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Cognitive flexibility gained through collaborative reflection on cognitive traces

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Cognitive traces

- Could mean different things for different agents...
- This creates collaborative situations
 - effective for learning
 - interesting to study

Cognitive traces in collaboration

- Collaborative situations tend to collect externalized cognitive traces.
- Externalized cognitive traces function to yield solutions/interpretations differing in their degrees of abstraction.
- Cognitive efforts to integrate these promote conceptual understanding.

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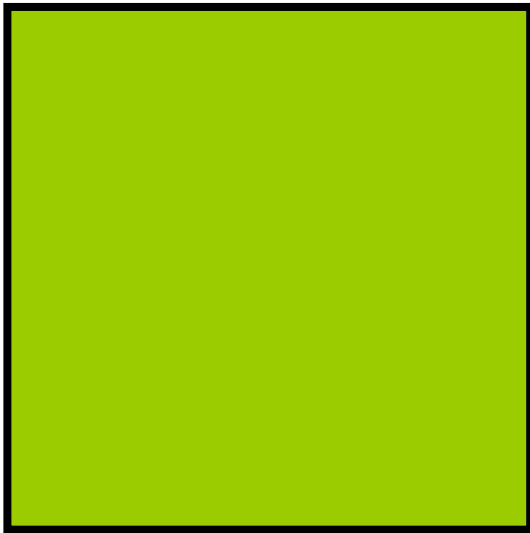
Establish the case and we could test this design methodologically.

Task

$$\frac{3}{4} \times \frac{2}{3} = \frac{1}{2}$$

“Shade $\frac{2}{3}$ of $\frac{3}{4}$ of the *origami* paper with oblique lines.”

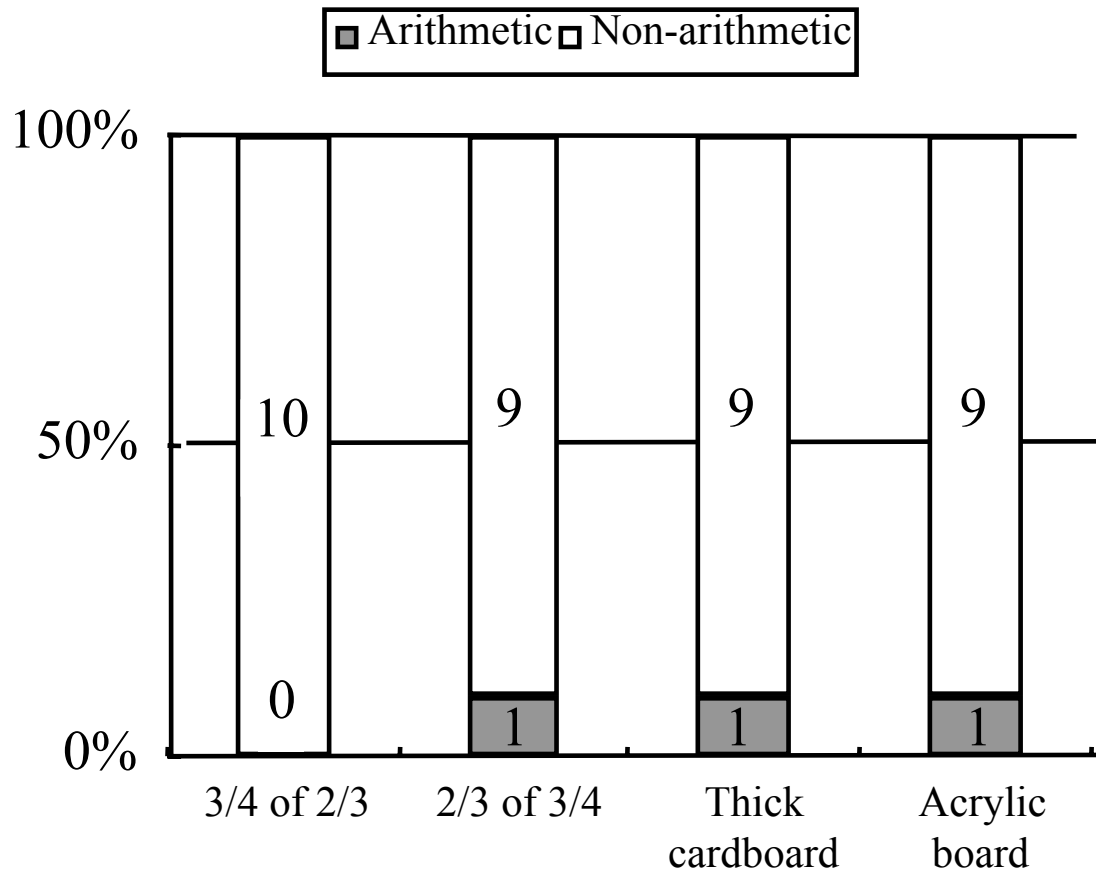
(Shirouzu, Miyake, & Masukawa,
Cognitive Science, 2002)



What would you expect?

- Do people calculate?
- Would $\frac{2}{3}$ of $\frac{3}{4}$ be different from $\frac{3}{4}$ of $\frac{2}{3}$?
- What if not origami paper but thick construction paper, or acrylic board?

Less than 10% calculate



“What’s the answer?”

- “Huh?”
- “This is it.”
- “Two-thirds of three-fourths.”
- They do not always describe the outcome as “one-half.” (Four out of 15, for example.)

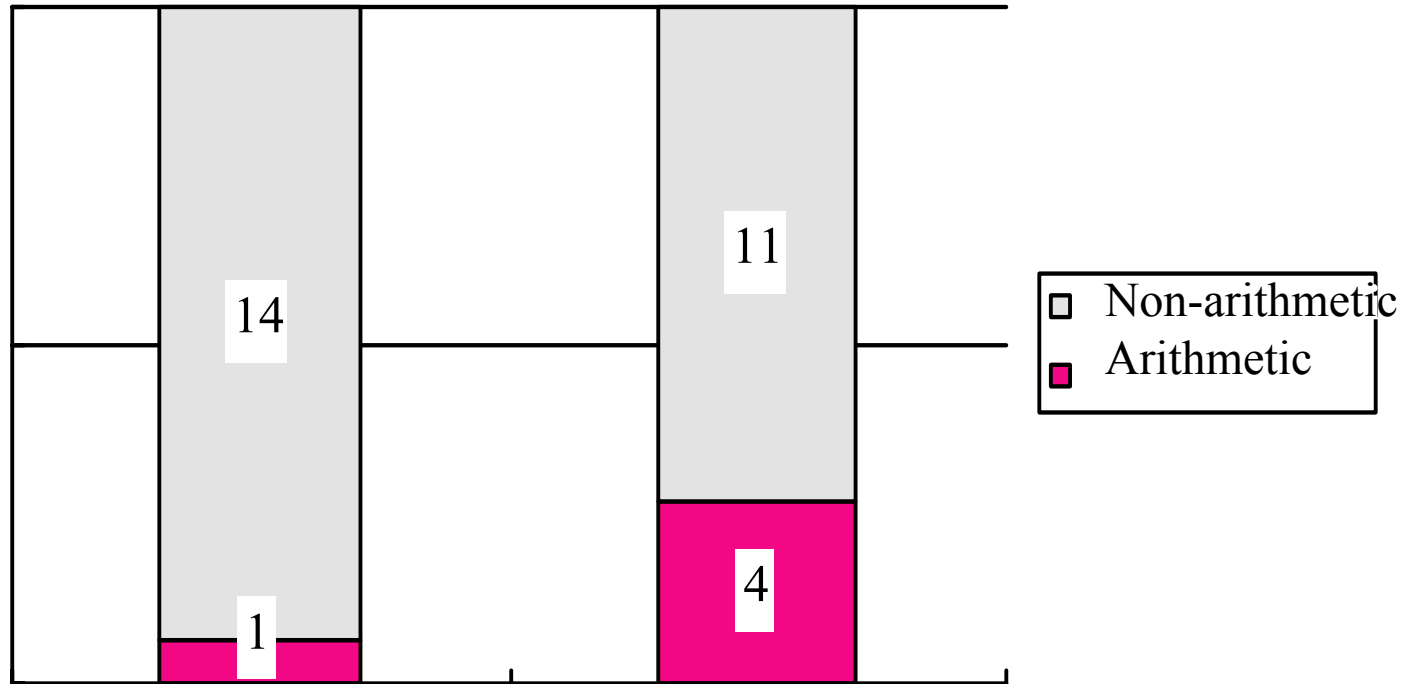
Sequential trials?

First trial : 2/3 of 3/4



Second trial : 3/4 of 2/3

Solo subjects

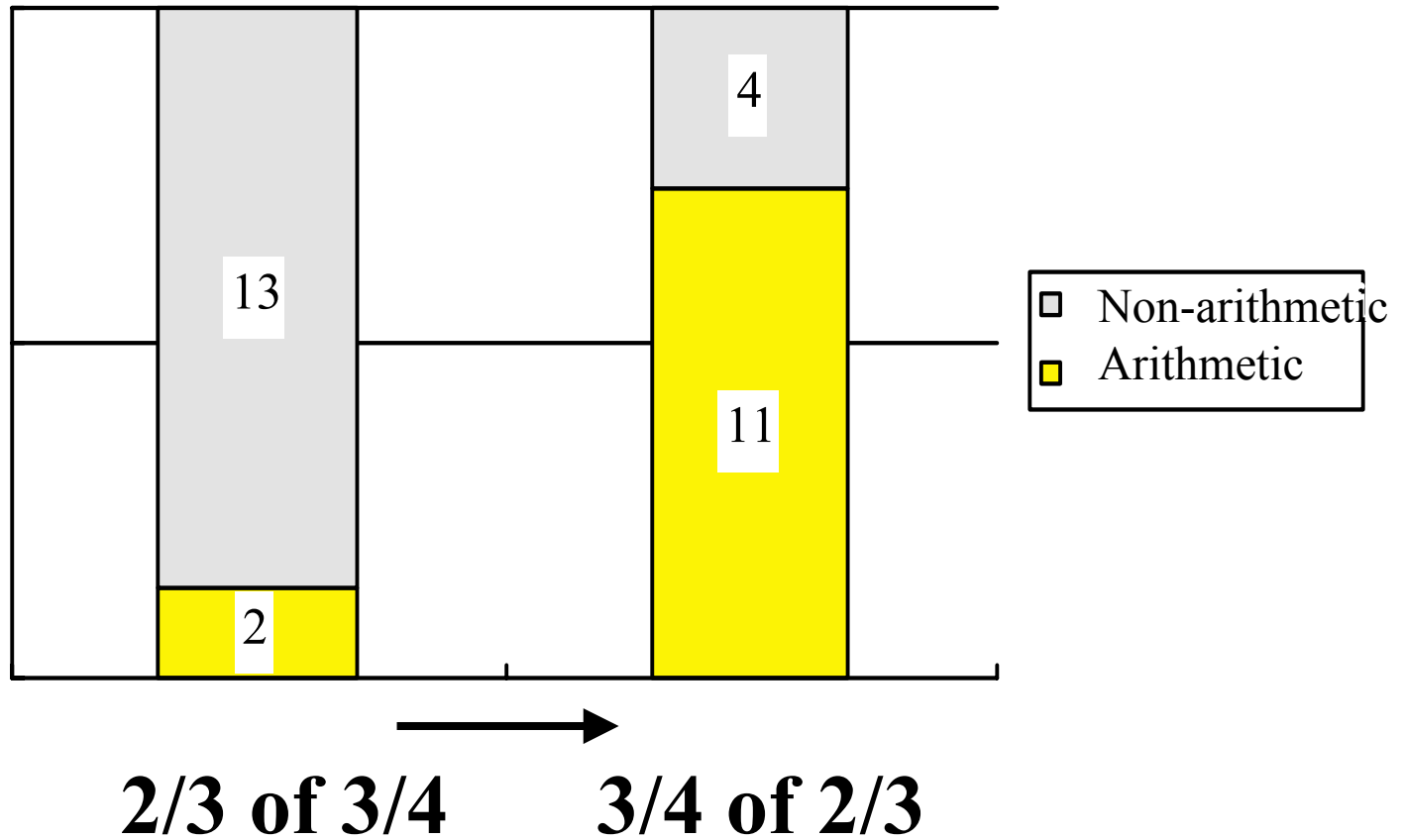


2/3 of 3/4



3/4 of 2/3

Paired subjects



What happens in pairs??

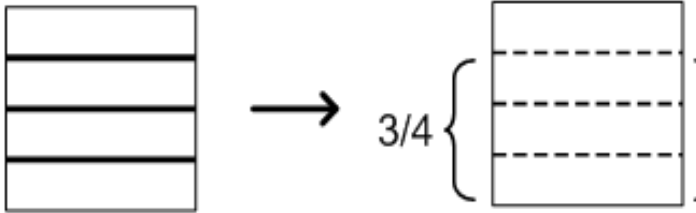
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Getting $2/3$ of $3/4$ (1)



i) Original

Getting $2/3$ of $3/4$ (1)

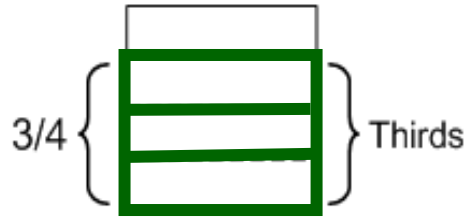


i) Original

Getting $2/3$ of $3/4$ (2)



i) Original

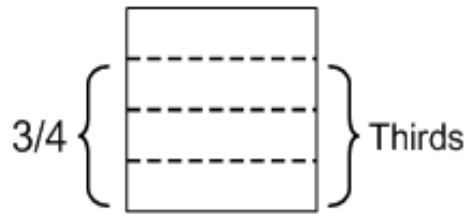


ii) 1st Re-interpretation

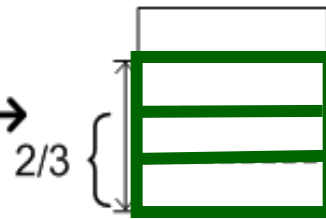
Getting $2/3$ of $3/4$ (3)



i) Original



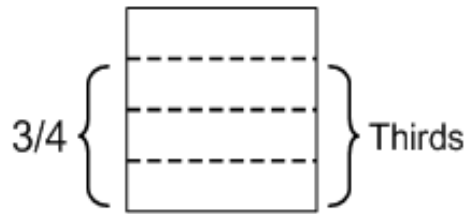
ii) 1st Re-interpretation



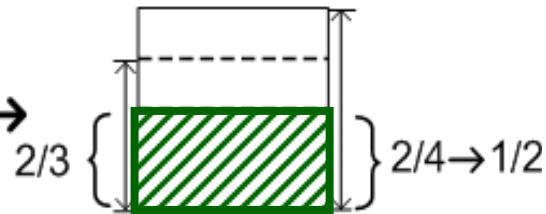
Getting $2/3$ of $3/4$ (5)



i) Original



ii) 1st Re-interpretation

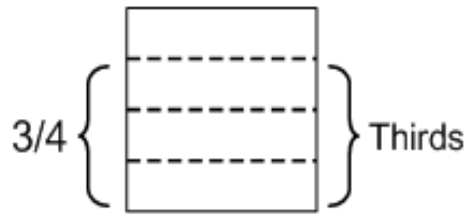


iii) 2nd Re-interpretation

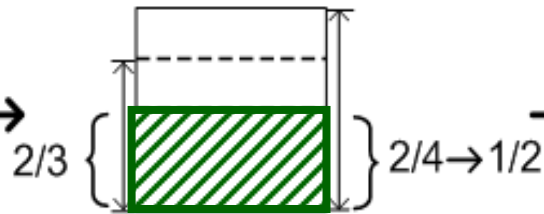
Getting $\frac{2}{3}$ of $\frac{3}{4}$ (6)



i) Original



ii) 1st Re-interpretation



iii) 2nd Re-interpretation

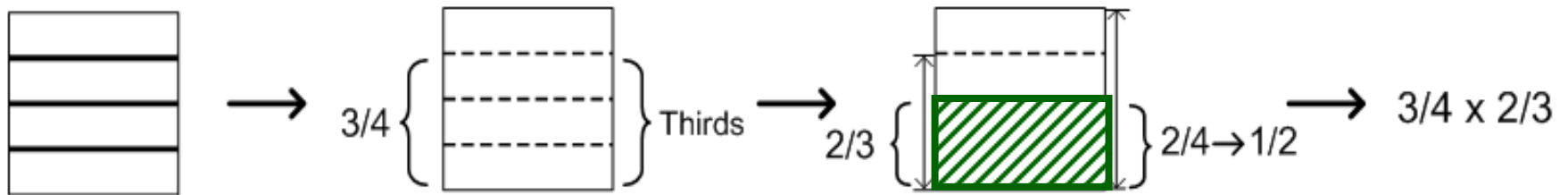


$$\frac{3}{4} \times \frac{2}{3}$$

iv) Calculation

Getting 2/3 of 3/4 (7)

Person 1



i) Original

ii) 1st Re-interpretation

iii) 2nd Re-interpretation

iv) Calculation

Monitoring

Task-doing

Monitoring

Person 2

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Collaboration yielded abstraction

- Among Paired subjects, 11/15 went up to 3rd to 4th level of abstraction.
- Solos did so only 4/15 times.
- Role exchange appears to be responsible.

Collaboration works because...

- Variations of solutions differing in the degree of abstraction, *which could create a “ladder” for subjects to climb up the levels.*
- Integration process involves language use for abstracted schema formation.
- Motivation for integration.

Designing collaboration for fostering understanding

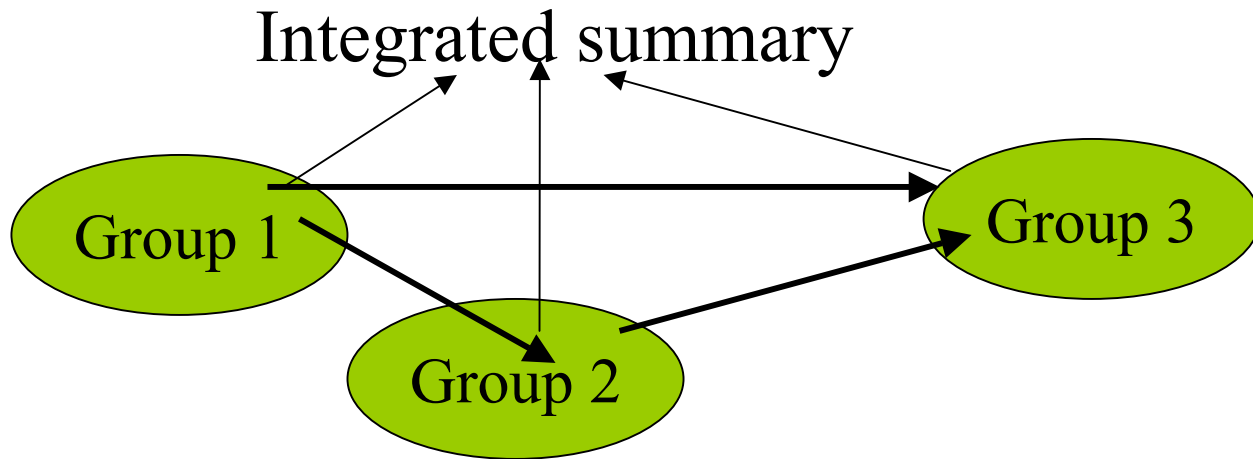
- 1) Encourage externalization
- 2) Solicit multiple re-interpretations
- 3) Iterate re-interpretation efforts
- 4) Support integration of different solutions/re-interpretations.

Context

- Teaching cognitive and learning sciences to undergraduates (grades 13 to 14)
- Main task: Integrate different research findings to come up with “applicable” theory-like understanding

1 : Integrations of research results

e.g., “What are the characteristics of human problem solving?”



- Report categories changes from “narrowly self-centered” to “integrated” (qualitative change rather than quantitative).

2 : Integration of different research findings of a shared theme

e.g. “What should we make out of series of research done on the ‘Wason selection task’?”

- “Theorize” and explain varying results
- Iterate presentation for three times

- Changes in integration and evaluation skills

Further research questions:

- Guiding variations? (Currently mostly depending on spontaneous generation)
- Does this mechanism work situationally in emergent ways, or is it “guidable” as a cognitive skill?

Summary :

- Theorizing effects of cognitive traces for effective collaboration seems possible, and
- Getting guidelines for designing effective collaborative learning environments of this kind may be due.

Performances

- Quality of final reports
 - 1998: Students started to turn in more integrated term papers, referring to many of the research covered in the class (50% to less than 10% in previous years).
 - 2000: 80% of the papers applied integrated “theory-like” understanding, referring to more than three concrete research examples.

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Analyses of performances

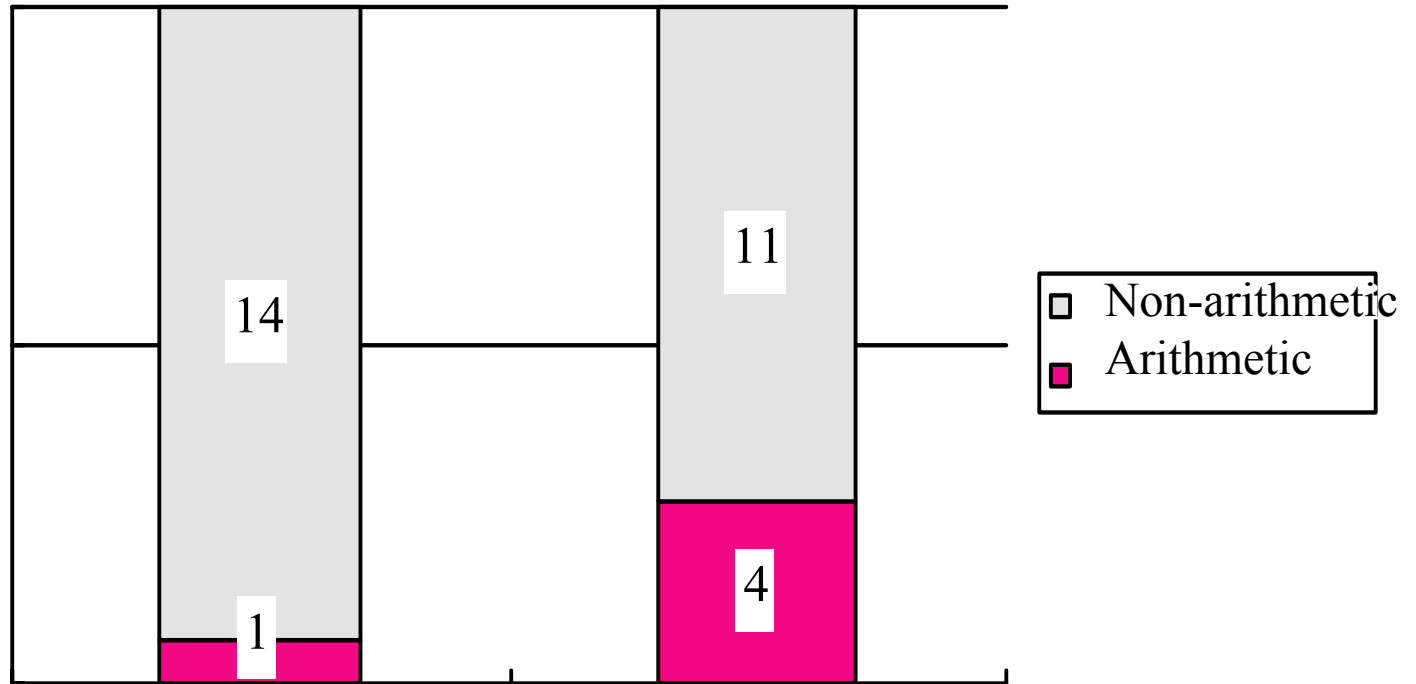
- Numbers of notes and links
- Content types of notes and links
 - What kinds of links did students make?
 - Any effects of raised “visibility” of links to the use of notes?

“What’s the answer?”

Categories	Non-arithmetic	Arithmetic
Explicit 1/2	10	4
Vague	3	0
No verbalization	19	1

N.B. 3 hard to analyze cases omitted

Solo subjects

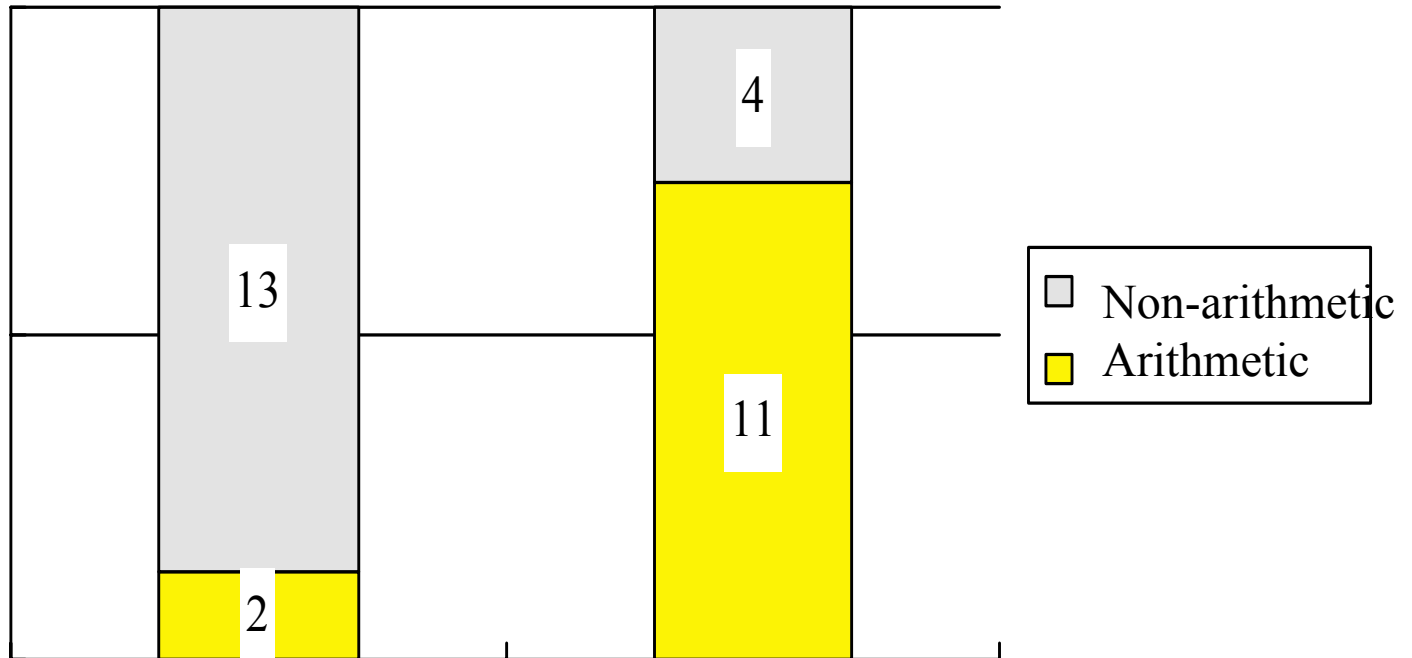


2/3 of 3/4

3/4 of 2/3

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Paired subjects



2/3 of 3/4

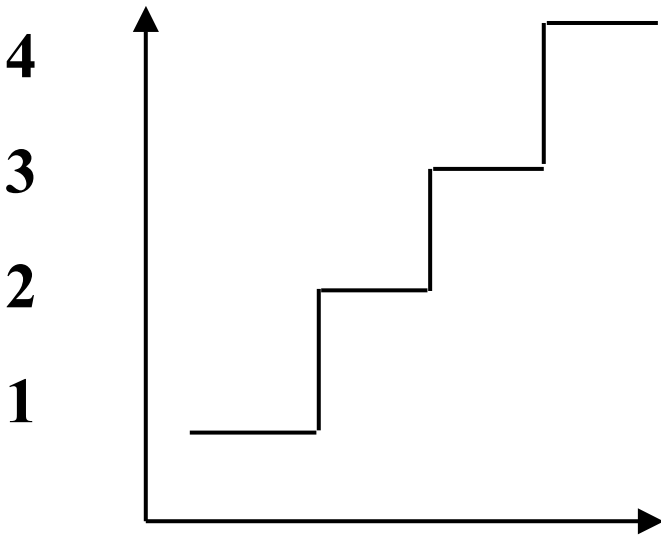


3/4 of 2/3

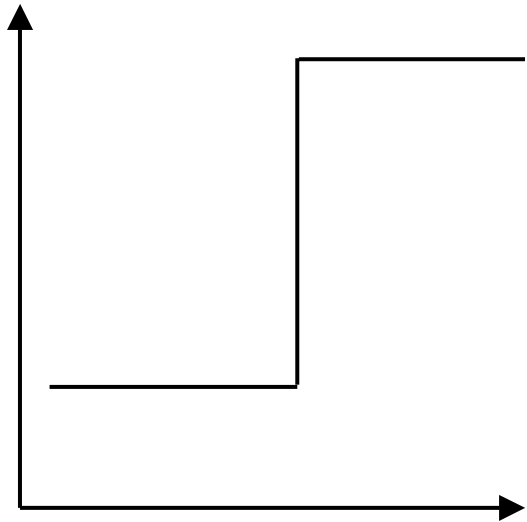
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Schematic shifts

Levels



?



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Expected moves

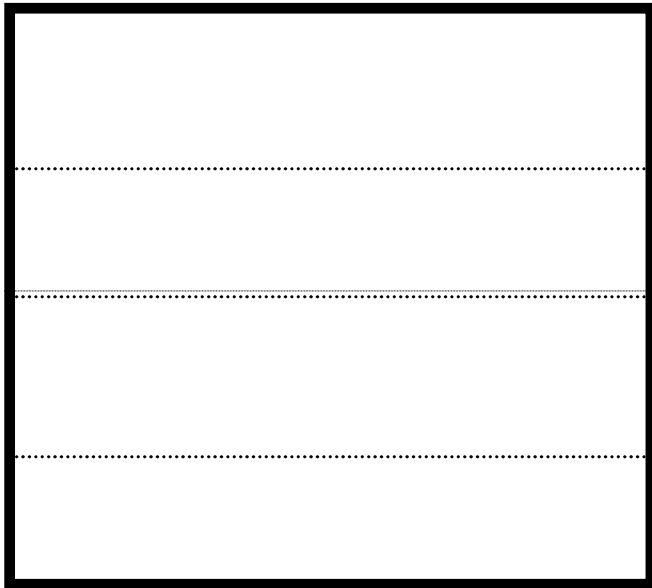
Level 1 to Level 2	7
Level 2 to Level 3	5 (7)
Level 3 to Level 4	3 (5)
Sum	15 (19)

Who initiated the shifts?

	Total	Monitor	Doer
Level 1 to Level 2	7	7	0
Level 2 to Level 3	5 (7)	3 (4)	2 (3)
Level 3 to Level 4	3 (5)	1 (1)	2 (4)
Level 2 to Level 4	2 (0)	1 (0)	1 (0)
Sum	17 (19)	12 (12)	5 (7)

Note. Numbers in parentheses are those when implicit Level 3 is included as Level 3.

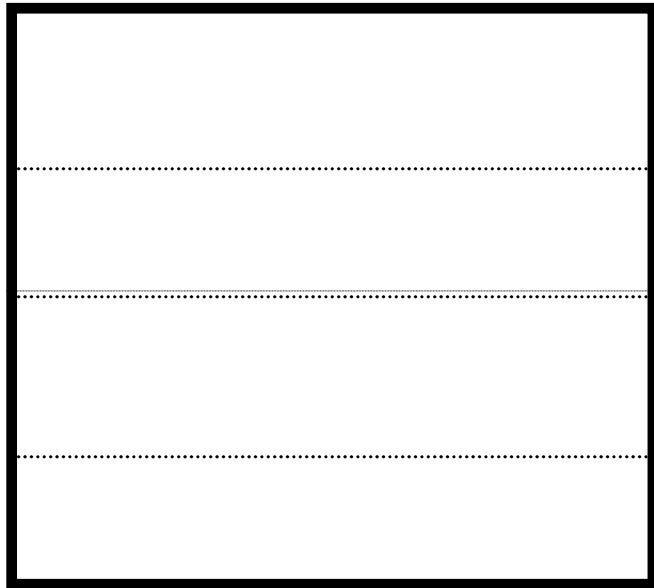
Possible solutions (2/3 of 3/4)



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Possible solutions (2/3 of 3/4)

pleats



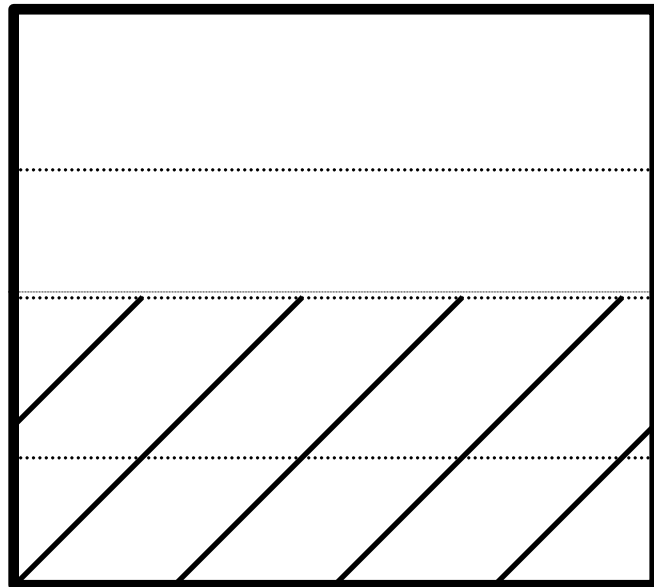
squares



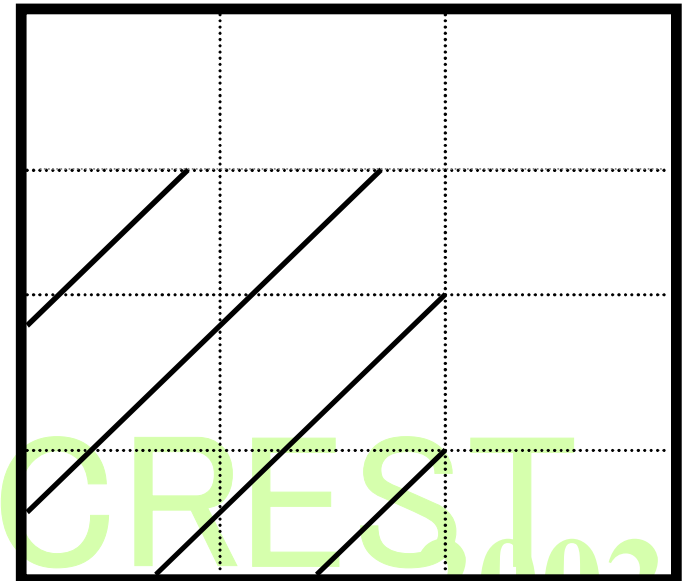
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Possible solutions (2/3 of 3/4)

pleats



squares

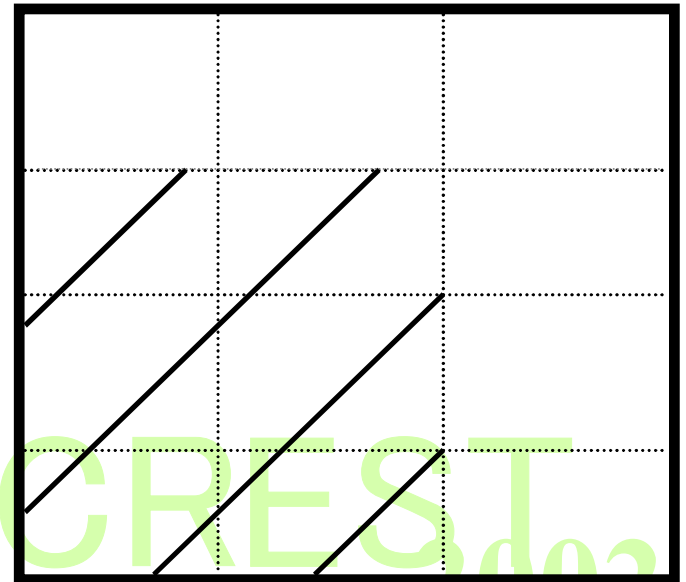


Visibility of 1/2-ness

pleats
higher



squares
lower



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Objective visibility

- works differently from individuals to pairs.
- Individuals tend to see what they want to see, while
- Pairs tend to change their views.