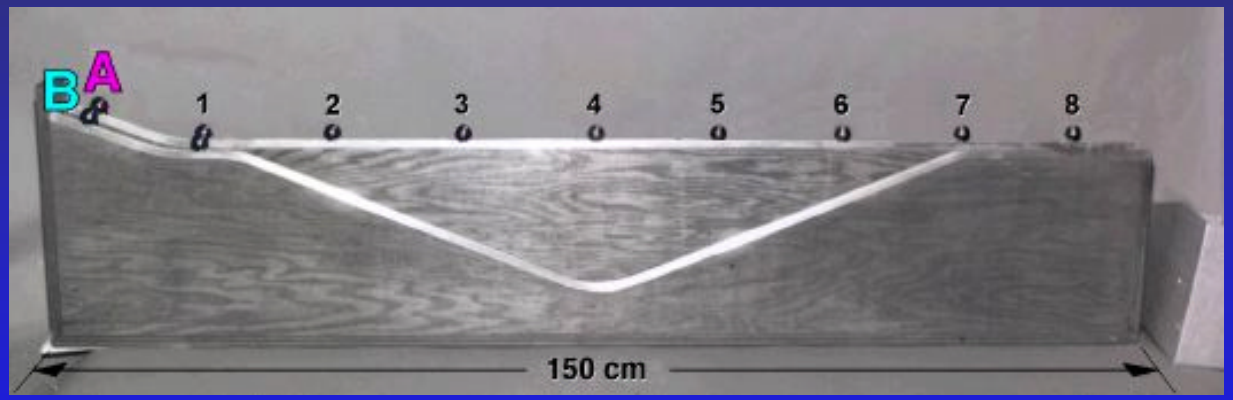
Using Coordination Classes to Understand Students' Judgments of Motion*



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Methods / Samples

- Directions: Choose the animation depicting motion most like what would happen with real balls and real tracks.
- Individual interviews.
- Students describe reasoning while viewing animations.
- Students control computer.
- One-ball animations before two-ball animations.

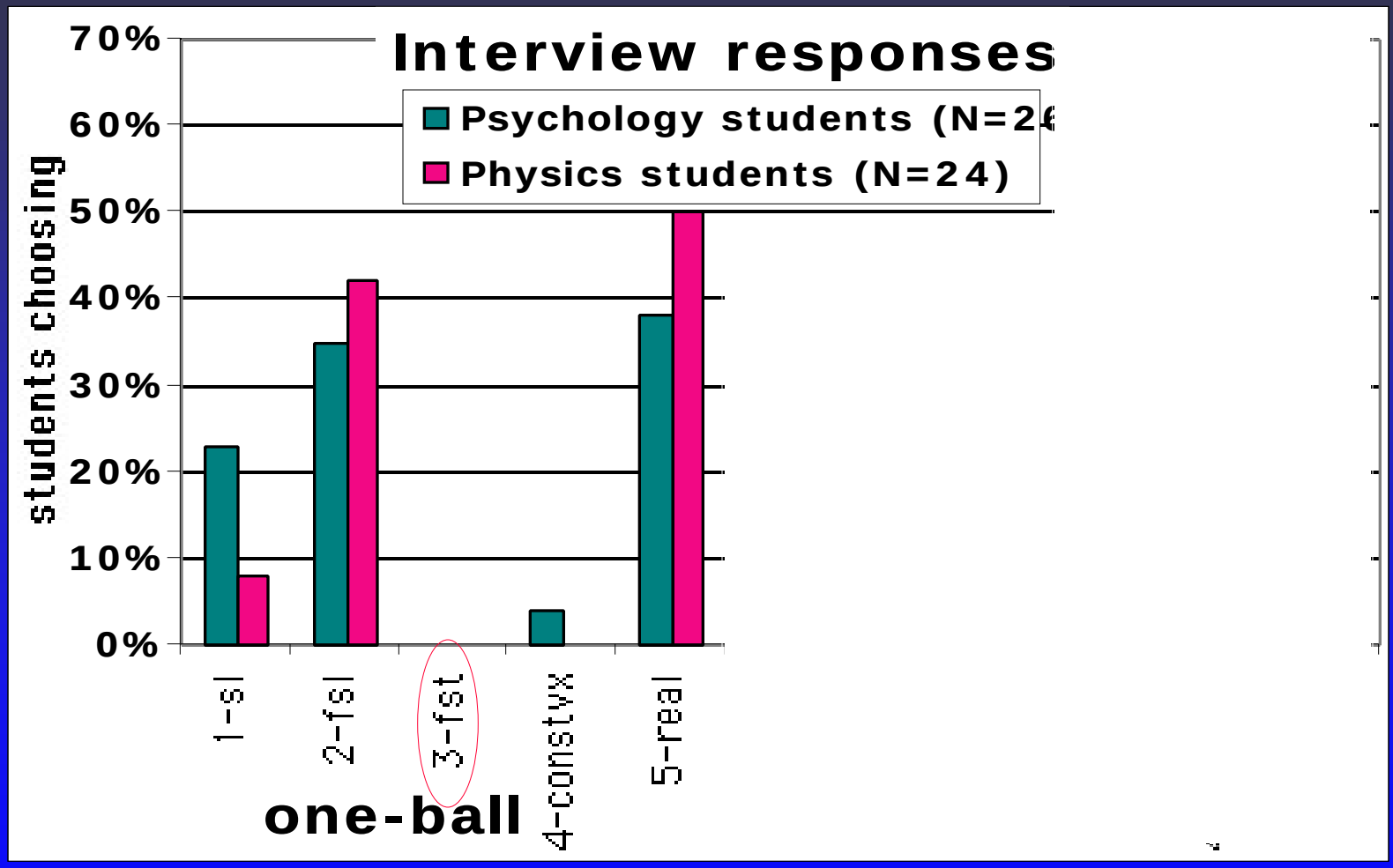
- Students from Ed. Psychology class (N=26)
  - 6 have had no physics, 14 H.S. physics, 7 post-H.S. phys
- Students from Honors Calculus-based Physics class (N=24)
  - late in first semester course

- Audio taped and transcribed (24 Psychology, 12 Physics).

Show 1-ball animations (V-valley)

http://groups.physics.umn.edu/physed/People/Tom%20Koch/2_tracks/index.html

Response Patterns*

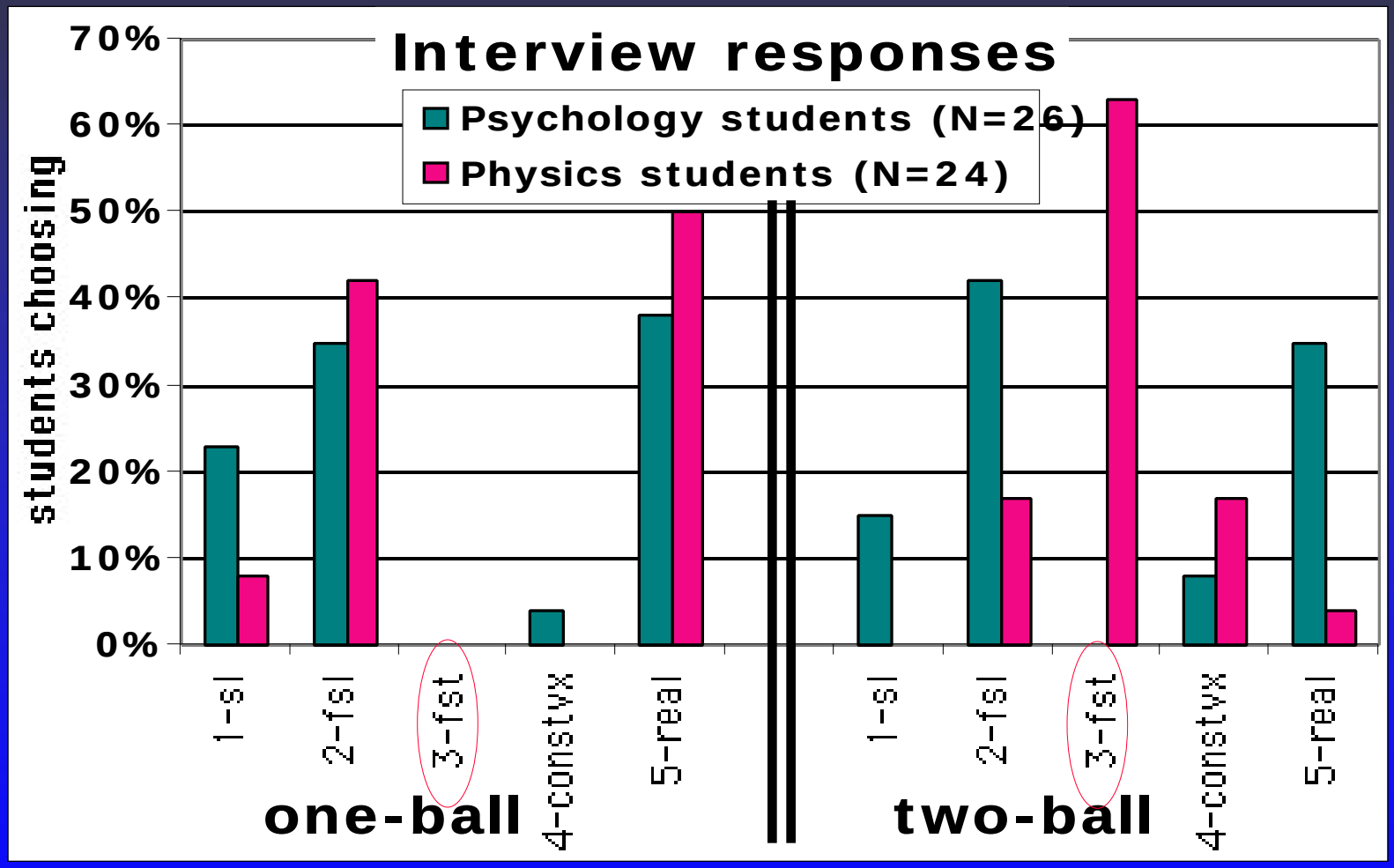


*Response patterns have been essentially reproduced with large N

Show 2-ball animations (V-valley)

http://groups.physics.umn.edu/physed/People/Tom%20Koch/2_tracks/index.html

Response Patterns*



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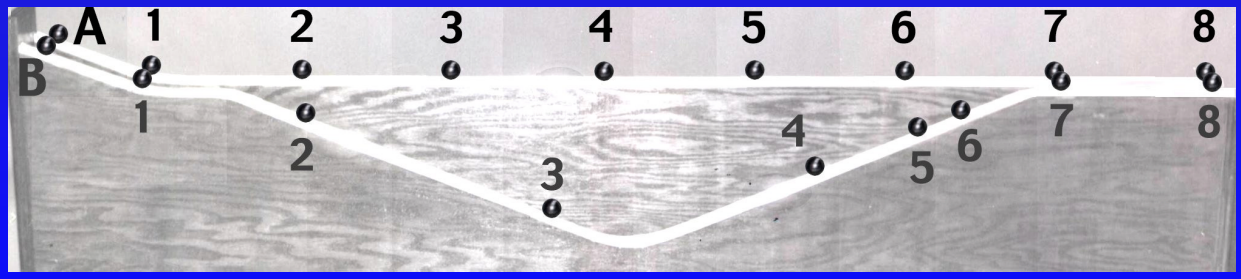
To Investigate Decision-Making:

- Use Coordination Class model.
- Analyze interview transcripts.

Example -- Decisions about animation #3.



Coordination Class model*

A person with a Coordination Class *for a particular class of information can coordinate multiple observations and prior knowledge to reliably "see" information of that class in a range of situations.*

Structural parts	Reliability criteria
➠The causal net	➠Integration
➠Readout strategies	➠Invariance

*diSessa & Sherin (1998). What changes in conceptual change? *International Journal of Science Education*, *20* (10), 1155-1191.

Mapping Coordination Model to Interview Analysis

Students presumably asking: "Does this animation depict realistic motion?"

Integration

- Observations lead to consistent conclusion

Invariance

- Same judgments about one-ball and two-ball depictions of same motion

Causal Net Elements

- Expectations about realistic motion

Readout strategies

- Strategies for observing motion

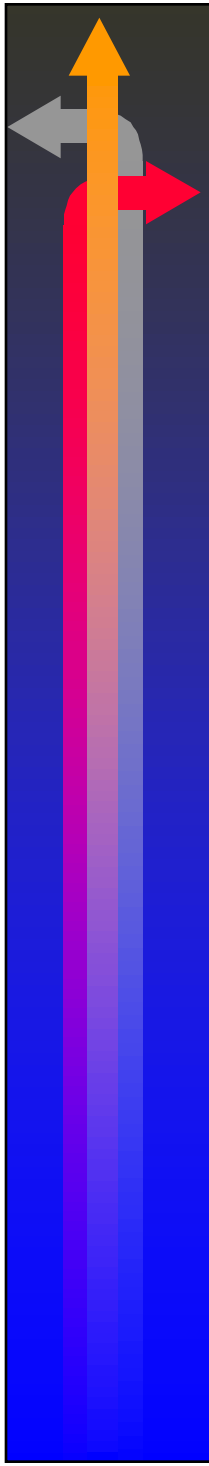
Coordination processes

Causal net elements
(% of *students expressing*)

	One-ball		*Two-ball*	
Expectation Description	***Psych***	***Physics***	***Psych***	***Physics***
Speed should decrease when rolling uphill.	**83%**	**83%**	**58%**	**83%**
Speed should increase when rolling downhill.	**79%**	**92%**	**75%**	**100%**
Ball B should have the same speed before and after the valley.	**13%**	**50%**	**0%**	**50%**
Speed should not increase without an apparent cause.	**83%**	**100%**	**75%**	**25%**
The balls should reach the ends of their tracks simultaneously.	**--**	**--**	**29%**	**92%**

N=24 Psychology students; N=12 Physics students

Note: All expectations but TIE are appropriate for the situation.



Readout strategies
(for observing speed changes)

Fixed-referent readout strategies

- Inferring speed of ball relative to background.

Relative motion readout strategies

- Using observations about relative positions
- Relative position changes often misinterpreted

Ahead <--> faster

Tied <--> same speed

Ball A catches up <--> Ball B slows down

a la Trowbridge & McDermott (1980)

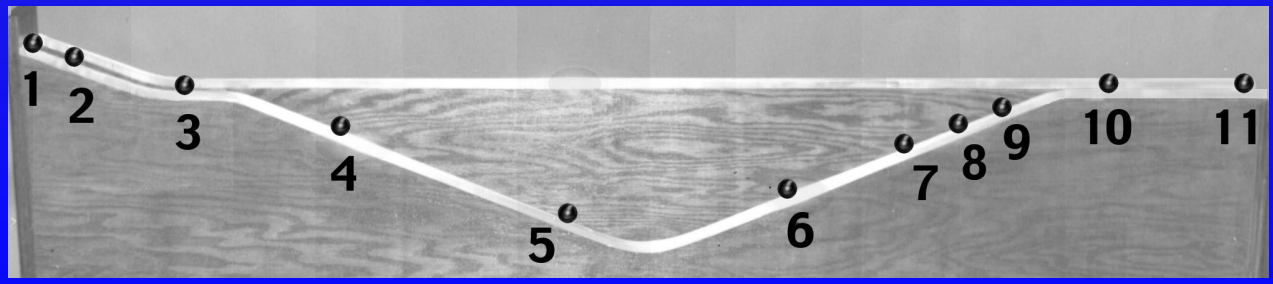
Physics Student (1)

Physics student Isaac:* "It accelerates at, once it gets, it goes down this V and then goes back up, it seems to accelerate right here.

<I: "So just to record, you're pointing about two thirds of the way up this second part of the V.">

Isaac: "Yeah. It seems to slow down and then for some reason it picks up some speed."

** Student names are pseudonyms*



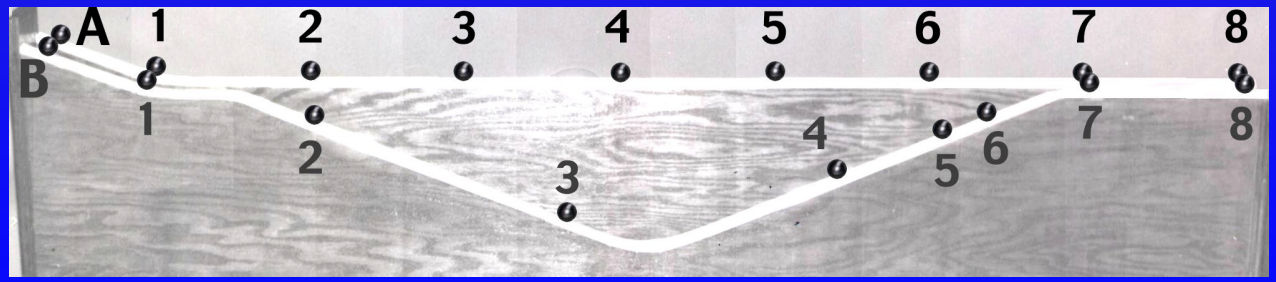
Interpretation: Phys (1)

- "…It seems to slow down and then for some reason it picks up some speed."

- Causal net element:
  - *Speed should not increase without an apparent cause.*
- Readout strategy:
  - *Fixed referent.*

Psychology Student (2)

Psychology student Phyllis: "I like how it sped up down the hill and slowed down, and it almost seemed like getting over that hill, almost pushed it, gave it some momentum, was a little weird."



Interpretation: Psych (2)

- "I like how it sped up down the hill…"

- Causal net element:
  - *Speed should increase when rolling downhill.*
- Readout strategy:
  - *Fixed referent?*

Interpretation: Psych (2)

- "I like how it sped up down the hill…"
- "…and slowed down…"

- Causal net element:
  - *Speed should decrease when rolling uphill*
- Readout strategy:
  - *Fixed referent?*

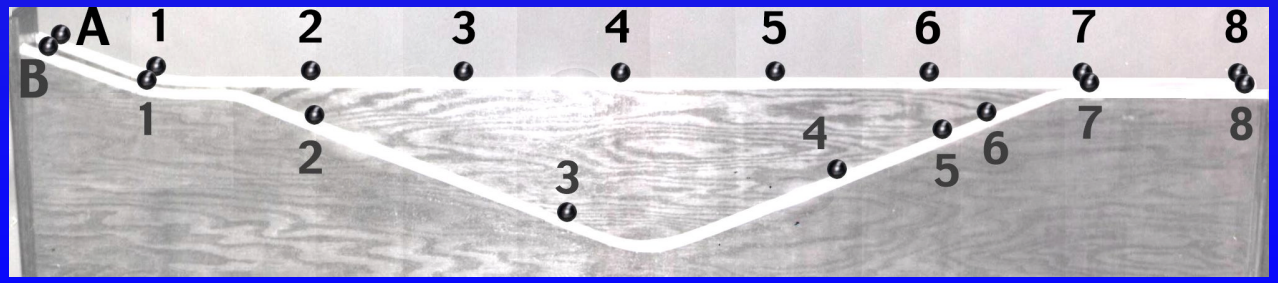
Interpretation: Psych (2)

- "I like how it sped up down the hill…"
- "…and slowed down…"
- "…and it almost seemed like getting over that hill, almost pushed it, gave it some momentum, was a little weird."

- Causal net element:
  - *Speed should not increase without an apparent cause.*
- Readout strategy:
  - *Fixed referent?*

Physics Student (2)

Physics student Isaac: "… the one that goes down the V accelerates so that it um is a little bit ahead of the ball that is on the flat track ... when it goes up ... the V it decelerates again to the point where um, it meets with the the uh ball ... on the flat track because they have the same um amount of energy and should uh be together because they were at the same height; it doesn't matter that it went down and then went back up, the uh acceleration and deceleration should cancel each other out."



Interpretation: Phys (2)

- "…accelerates so that it um is a little bit ahead…"

- Causal net element:
  - *Speed should increase when rolling downhill.*
- Readout strategy:
  - *Relative motion?*

Interpretation: Phys (2)

- "…accelerates so that it um is a little bit ahead…"
- "… decelerates again to the point where um, it meets…"

- Causal net element:
  - *Speed should decrease when rolling uphill*
- Readout strategy:
  - *Relative motion.*

Interpretation: Phys (2)

- "…accelerates so that it um is a little bit ahead…"
- "… decelerates again to the point where um, it meets…"
- "… they have the same um amount of energy and should uh be together … same height … acceleration and deceleration should cancel each other out.

- Causal net element:
  - *The balls should reach the ends of their tracks simultaneously. (and justification.)*
- Readout strategy:
  - *Relative motion!*

Conclusions

- Perception can be driven by knowledge -- different observations “weighted” differently -- physics knowledge apparently supported inappropriate weighting.
- Coordination Class analysis led to:
  - identification of knowledge elements.
  - identification of observation strategies.
  - description of coordination processes.
  - description of coordination reliability.
  - *NOT to identification of concepts or misconceptions.*

Related Information

Website (animations and dissertation)

- Thaden-Koch link at *http://groups.physics.umn.edu/physed/*

AAPT / PERC presentations: Animations results

- T. Thaden-Koch, R. Dufresne, W. Gerace, J. Mestre, & W. Leonard. A coordination class analysis of judgments about animated motion. *Poster, PERC 2003, Madison.*
- Koch et al, Student reasoning about balls rolling along tracks: Does introductory physics help or hinder? *AAPT w2002, Philadelphia.*
- Koch et al, Student reasoning: Race results vs. realistic rolling. *AAPT w2001, San Diego.*

TPT article: two-tracks demonstration

- Leonard & Gerace (1996). The power of simple reasoning. *The Physics Teacher, 34* (5), 280-283.