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Externalized Cognitive Processes for Collaborative Knowledge Construction

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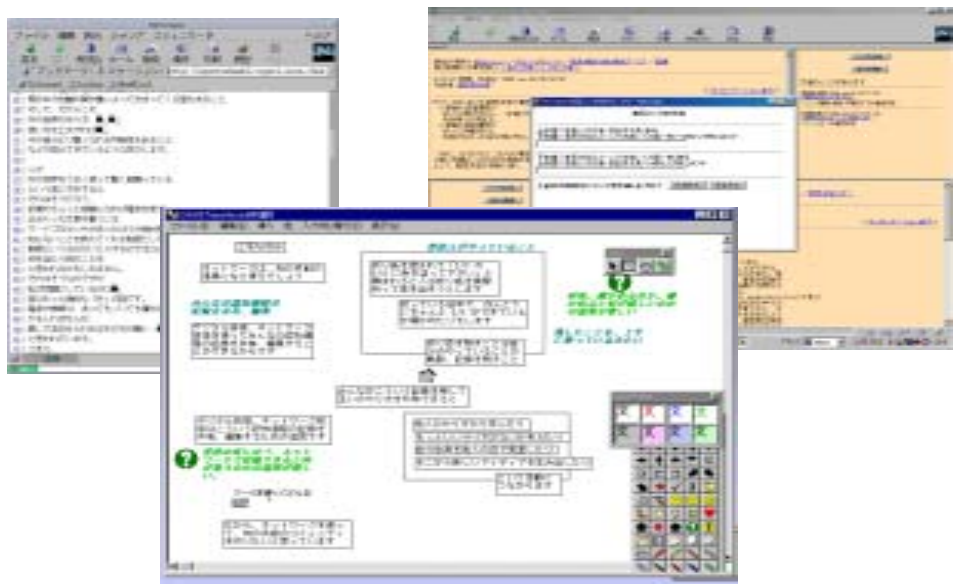
Self introduction

- **UCSD in 1977-82**
  - **“Constructive interaction” in 1986**
- **SCCS, Chukyo U. since 1991**
  - **Interaction of internal-external resources**
  - **Collaborative learning environments**

Cognitive science for me

- **Study of cognitive processes in the real world**
  - **External resources**
  - **Other people**
- **Implications/Pragmatic values**
  - **Learning sciences**

Taking “developing leaning environments” rather seriously, and doing more fundamental work to support this…



Internal-external interaction

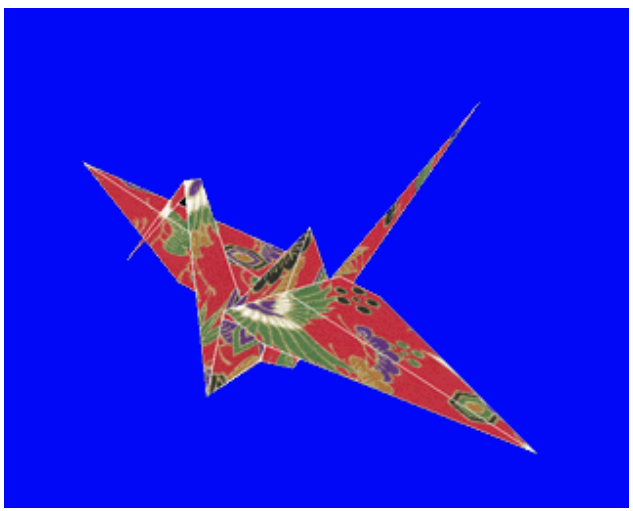
- **One particular task**

Task

3/4 × 2/3 = 1/2

“Please indicate 2/3 of 3/4 of this *origami* by shading with oblique lines.（この折紙の3/4**の**2/3**の部分に斜線を引いて下さい）”**

(Miyake, Shirouzu, & Masukawa, 1998)

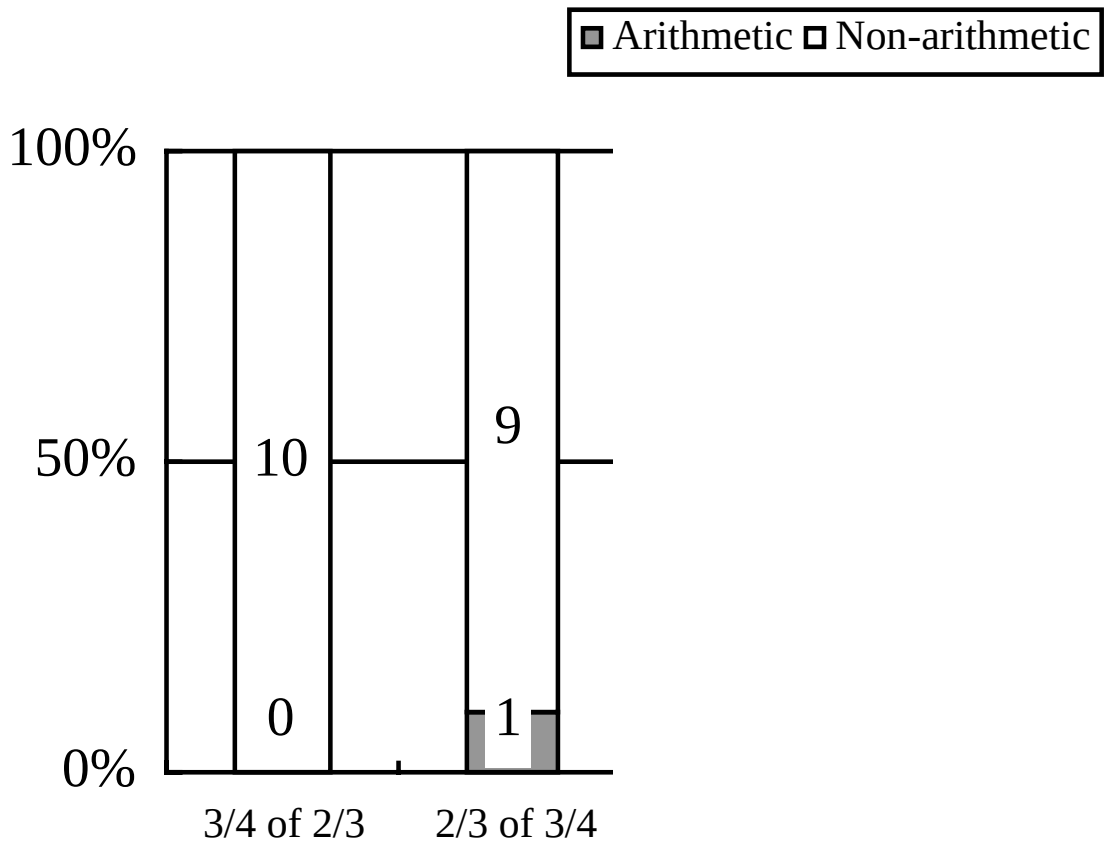


A crane
made from Japanese origami paper.

What would you expect?

- **Would 2/3 of 3/4 be different from 3/4 of 2/3?**

To what extent did the subjects use the external resources?

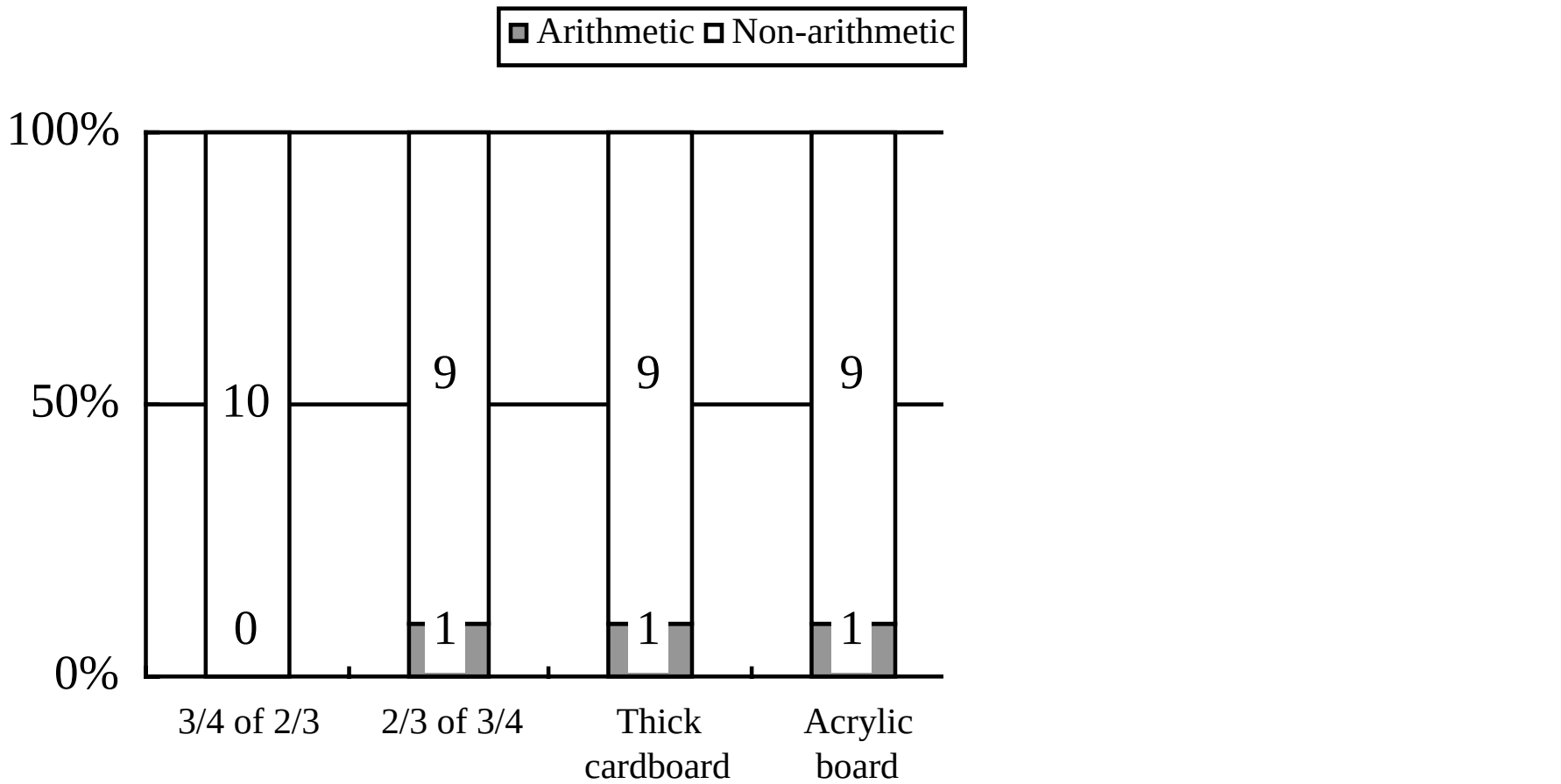


What would you expect?

- **Would 2/3 of 3/4 be different from 3/4 of 2/3?**

- **What if not origami paper but thick construction paper, or even board?**

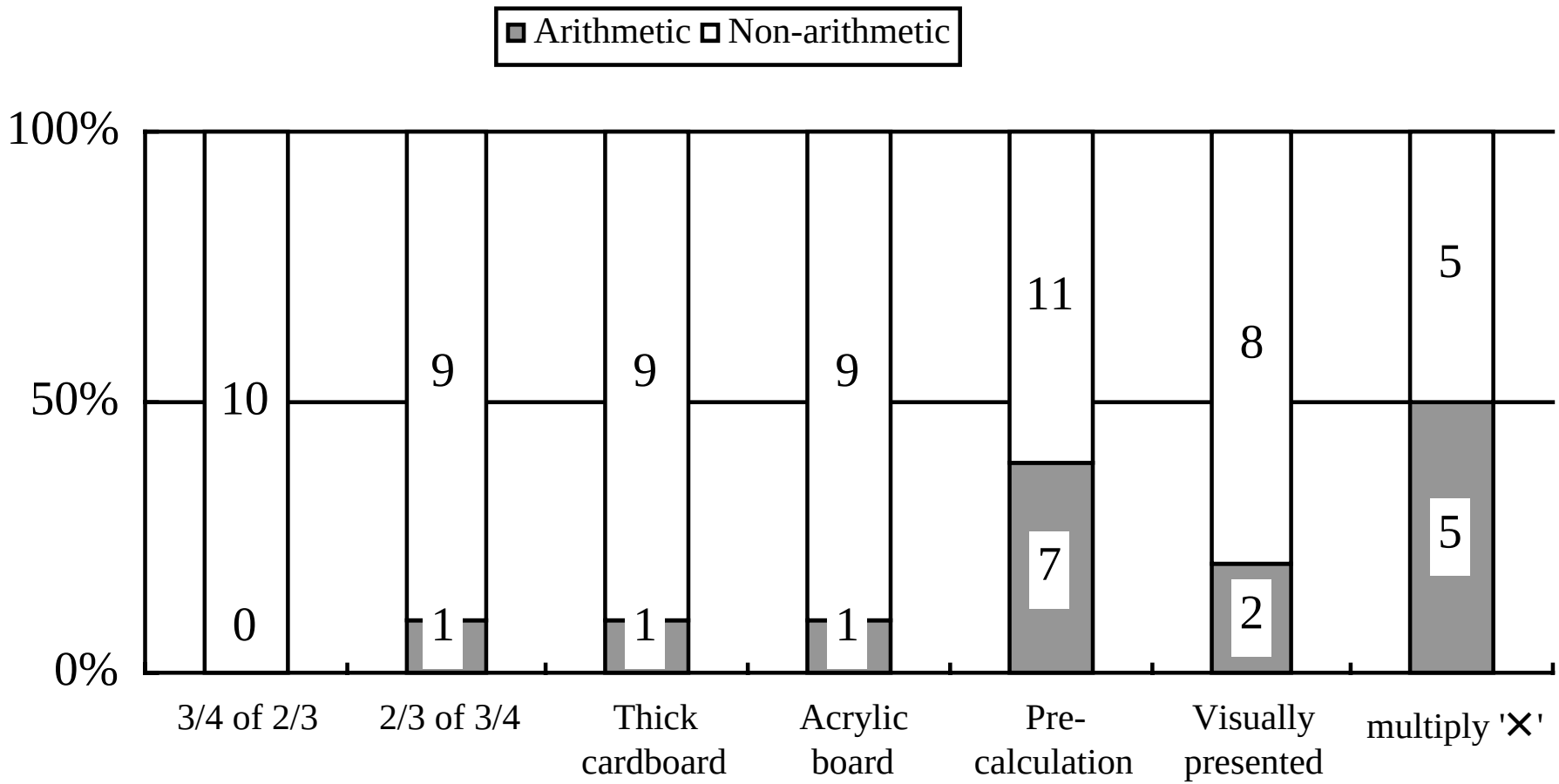
To what extent did the subjects use the external resources?



What would you expect?

- Would 2/3 of 3/4 be different from 3/4 of 2/3?
- What if not origami paper but thick construction paper, or even board?
- **Other manipulations?**

To what extent did the subjects use the external resources?

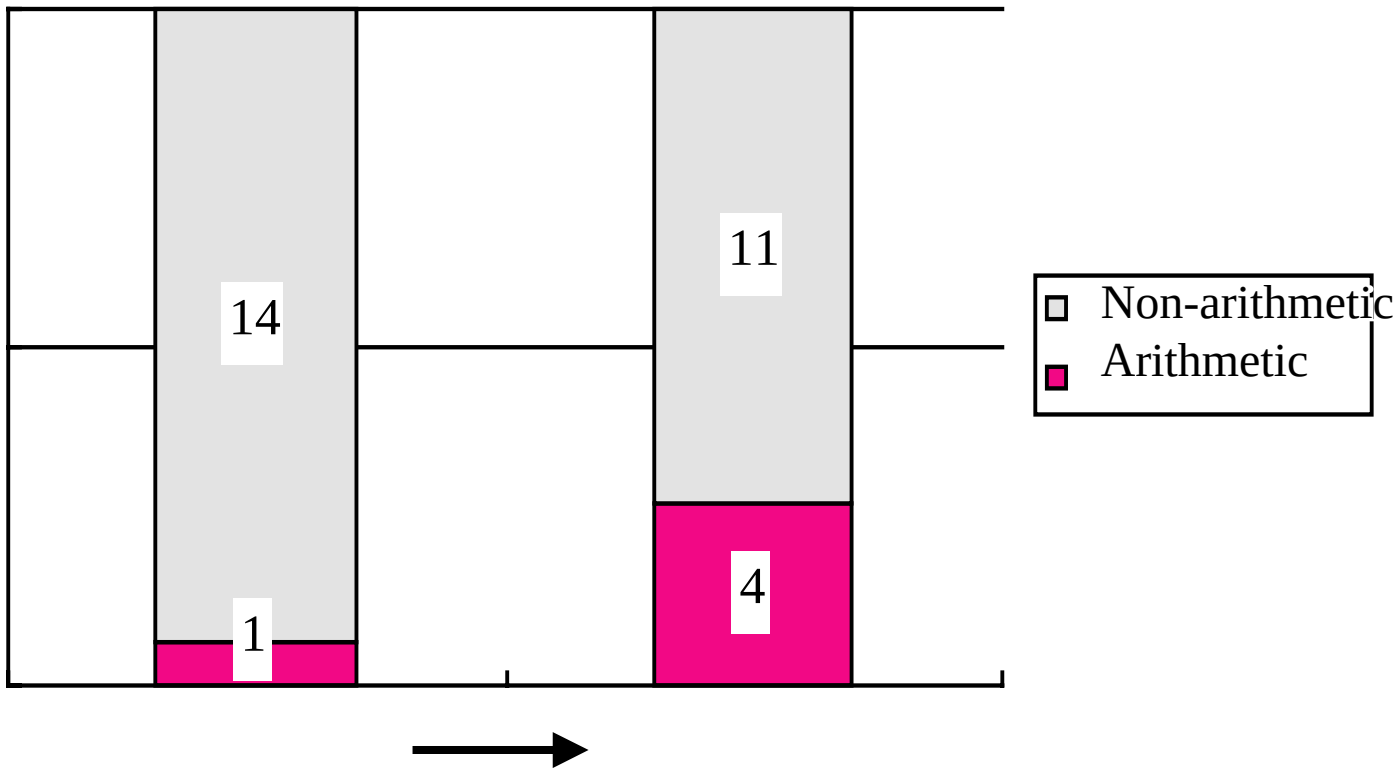


Sequential trials

First trial : 2/3 of 3/4

↓

Second trial : 3/4 of 2/3



2/3 of 3/4 3/4 of 2/3

“Answer” as externalization

- **What do subjects “see” in their answers to the first question?**

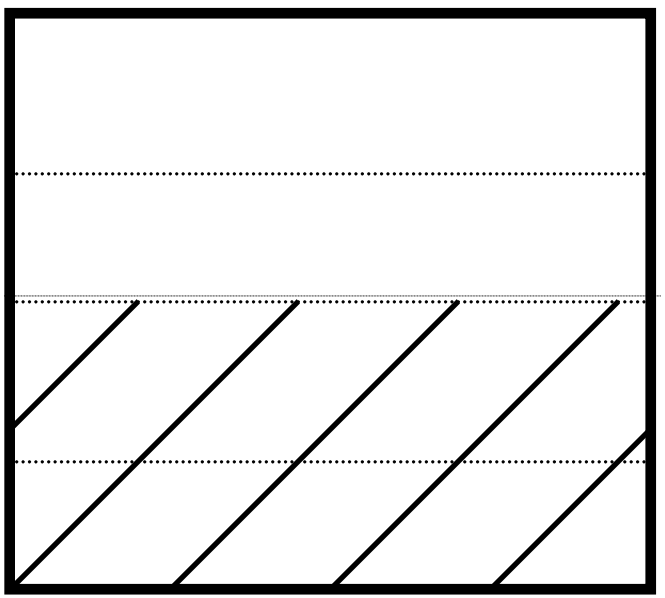
“What’s the answer?”

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

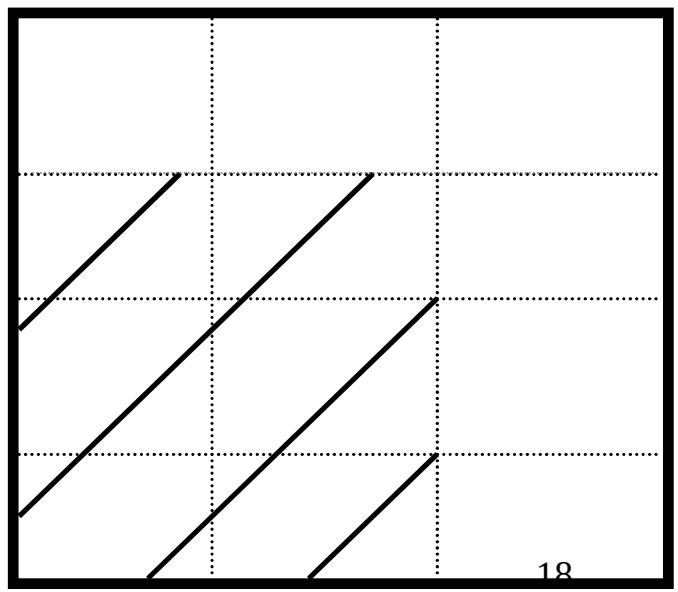
N.B. 3 hard to analyze cases omitted

Possible answers (2/3 of 3/4)

pleats



squares



Number of Subjects who mentioned One-half-ness of the Answer

	Clear	Unclear
Mentioned	**6**	0
Not mentioned	1	**5**

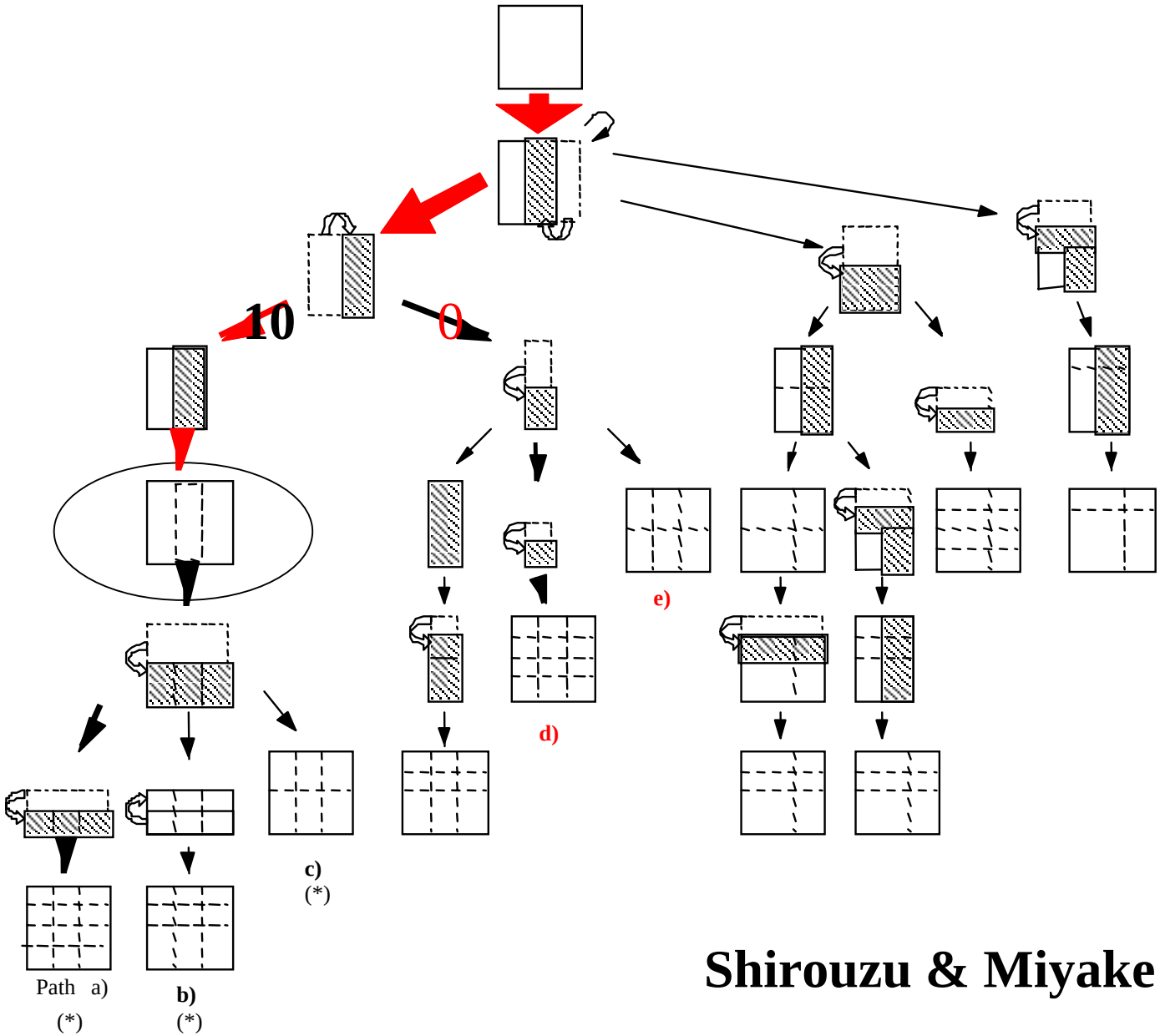
When it was highly visible, the subjects tended to report their answer as “one-half（**「半分，2分の1」**）.”

Number of Subjects who **shifted** after mentioning One-half-ness

	Clear	Unclear
Shifted	**2**	0
Not shifted	5	**5**

Most of the subjects tended to maintain the nonarithmetic strategy regardless of the appearances.

Process analysis



Shirouzu & Miyake (1999)

What were they doing??

- **That is the path which allows them to confirm what they are making is really 2/3.**

What were the subjects doing?

- **They seem to have their “own” way to solve the problem, and rather strongly peruse it.**
- **They are *not* passive responders to outside appearances.**

What else?

Who shifted at all?

	Clear appearance	Unclear appearance
Shifted	2	**5**
Not shifted	**5**	0

There was the prompt from the experimenter.

Pair Condition

- “The externalization of intermediate results could make the solving processes sharable with others.”

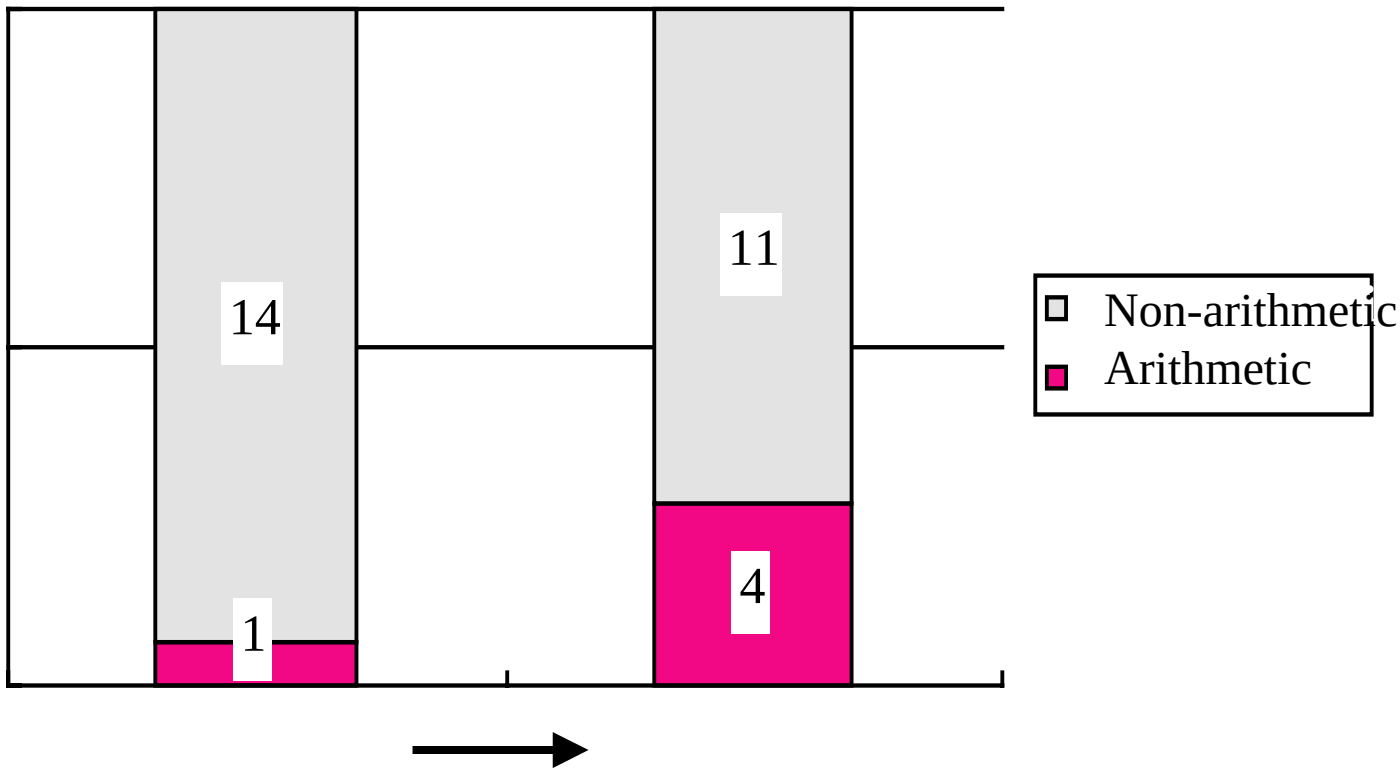
- **Pair Condition (15pairs) vs. Solo Condition (15solos) on the sequential trials.**

1st trial : 2/3 of 3/4

↓

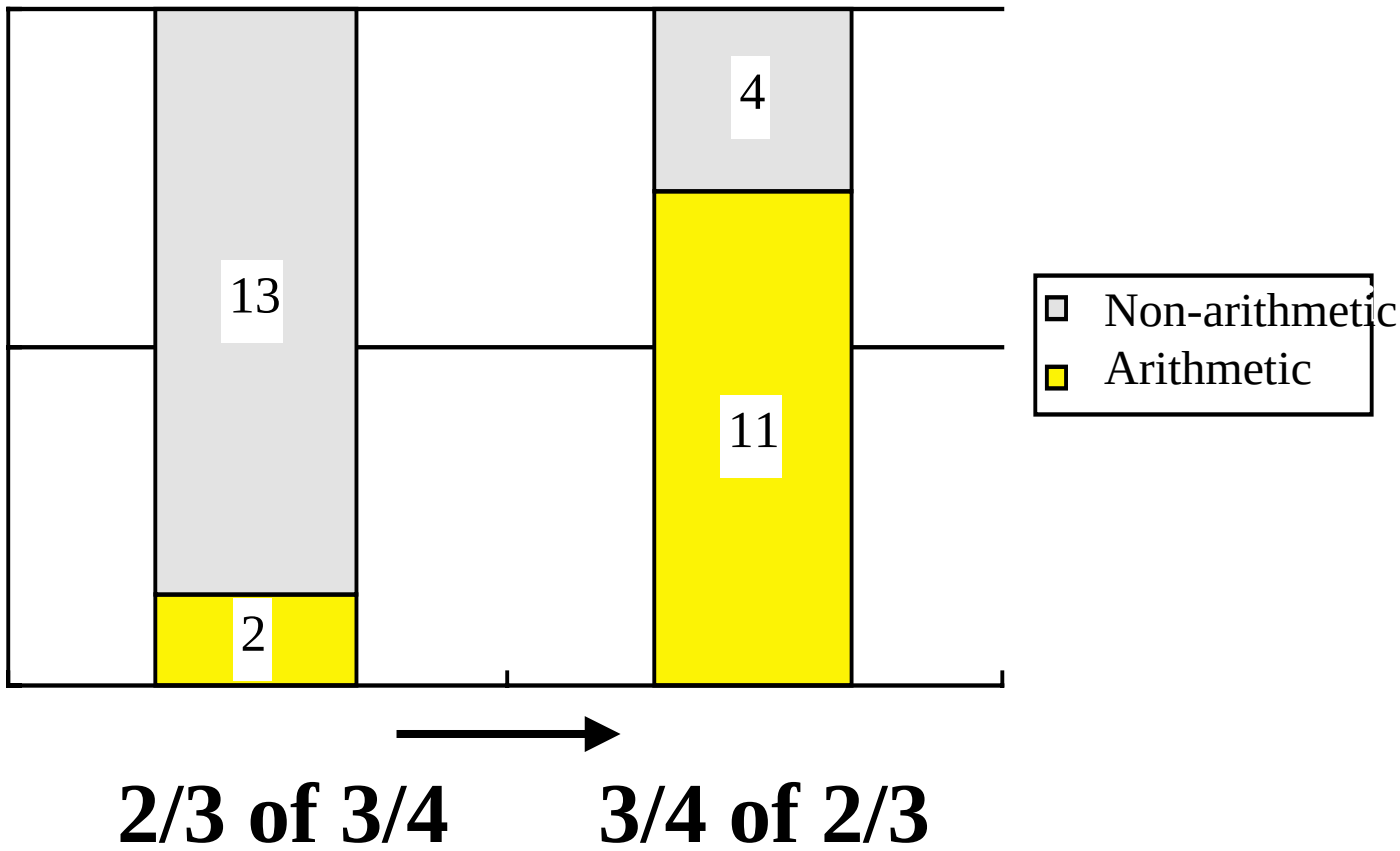
2nd trial : 3/4 of 2/3

In Solo Condition



2/3 of 3/4 **3/4 of 2/3**

In Pair Condition



What were the pairs doing?

Number of Pairs who mentioned One-half-ness of the Answer

	Clear	Unclear
Mentioned	**5**	0
Not mentioned	1	**4**

(One pairs eliminated)

Whether the subjects reported their answer as one-half depended mainly on its visibility.

Number of Pairs
who shifted after mentioning the One-half-ness

	Clear	Unclear
Shifted	**6**	1
Not shifted	0	**3**

(One pairs eliminated)

When seeing the clear appearance, all the pairs shifted to the arithmetic strategy. With unclear appearance, most of them did not.

The difference between the two on how to fold more

1: A1: Here is the three-fourths

2: A2: We can pick out this area, can't we?

3: : So folding this area into thirds as futon, then..

4: A1: Huh, you seem to have a different image than I

5: : You, try it [handing the paper to A2]

6: A2: Folding it this way, we can get two-thirds of three-fourths

7: A1: Wait, wait

8: : This line is the three-fourths [tracing the line]

9: A2: Uh huh

10: A1: So folding this area as *futon*

11: : we can get a one-third, you see?

[starting to fold it into three-fourths again]

A2's awareness of the emerged answer and A1's reference to its one-half-ness

10: A1: So folding this area as *futon*
11: : we can get a one-third, you see?
12: A2: Of three-fourths…
13: : Aha,
14: : Two-thirds of three-fourths is,
15: : so, of three-fourths…
16: : the two-thirds are here (2/3ってここじゃん)
17: A1: Oh, silly
18: A2: Yeah, silly
19: A1: This is the half (半分じゃん，これじゃ)

Tracing the process again for clearer comprehension

24: A2: First, where are the 3/4?

25: A1: Yes, here is, these are the 3/4

26: A2: Yes, these are, these are the 3/4

27: : then, the 2/3

28: A1: Then, the 2/3 of this is

29: A2: Where is it?

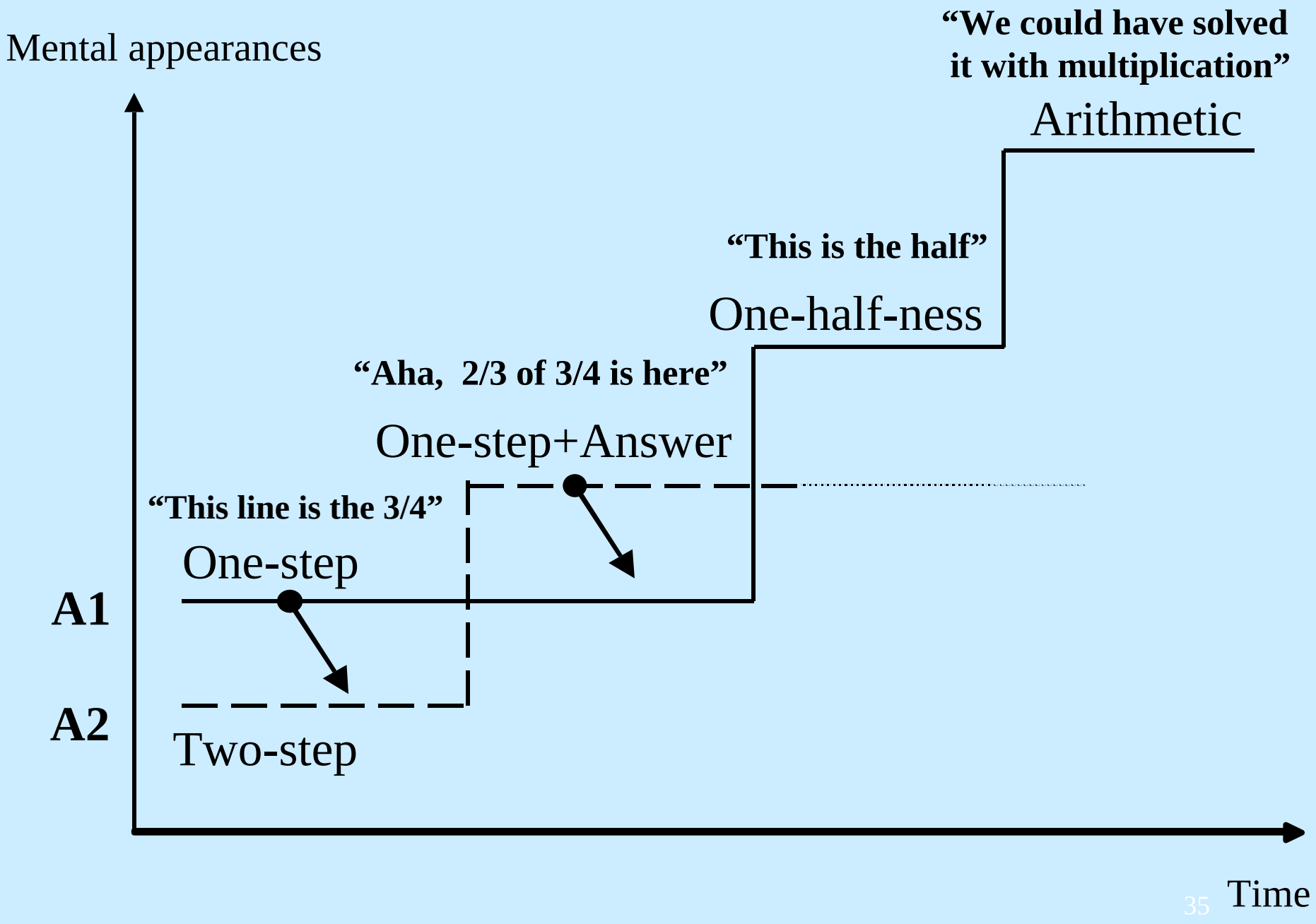
30: A1: Ahhh, it's here

31: A2: It's a trick!

32:A1: Oh, I got it. We could have solved it with multiplication (掛け算すりゃいいじゃん)

33: A2: We could have (すりゃね)

34: A1: The answer is the half (半分じゃん)


Mental appearances
"We could have solved it with multiplication"
Arithmetic
"This is the half"
One-half-ness
"Aha, 2/3 of 3/4 is here"
One-step+Answer
"This line is the 3/4"
One-step
A1
A2
Two-step
Time

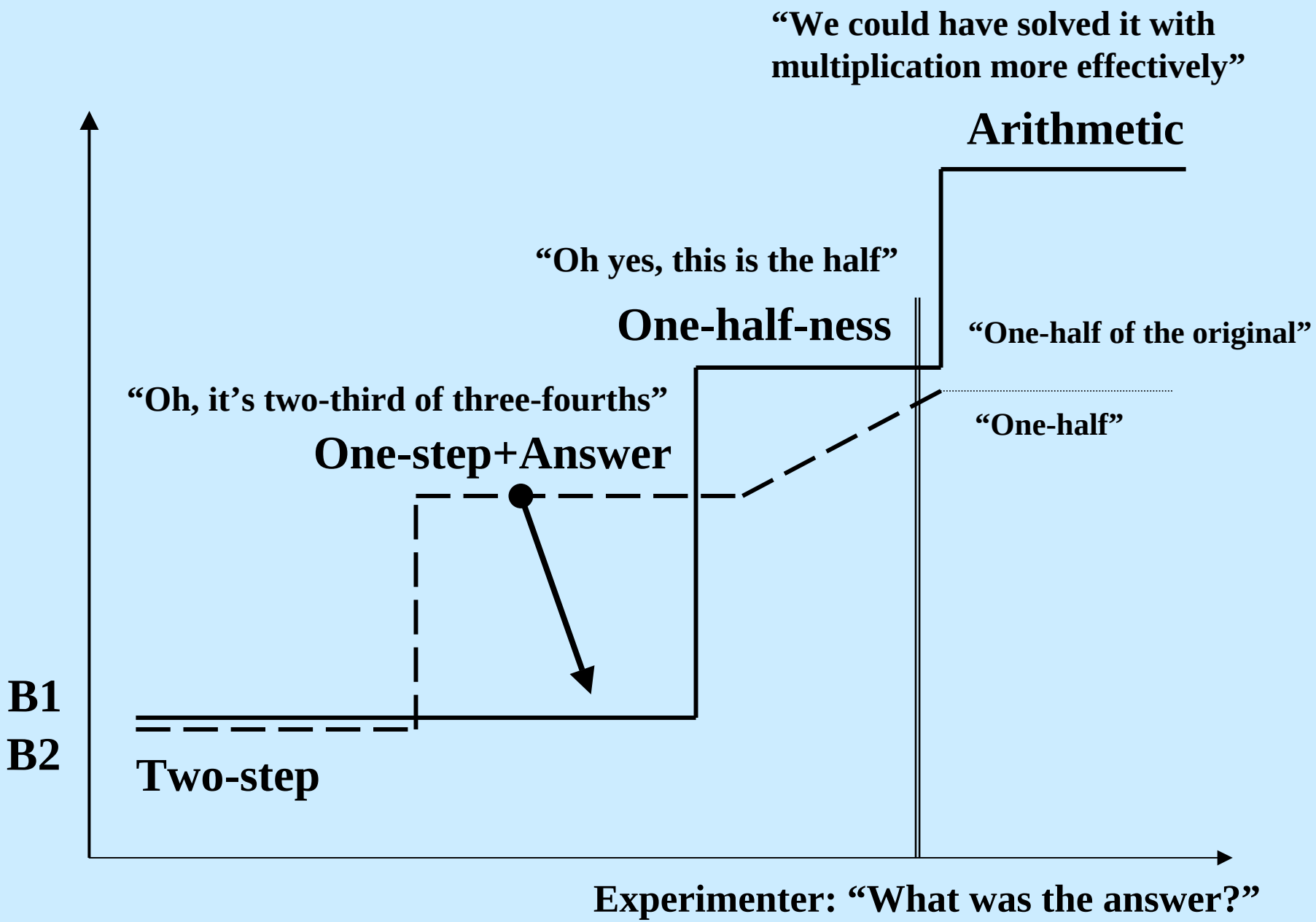
Assumed steps

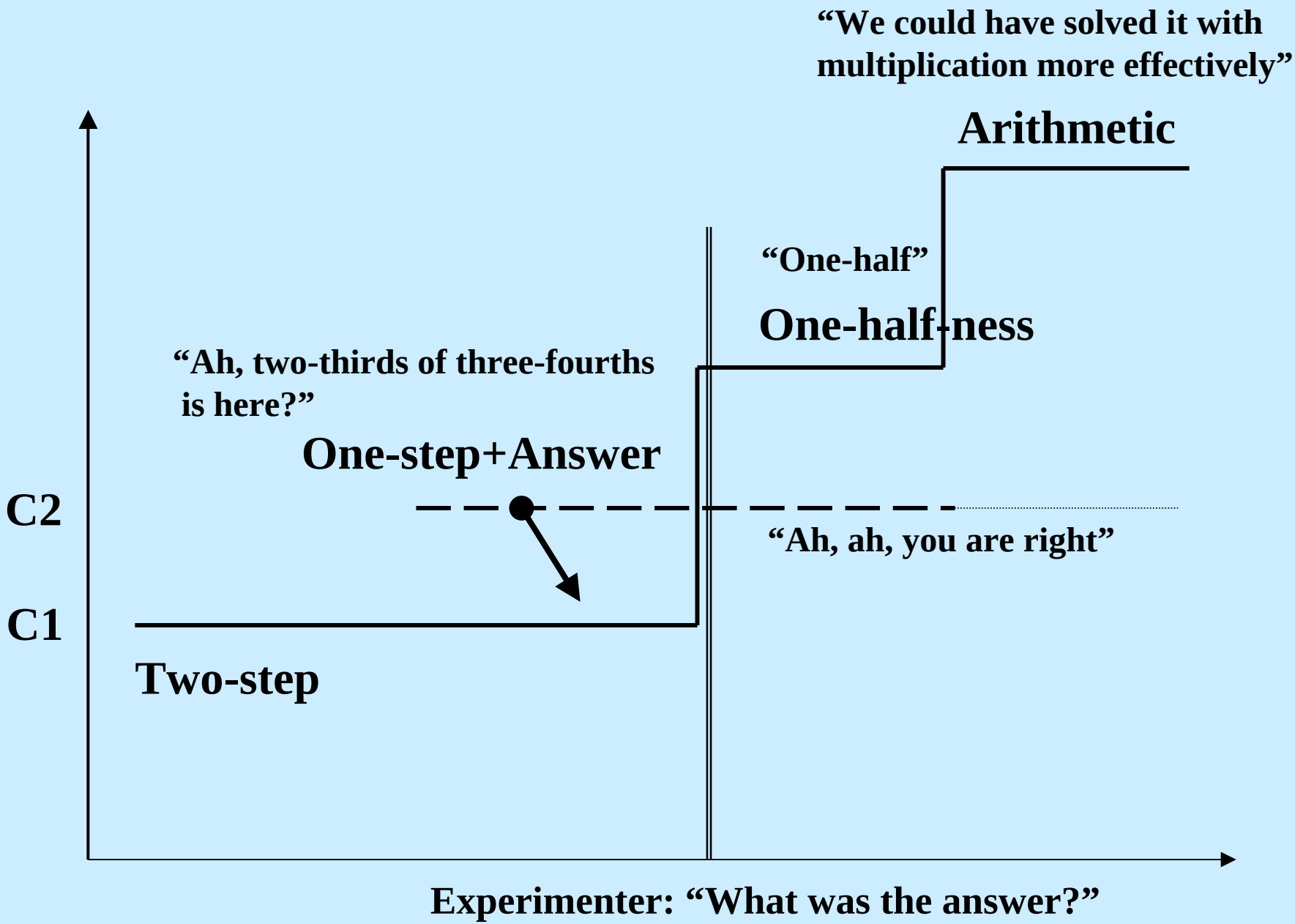
- **Arithmetic solution (1/2 = 3/4 ✕ 3/4)**
  - **We could have calculated.**

- **The answer is one half**
  - **Just picking out three out of already existing 4/6 makes one-half**

- **One step solution---the answer is out there**
  - **Folding “2” of 2/3 into four gives us 4/6**

- **Two step solution---we have to keep working**
  - **Now let’s get 3/4out of this “2” of 2/3.**


"We could have solved it with multiplication more effectively"
Arithmetic
"Oh yes, this is the half"
One-half-ness
"One-half of the original"
"Oh, it's two-third of three-fourths"
"One-half"
One-step+Answer
B1
B2
Two-step
Experimenter: "What was the answer?"


"We could have solved it with multiplication more effectively"
Arithmetic
"One-half"
One-half-ness
"Ah, two-thirds of three-fourths is here?"
One-step+Answer
C2
"Ah, ah, you are right"
C1
Two-step
Experimenter: "What was the answer?"

Summarizing hypothesis

- **People use external resource actively.**
- **The externalized trace of such activity is, in principle, interpretable in multiple ways.**
- **This multiplicity is not easily available to the “owner” of the process (because of her/his “active-ness.”)**
- **In a collaborative situation, while one is an active task-doer, the other can take the monitoring role who has a better chance of picking out the “next” step.**
- **And this iterates.**

Any practical value?

- **Creating learning environments for undergraduate cognitive science courses,**
  - **by encouraging and supporting externalization**
  - **by enhancing collaborative reflection on the externalized traces**

Bridging research to application

i.e. Designing a collaborative learning environment

- **Knowing what it means to collaborate is important**
  - **Laborious**
  - **Initial hypothesis**
  - **Motivation for “change”**

Verbalization

- **How verbalization affects abstraction of procedural knowledge (e.g., Tower of Hanoi puzzle)?**

…. **….**

- **How to support small group discussion for learning?**

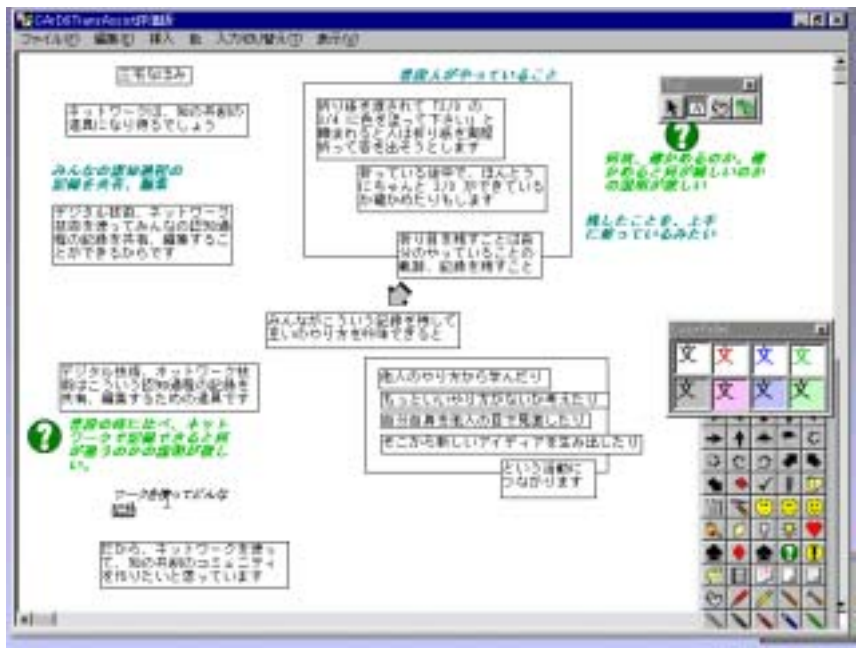
Record keeping

- **How traces of sentence-card placement facilitates meta-cognitive reading?**

- **How to support reading, writing, and other semantic integration processes.**

Card Arrangement Displayer

(by K. Noda)

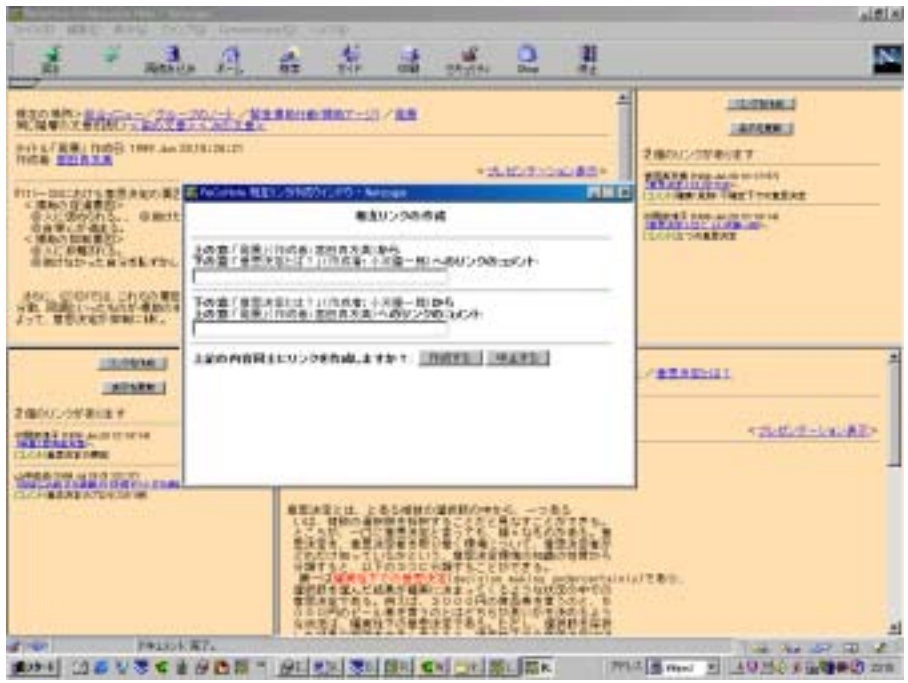


Collaborative learning

- **How to develop curricular to take fuller advantage of note-sharing, relation-making technology?**

Reflective Collaboration Note

(by H. Masukawa)



Taking cognitive science into the real world …