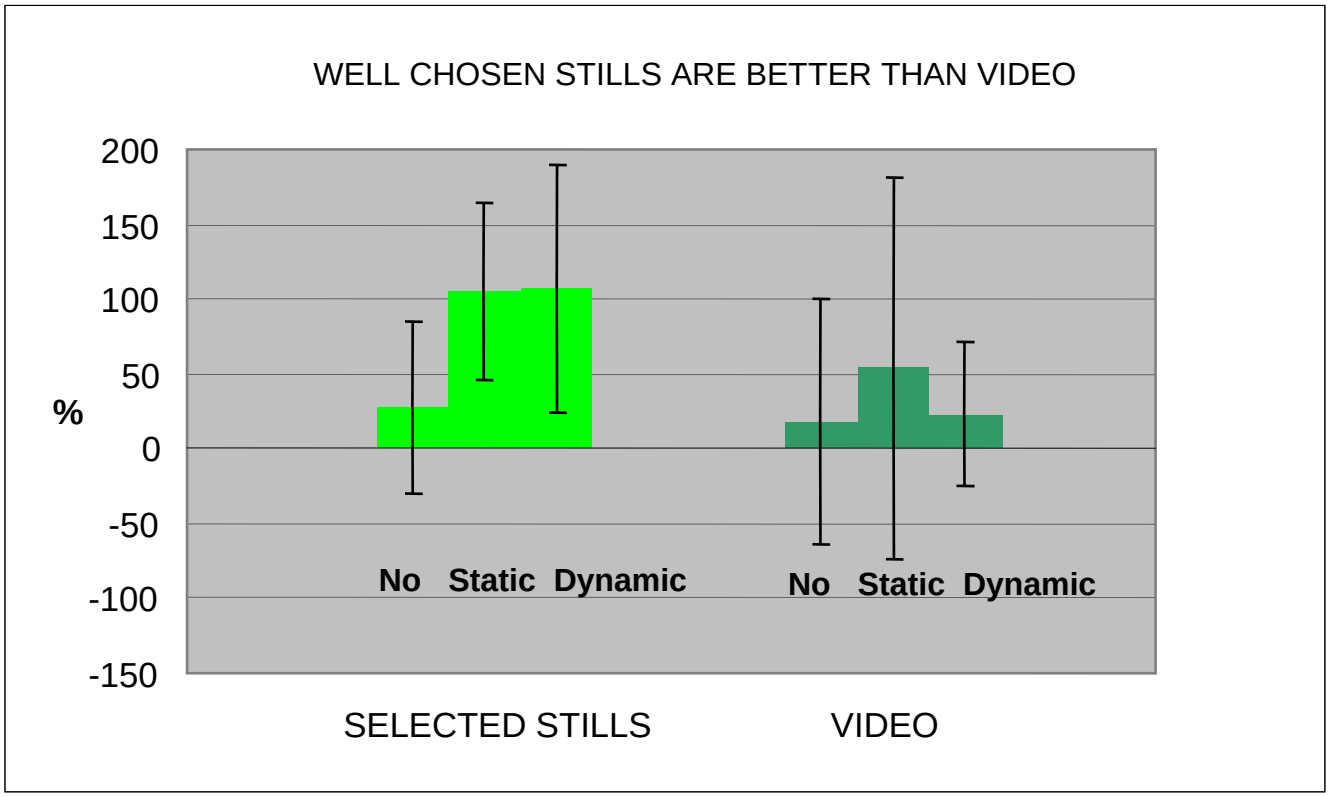


# Well chosen stills = Well chosen video

- Video snippets without annotations are not significantly better or worse than selected stills without annotations – the without annotation condition means presentations with voice but no graphic annotation.



# Well chosen stills best




(F(1,70)=4.528 p=.037)

# Video may not be worth it

- well chosen stills are like well chosen illustrations,
  - literature has shown that illustrations are often better than videos or animations at communicating structural, strategic and resource information.
  - if the process being described is not too complex all the important transitions and states of the process can be identified in static images.
  - Static images allow viewer greater control over attention management to move at their own pace
- May not be true if video or dynamic annotations are used to carry extra information about speed, rate of progress and other time sensitive elements.

# Next step

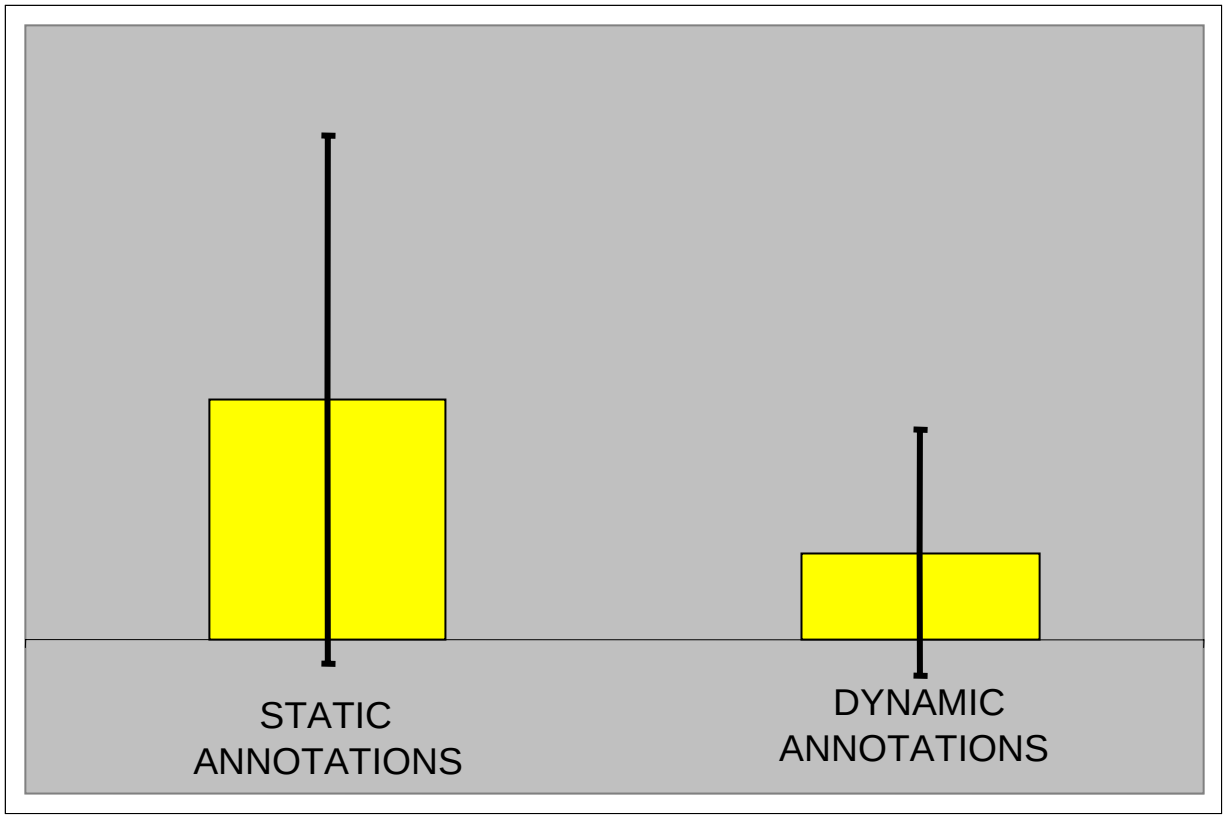
- To explore this unexpected results we have begun looking at how frequently presenters actually used dynamic annotations to convey dynamic information, and we have been analyzing whether there is much to be gained by presenting dynamic information.

# 4. Dynamic annotations

- As predicted: dynamic annotations are less helpful on video snippets than static graphical annotations are.
- Reason:
  - cognitive load
  - distraction of video on video
  - Forces interpretation in presenters pace

# Annotations on Video

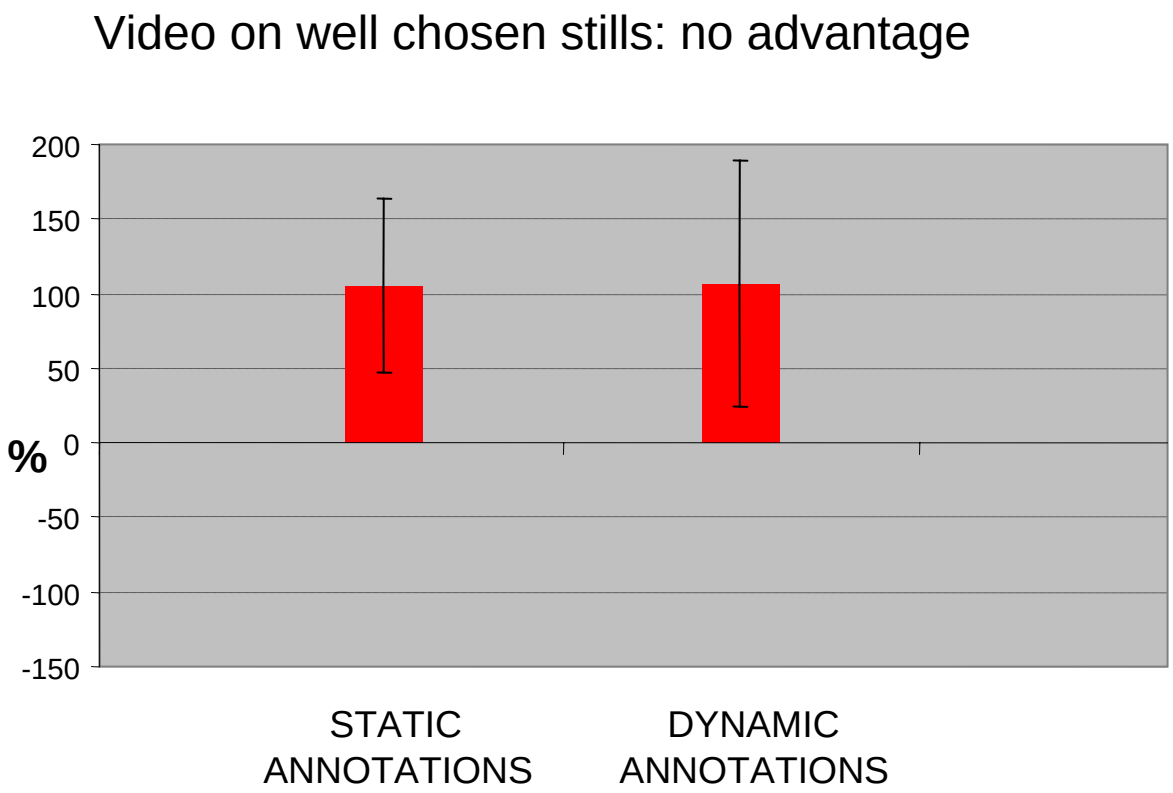
Video on video: trending to worse than static annotations on video (F(1,19)=1.28 p=.27)



# 5. Dynamic annotations surprise: not better on selected stills than static annotations

- Surprise 3: dynamic annotations are not better on selected stills than static annotations and may at times be worse.

# Annotations on Well Chosen Stills



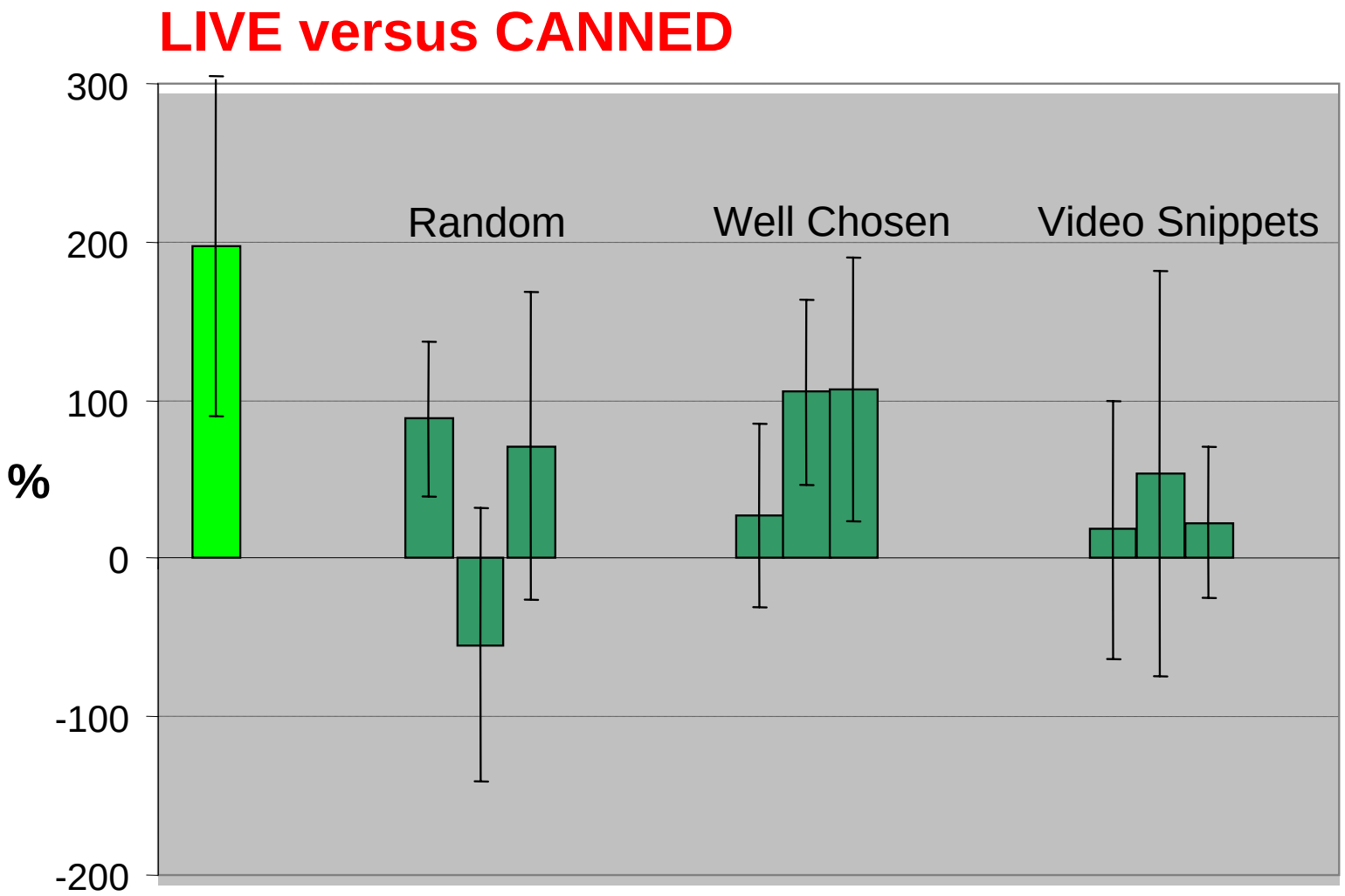
# Dynamic annotations surprise ... Cont

- Video annotation overlays, even on static images, do not add anything extra, and may sometimes add less than static annotations. Although we were not surprised that video on top of video snippets was not as helpful as static on top of video it is surprising that video on top of stills is not the best way to communicate.
- Evidently they too must be distracting for viewers who are trying to listen to the audio commentary. This is another area in which more research is needed.

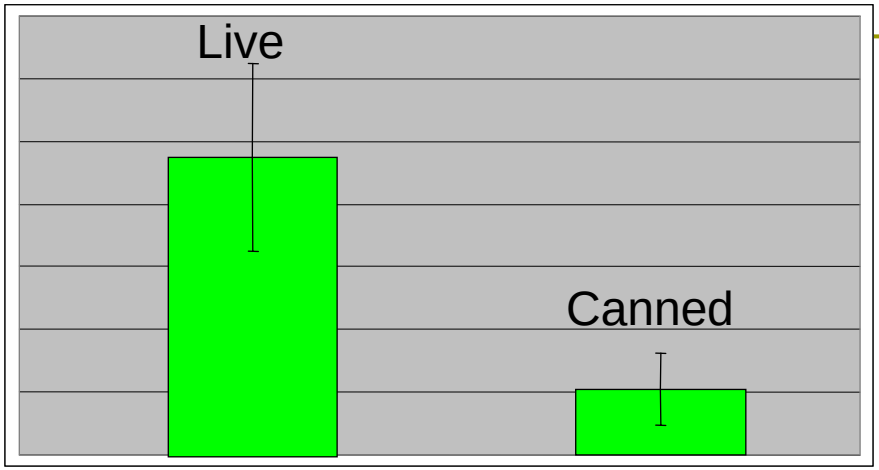
# 6. Live presentations

- Surprise 4: Live presentations to the person who will take over are better than all forms of canned presentations.
  - They are very much faster and easier to make.
    - Live presentations contain gestures that function like graphic annotation and
    - they contain mouse pointing which also serves as an attention management mechanism, much like many of the graphical annotations found in our canned presentations.

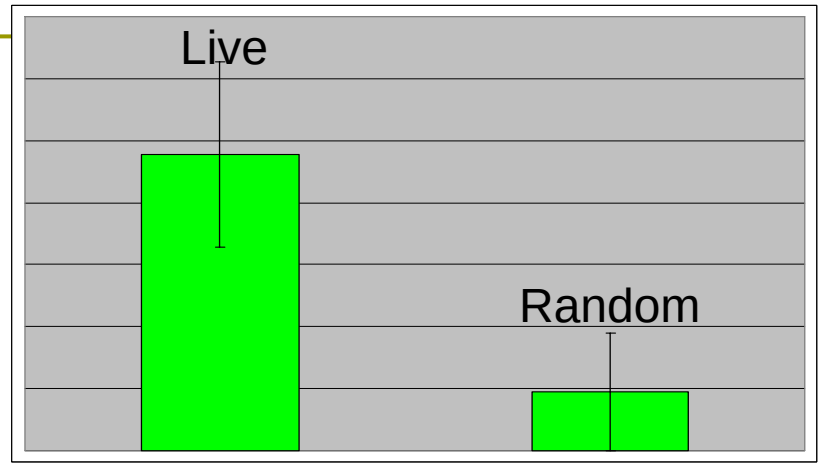
# Live presentations



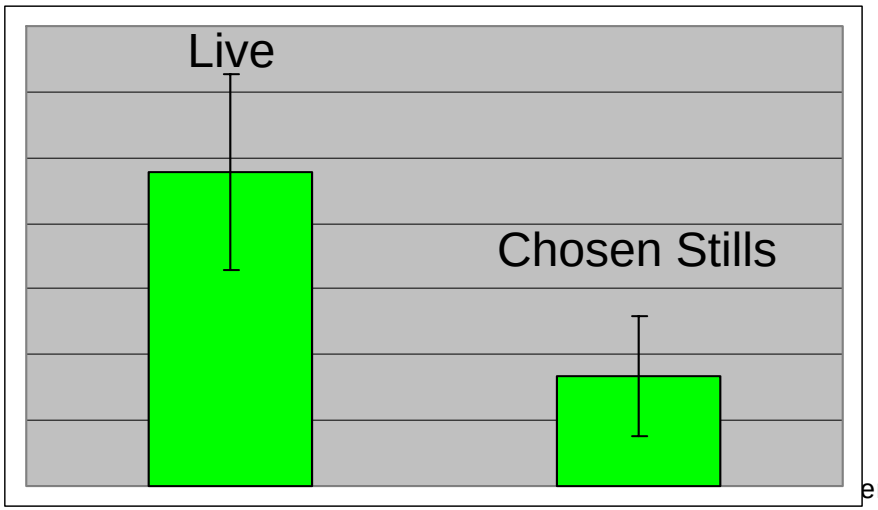
# Live versus Canned



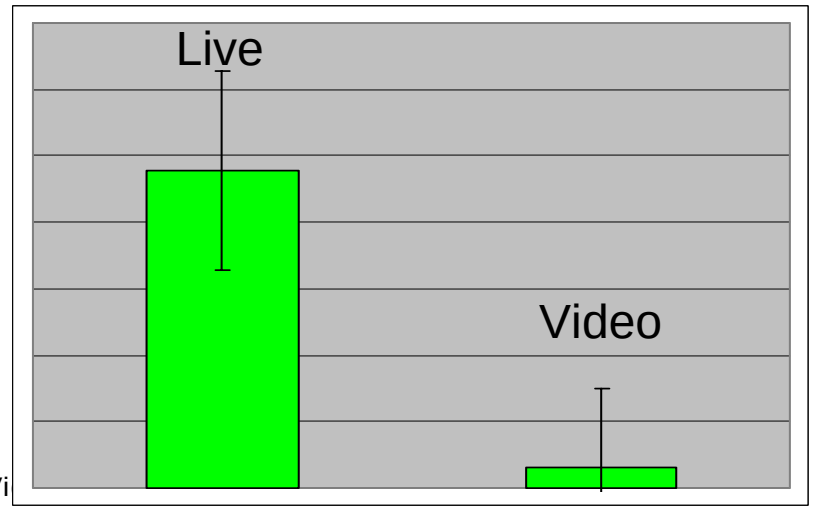

Live versus all Canned p=.001




Live versus Random p=.003




Live versus Chosen Stills p=.006




Live versus Video p=.0004

# Live presentations

- Is the performance boost coming from
  1. giving more relevant information
  2. interaction with presenters – asking questions or showing interest in certain areas
  3. the pace that presenters adopt as a result of subtle interpersonal cues apparent in the face to face condition
  4. gesture

# New Results – initial

- We tested live transfer in two ways

| Expert to Expert | Live | Canned |
|---|---|---|
| 4 min - unlimited | | |
| 2 min | | |

- Finding: presentations have to be long enough for canned to be effective

| Expert to Expert | Live | Canned |
|---|---|---|
| 4 min - unlimited | good | good |
| 2 min | good | Not good |

p = .0003  live is better than canned for 2 min

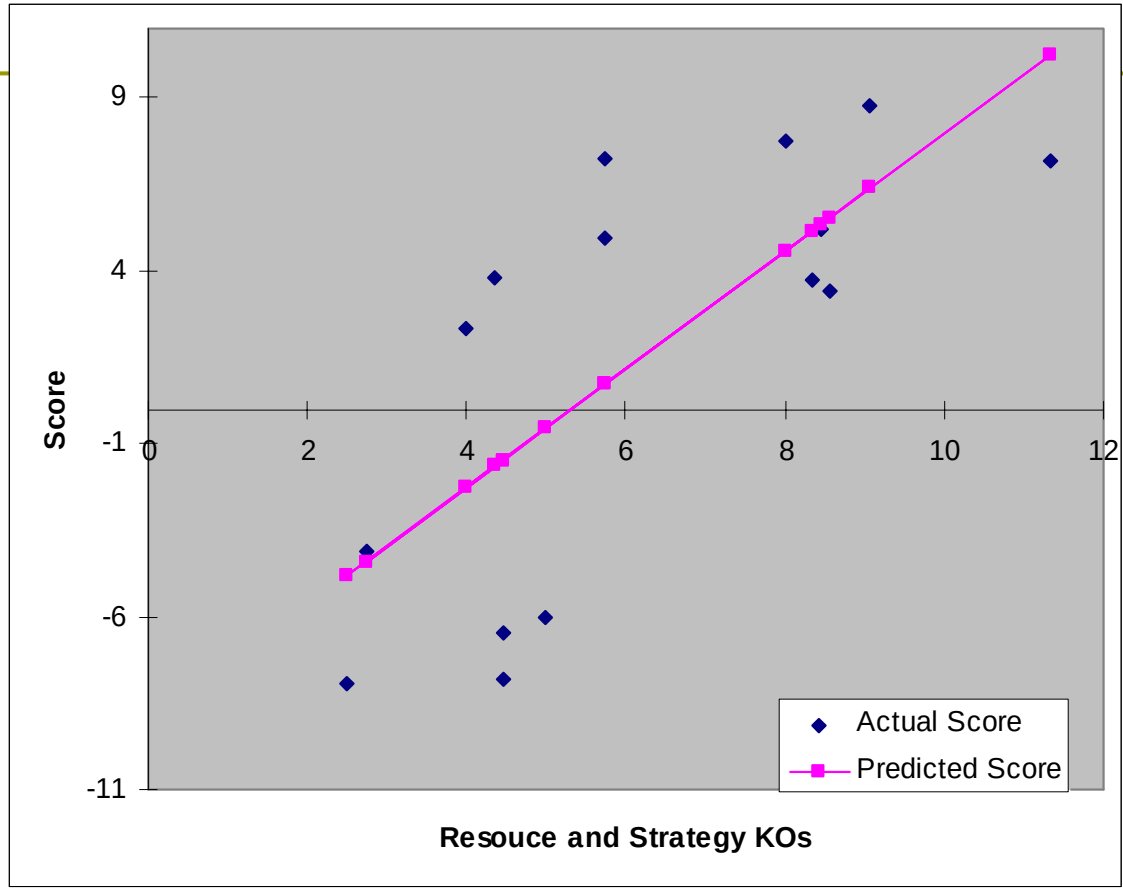
# 7. More Knowledge Objects of the right type the better

- Best type of Knowledge
  - Strategy
  - Resource
- KO's that are a waste of time
  - Didactic
  - Past event
- Slightly better to give the strategy and resource KO about the enemy rather than about our side

# More Knowledge objects the better

- As predicted: Good presentations have significantly more knowledge objects than bad presentations.

# More KO's the better – Resource and Info




- Limited to KO's of resource and strategy
  - The regression shows how effective a predictor resource and strategy KO are of score

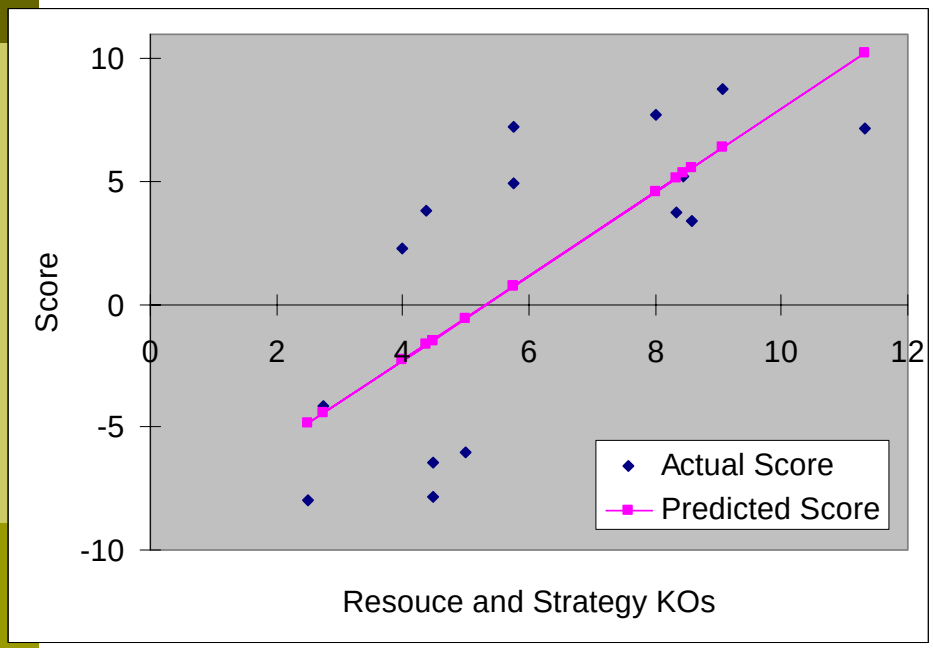
# Didactic KO's are harmful

- As predicted: Being didactic with other experts is actually a bad thing.

  We found practically no didactic content in live presentations, and in all other forms of presentation, there was more didactic content than in presentations that resulted in bad performance than in ones that resulted in good performance.

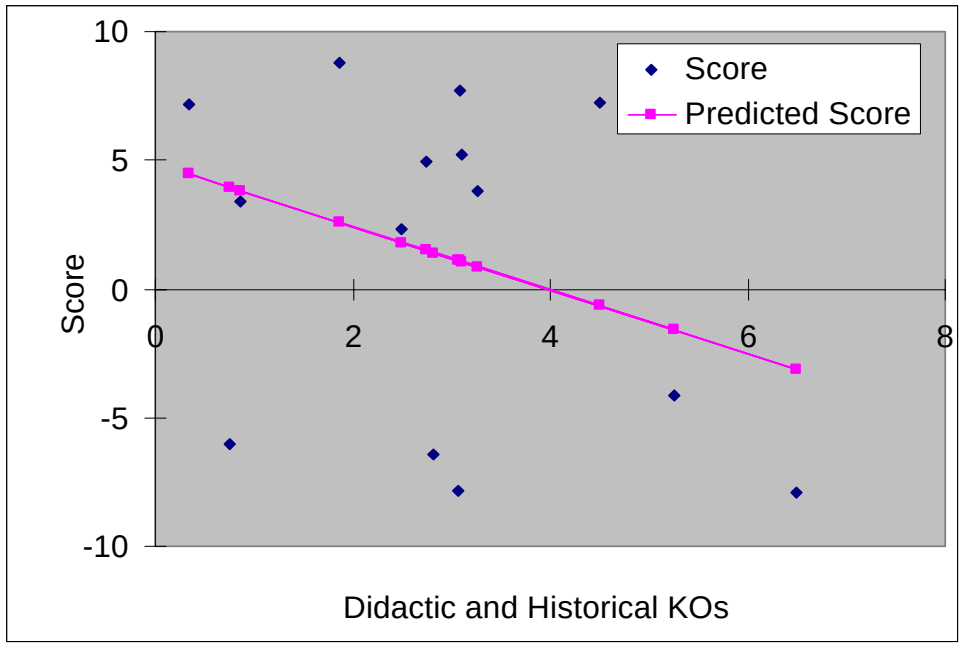
# Didactic and Past events are bad KO's

Resource and strategy [significant]




Positive correlation p=.002

Didactic and Past events [only a trend]




Negative Correlation p=.24

- do didactic KO's cause listeners to tune out?

# KO list

- Here we show the KO's that we used to analyze the stimuli
- This list has been revised several times
  A. Without consulting the stimuli
     1. Use one expert to list possible KO's
     2. Review list with several other experts and have them revise it
  B. After reviewing the stimuli
     1. Modify the list in terms of our experience using it to classify KO's as found in the stims
     2. Iteratively improve the list as we refine our analysis

# Didactic KOs

What are my units capabilities
What are the capabilties of my buildings
What does my upgrade do

What are the enemy units capabilties
What are the capabilities of the enemy buildings
What does the enemy updgrade do

# Strategic and Resource KO's

- As predicted: Strategic and Resource related knowledge objects are the most valuable knowledge objects to transfer and they explain why more knowledge objects are better. Didactic and Past event information is not helpful

# Strategy Knowledge Objects

Course of defense (type, location)
Course of attack (trajectory, timing, method)
Course of building (location, order, type)
Course of units (unit type, trajectory)
Course of reconnaissance (trajectory, timing, method)
Use of terrain
Possible expansion locations
Have I been aggressive or defensive

Expected course of enemy units
Expected course of enemy building
Expected course of enemy attack
Expected course of enemy defense
Expected course of reconnaissance
Enemy use of terrain
Possible Enemy expansion locations
Has the enemy been aggressive or defensive

# Resource KOs

My base location
My race
My expansion locations
My resource status (how much gas and mineral I have)
What buildings I have
What units I have
What upgrades I have
Location of my units (at some point in the game)
What are my defenses
Do I have detection units
Do I have transporting units
Do I have units in transports?
What is the general layout of the map
What is the terrain like near my base
Mineral resources at expansions

Enemy base location
Enemy race
Enemy expansion locations
Enemy's resource status
What buildings does the enemy have
What units the enemy has
What upgrades does the enemy have
Location of enemy troops (at some point in the game)
What are the enemy's defenses
What are the enemy's attacking forces
What is the terrain like near the enemy
Can the enemy see my base right now
What are the path(s) to the enemy base(s)

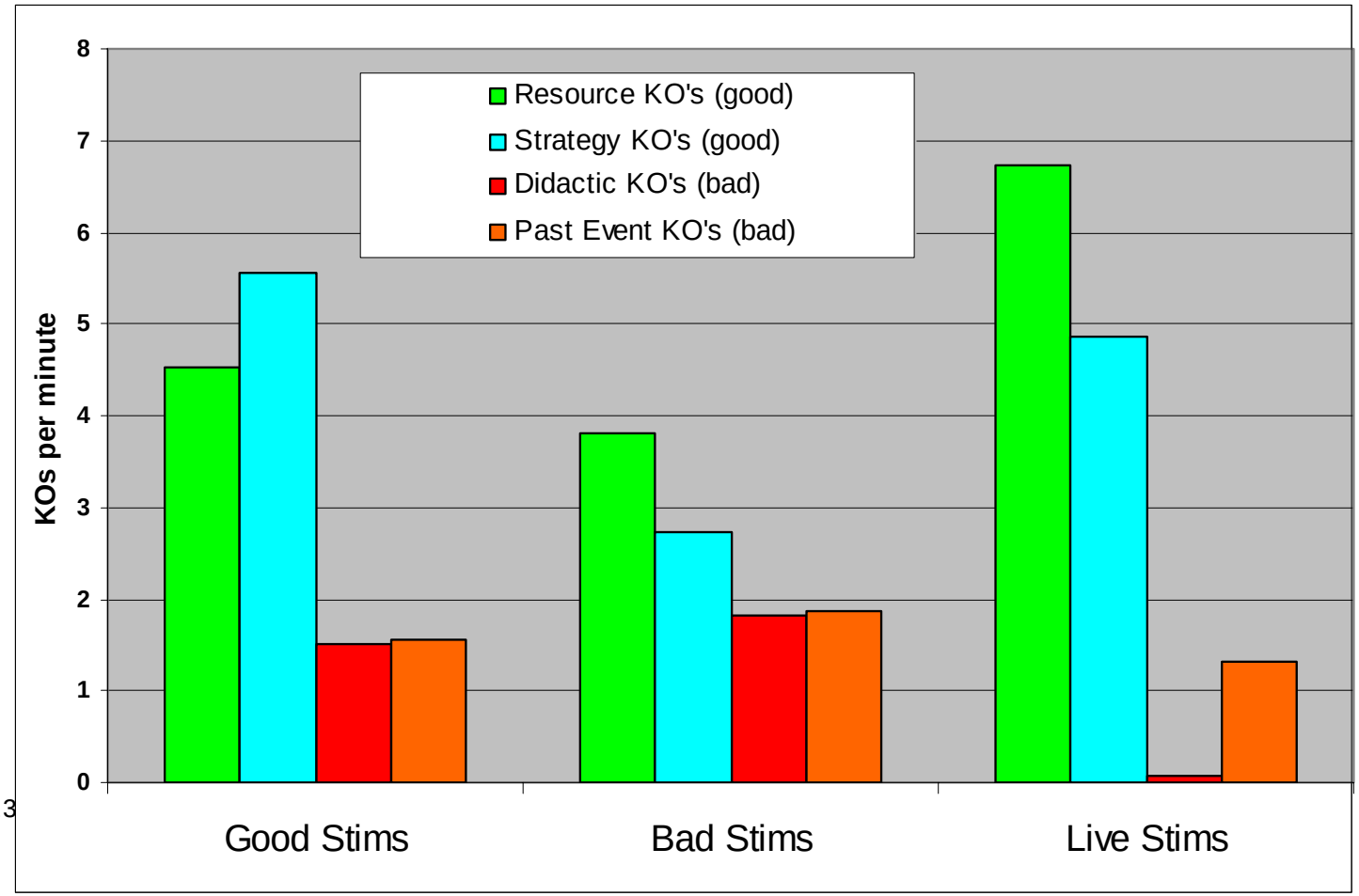
# Past Event KOs

Attacked the enemy
Spotted the enemy (but didn't engage)
Which units were killed
How many units were killed
Which buildings were destroyed
Which units were damaged
Which base was damaged
My expansion was destroyed

Enemy attacked
Enemy spotted me (but didn't engage)
Which enemy units were killed
How many enemy units were killed
Which enemy buildings were destroyed
Which enemy units were damaged
Enemy base was damaged
Enemy expansion was destroyed

# 8. Why are live stims better

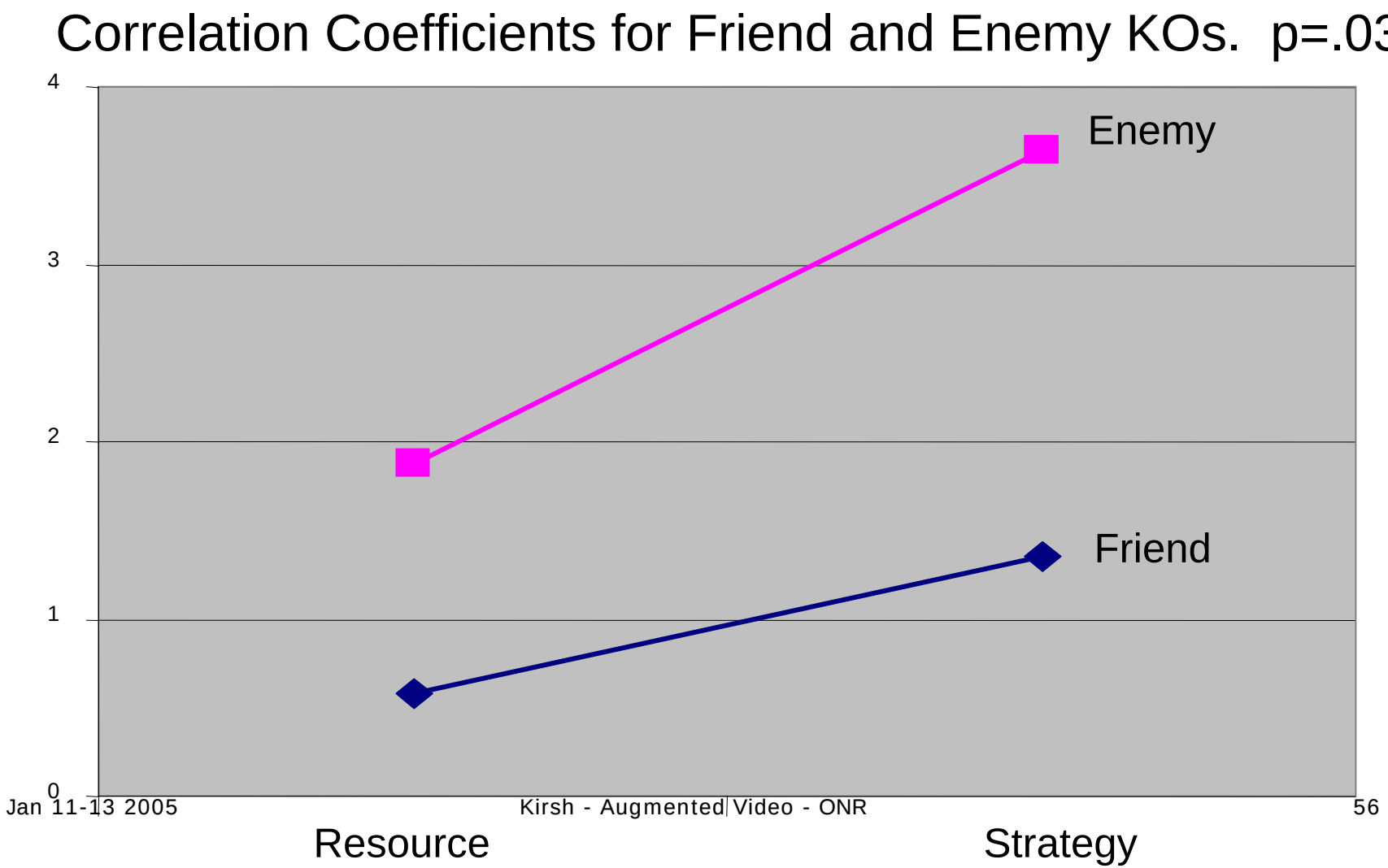
- They have more Good KOs
- They have virtually no didactic KOs



# Info about enemy better than info about our side

- As predicted: It is better to provide helpful information and knowledge (i.e. strategic and resource) about the enemy than it is to provide this same useful information about our own side.

# Info about enemy better than info about our side



# New Conjectures

- Intermediates find briefings more valuable than experts:
  - They need more explanation
  - They still benefit from teaching
- Experts find live briefings so much more valuable because
  - Experts like to drive information transfer more
    - Hence strongly prefer interactive (live) transfers,
    - respond less well to attention management (more headstrong)
  - Experts strongly prefer strategic information and stimulus makers did not include enough of them

# Static Annotation Graphics

# Circle


237
1546
51/67
Protoss Nexus
Building
MENU
Replay Progress
Speed: Fastest x 16
93/750 246/750
2
3
4
5

# Oval

# Circle Arrow

# Filled Circle

# Arrow Pointing at Circle

# Squares

# Straight Arrow

# Curved Arrow

# Straight Lines

# Curved Line

# Squiggly Line

# Continuous Line w/many Points

# Numbering

# Labeling


Defense
Scouts
Enemy Expansions
Island
Shuttle
Troops
Enemy Main

# Labeling in Circle

# Circle Line with Labeling

# Square Lines with Labeling

# X's


858
904
43/75
Protoss Pylon
Psi Used: 42
Psi Provided: 8
Total Psi: 75
Psi Max: 200
122/300 300/300
MENU
Replay Progress
Elapsed Time: 09:11
Speed: Fastest

# Arrows Pointing at Line

# Double Ended Arrows

# Underlines


-LEDGE!!!-
Anti-Air
Replay Progress
Elapsed Time: 05:00
Speed: Fastest
MENU

# Color Coding

# Double Circle Arrow

# Crossed Lines

# Labeled Arrows

# Converging Arrow

# Multiple Arrows from One Point

# X in Circle


394
632
28/49
Protoss Gateway
Opening Warp Gate
500/500 500/500
2 3 4 5
MENU
Replay Progress
Elapsed Time: 05:32
Speed: Fastest

# X-arrow


Protoss Gateway
MENU
Replay Progress
Elapsed Time: 09:27
Speed: Fastest
500/500 500/500

# Dynamic Annotation Graphics

# Dynamic Circle

# Dynamic Underlining

# Square Callout Labeling

# Circle Callout Labeling

# Little Map to Big Map Callout

# Dynamic x

# Building Progress Callout

# Dynamic Circle Line

# Dynamic Squiggly Line

# Dynamic Curved Arrow

# Dynamic Straight Lines

# Dynamic Arrows at circles

# Crossing Out

# Dynamic Numbering

# Dynamic Dotting

# Contribution to Resolving CKM Technical Issues

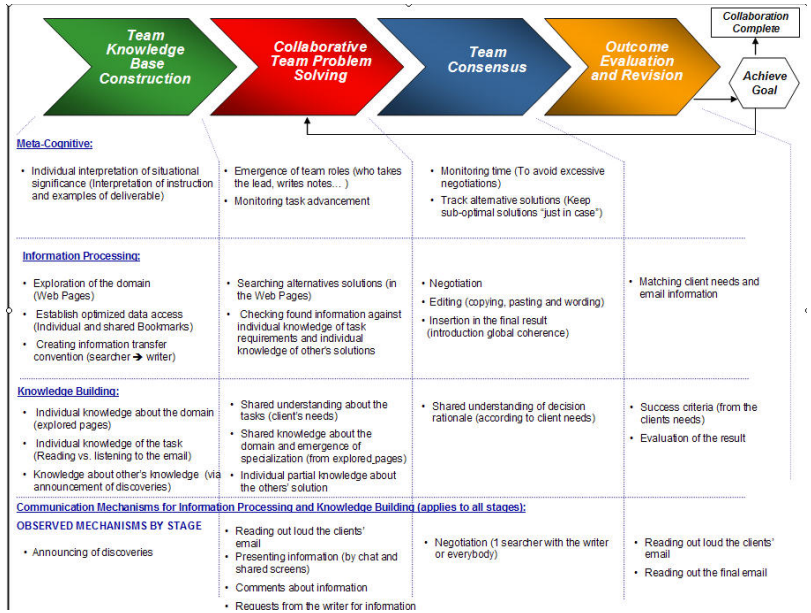
***V.*** ***Contribution to Resolving CKM Technical Issues***
annual identification of research issues
mapping project's scientific focus to CKM stage model

# Relevance to CKM Goals

| Operational Tasks of interest | Task 1<br>*Canned* | Task 2<br>*Live* | New |
|---|---|---|---|
| Team decision making focusing on selecting a course of action | | | |
| Development of shared understanding | X | X | X |
| Monitoring, analyzing, and responding to intelligence information | X | X | X |
| **Collaborative Situation Parameters** | | | |
| Offering help/collaborative preparation | | X | X |
| Time pressure | X | X | X |
| Information/knowledge uncertainty | X | X | X |
| Dynamic information | | X | X |
| Large amount of knowledge (i.e., cognitive overload) | X | X | X |
| Human-agent interfaces | X | X | X |
| **Team Type** | | | |
| Asynchronous | X | | Some |
| Distributed | X | | X |
| Culturally diverse | | | |
| Heterogeneous knowledge | | | E vs I ? |
| Unique roles | | | |
| Organizational Structure (hierarchical vs. flat) | | | |
| Rotating team members | X | | |

# Relation to stage model

- Finding efficient styles of briefing both live and canned are mainly relevant to
  - Team knowledge base construction
  - Team consensus



# Progress toward a Demonstrable Product

*VI.* ***Demonstrable Product***
Transferable products
Transferable project concepts

# Progress toward a Demonstrable Product

- Methodology for experimentally determining quality of shared understanding
- Partial progress toward guidelines for using annotation to asynchronously share understanding
  - New focus on type of graphics used
  - New focus on understanding what makes live presentations effective

# Relevance to Operational Requirements of Program

**VII. Relevance to Program**

concepts improve team collaboration performance.
Clear fit with CKM scenarios

# Concepts Empirically Shown To Improve Team Performance

- Annotation has been empirically shown to improve team performance **but:**
  - Video not always better than still
  - Moving annotation not always better than static annotation
  - Experts need less annotation and less transfer time and want different info than intermediates
  - One size does not fit all

# Fit with CKM goals

- Analysts need briefings on real time info coming from UAV's – in situation rooms, privately during the information gathering phase
- Commanders must communicate intent to distributed teams: both to other decision makers for ratification and to action teams in the field.
- In long scenarios analysts will need to be spelled and pass off their station to another analysts
- New action teams coming into the field will have to be briefed on both the commanders intent and the experience of other action teams

# The End