CHILDREN'S CONCEPT LEARNING IN SOLVING LOGIC PROBLEMS

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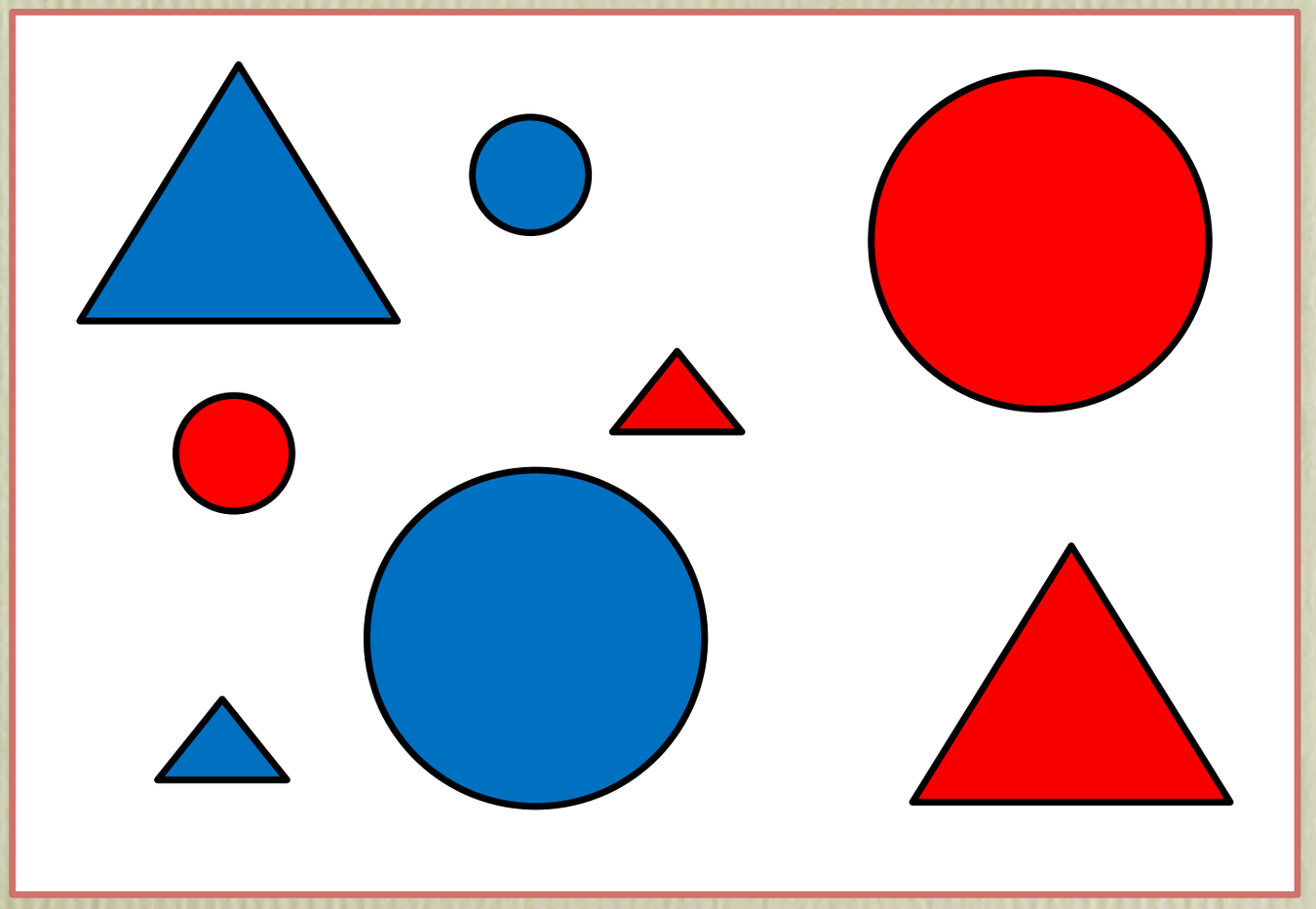
Outline

- Boolean concepts learning. Math complexity
- Algebraic structures. Boolean cube. Matrix
- Set game logic problem
- Function of regularity as Cognitive complexity
- Experiments
- Conclusions

Complexity of logic problem

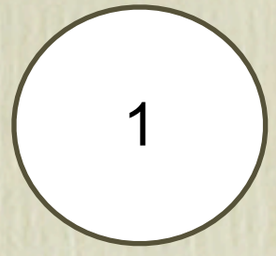
- Mathematical complexity vs. Cognitive complexity
- Mathematical complexity of logic problems:
  - Shannon
  - Kolmogorov
- Feldman's complexity - the number of literals in the minimal Boolean expression.

Boolean concepts



x - Shape

y - Size



z - Color

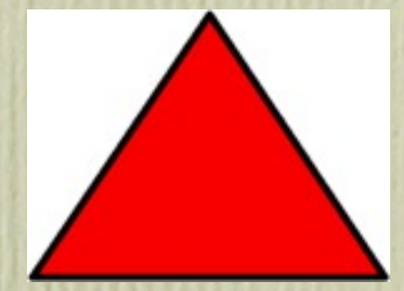
Boolean concepts

100

000

101

001



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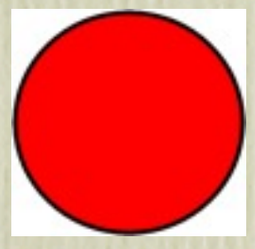
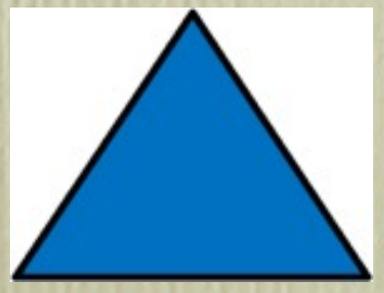


010



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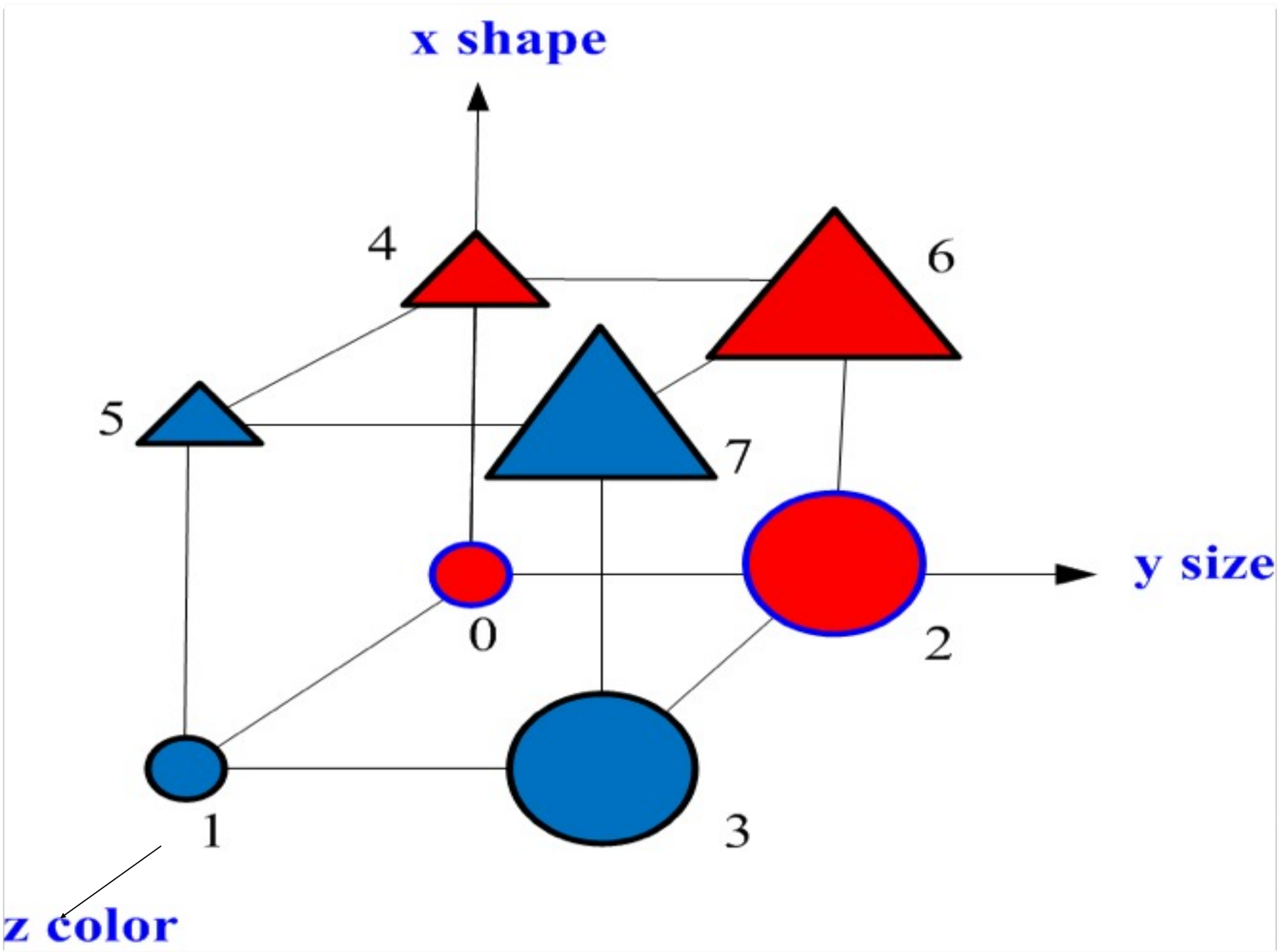
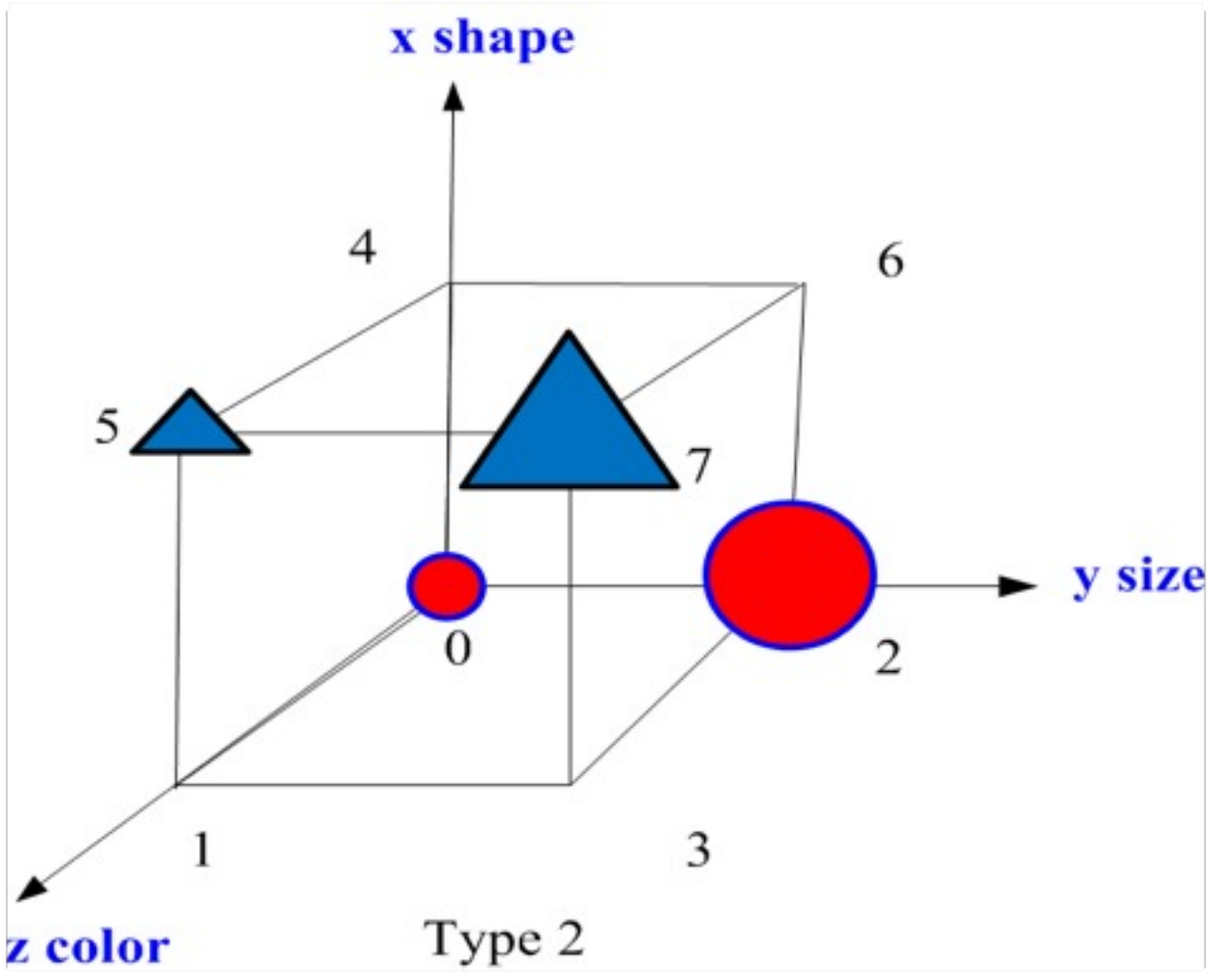
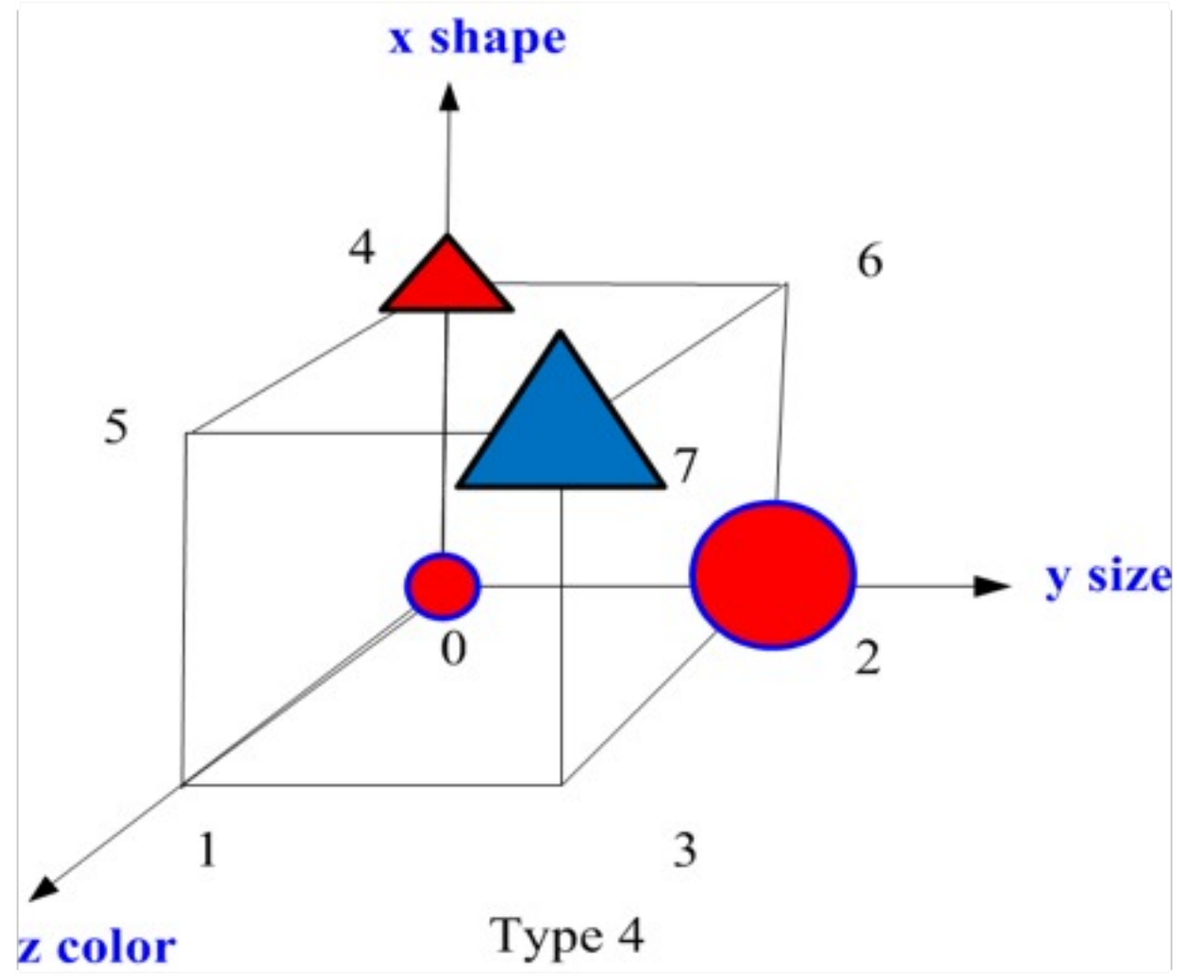
Boolean cube



Complexity of 4 elements recognition



Type 2



Type 4

What is more complex for humans?

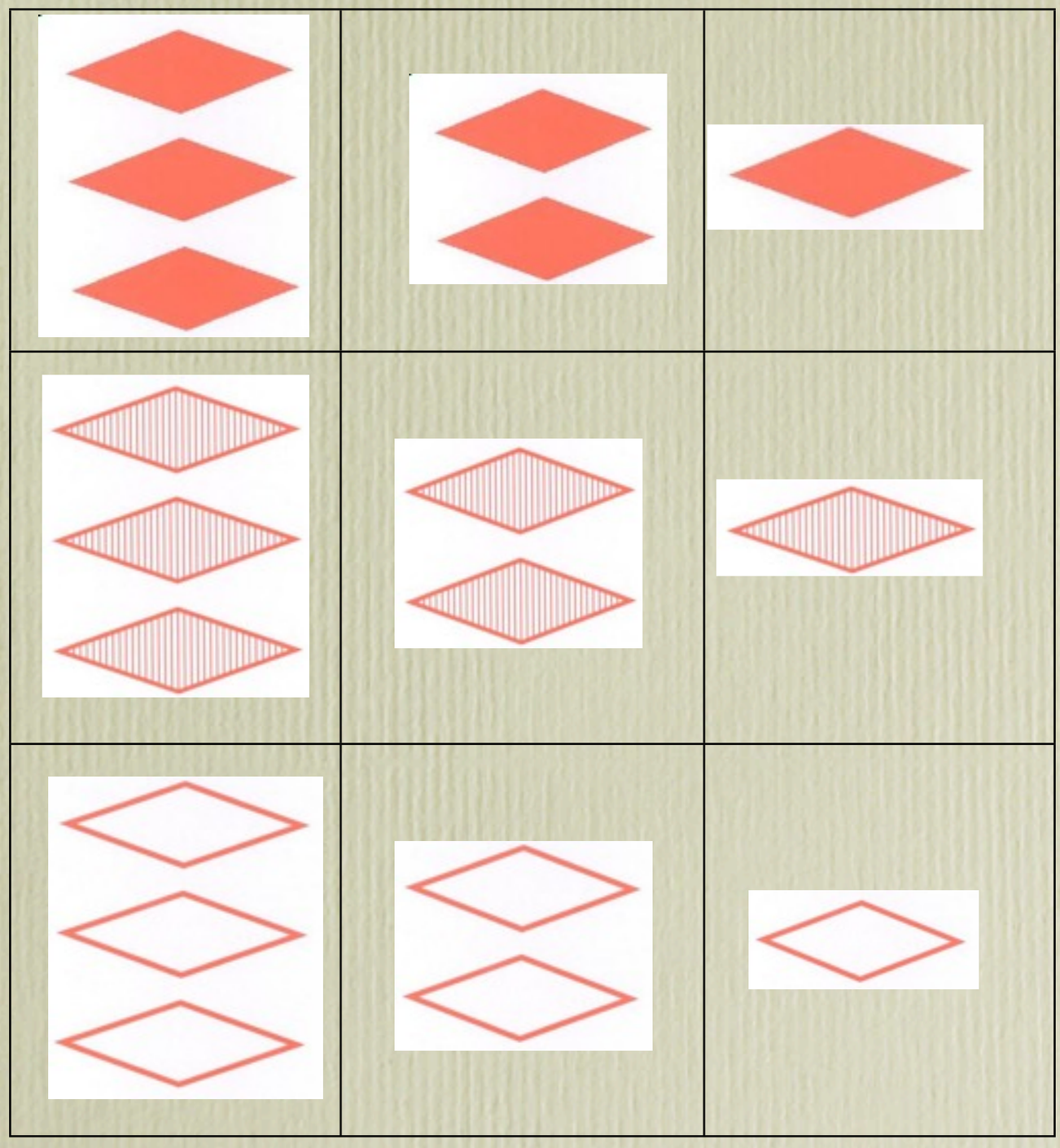
$$xz + \overline{x}\,\overline{z}$$

$$\overline{y}\,\overline{z} + xyz + \overline{x}y\overline{z}$$

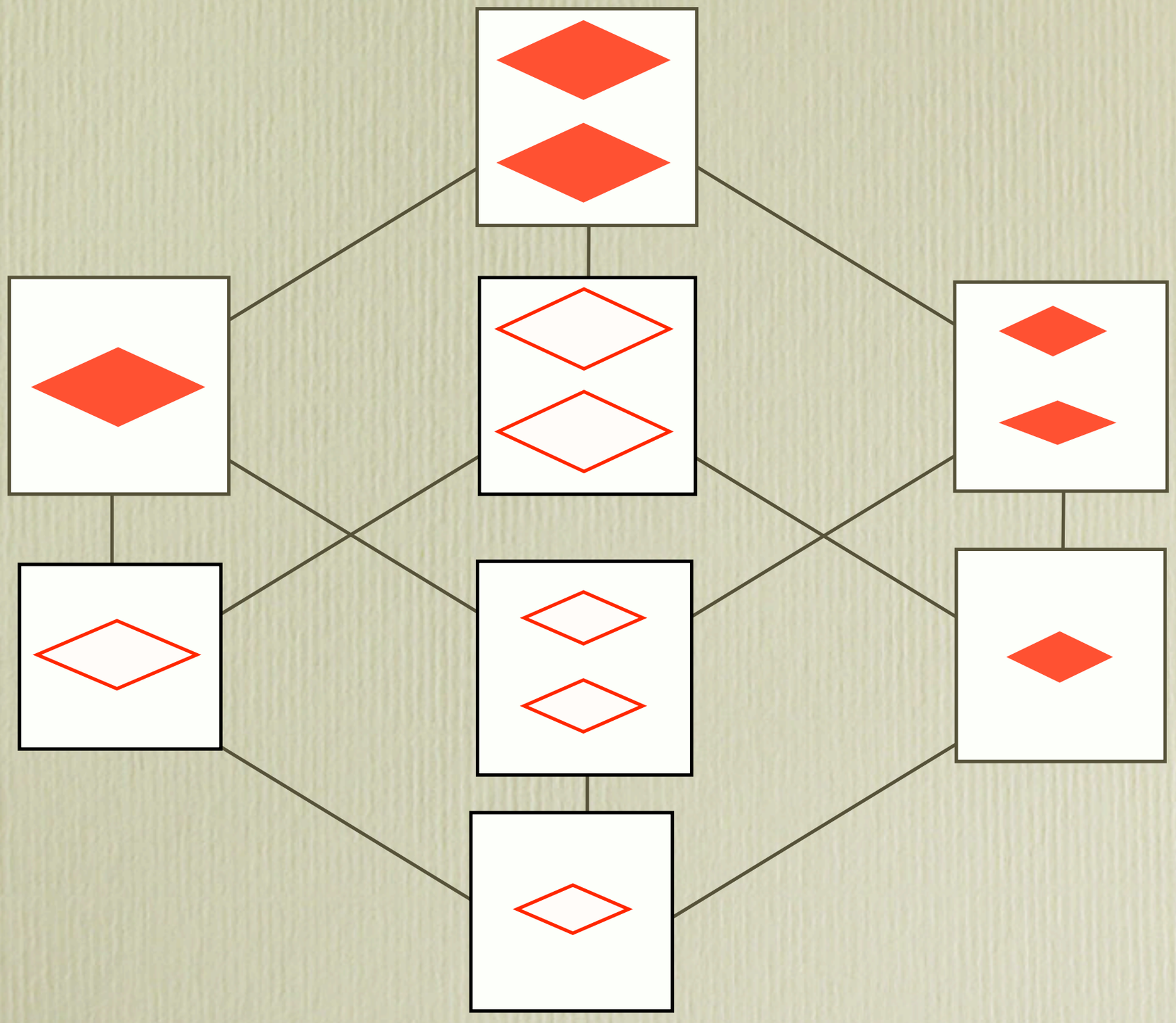
Our study

- Use the Set game® cards to answer the question
    - Does the math complexity (Feldman) reflects the ability of young children in solving logic problems?
    - Does recognition of specific regularities support children success in solving logic problems (decrease the cognitive complexity)?

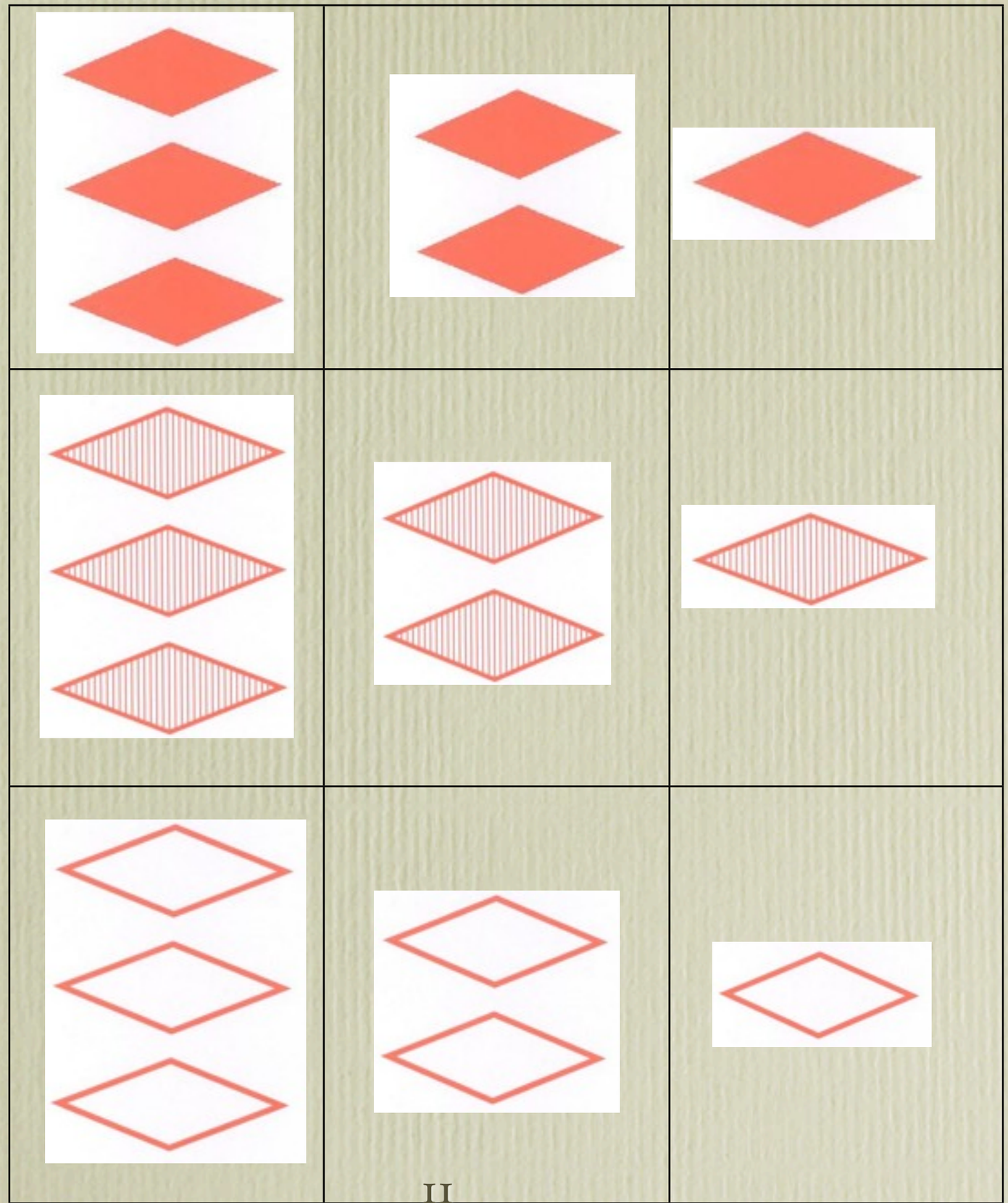
Set game®



Boolean cube of cards for Set game

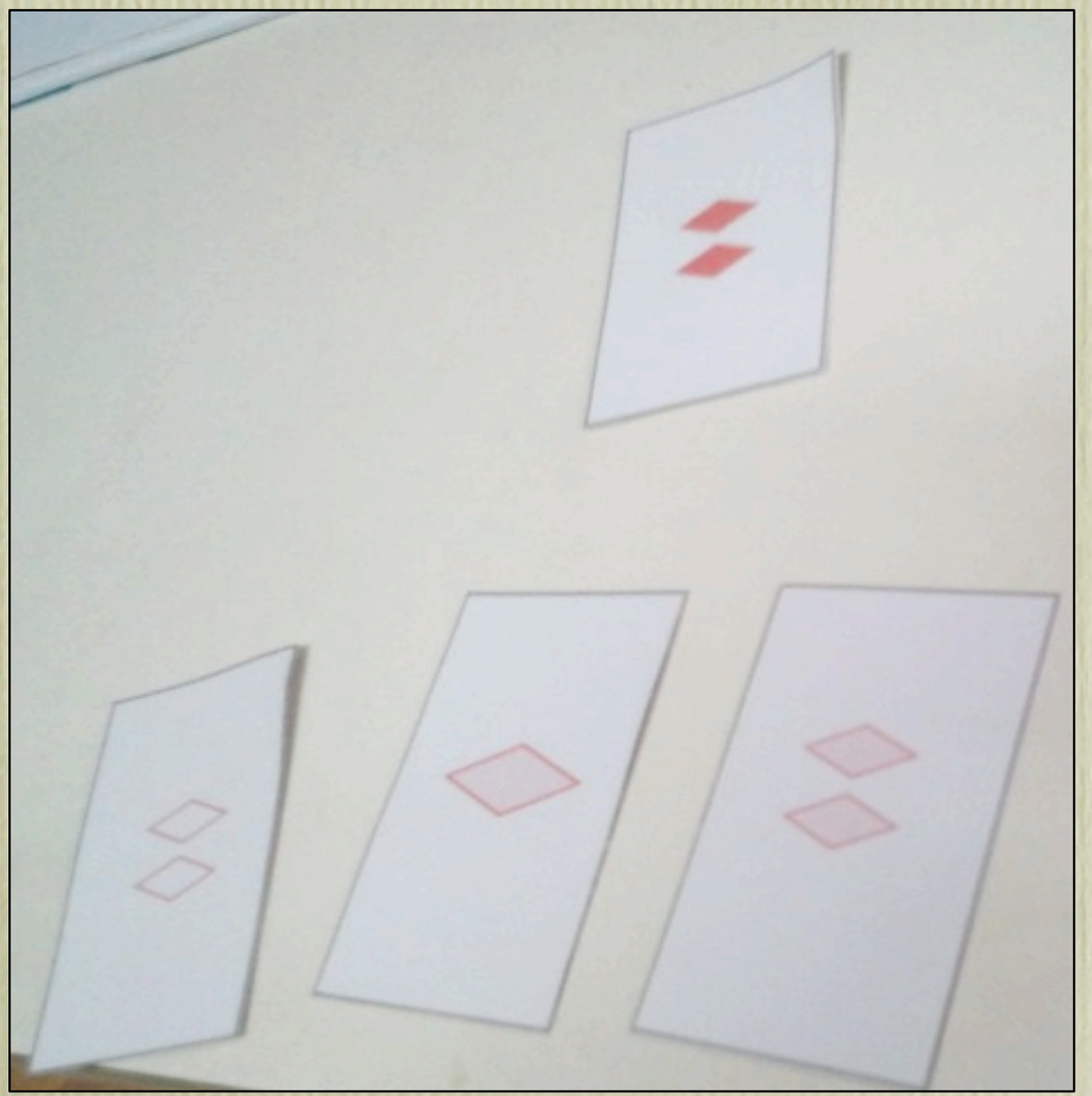


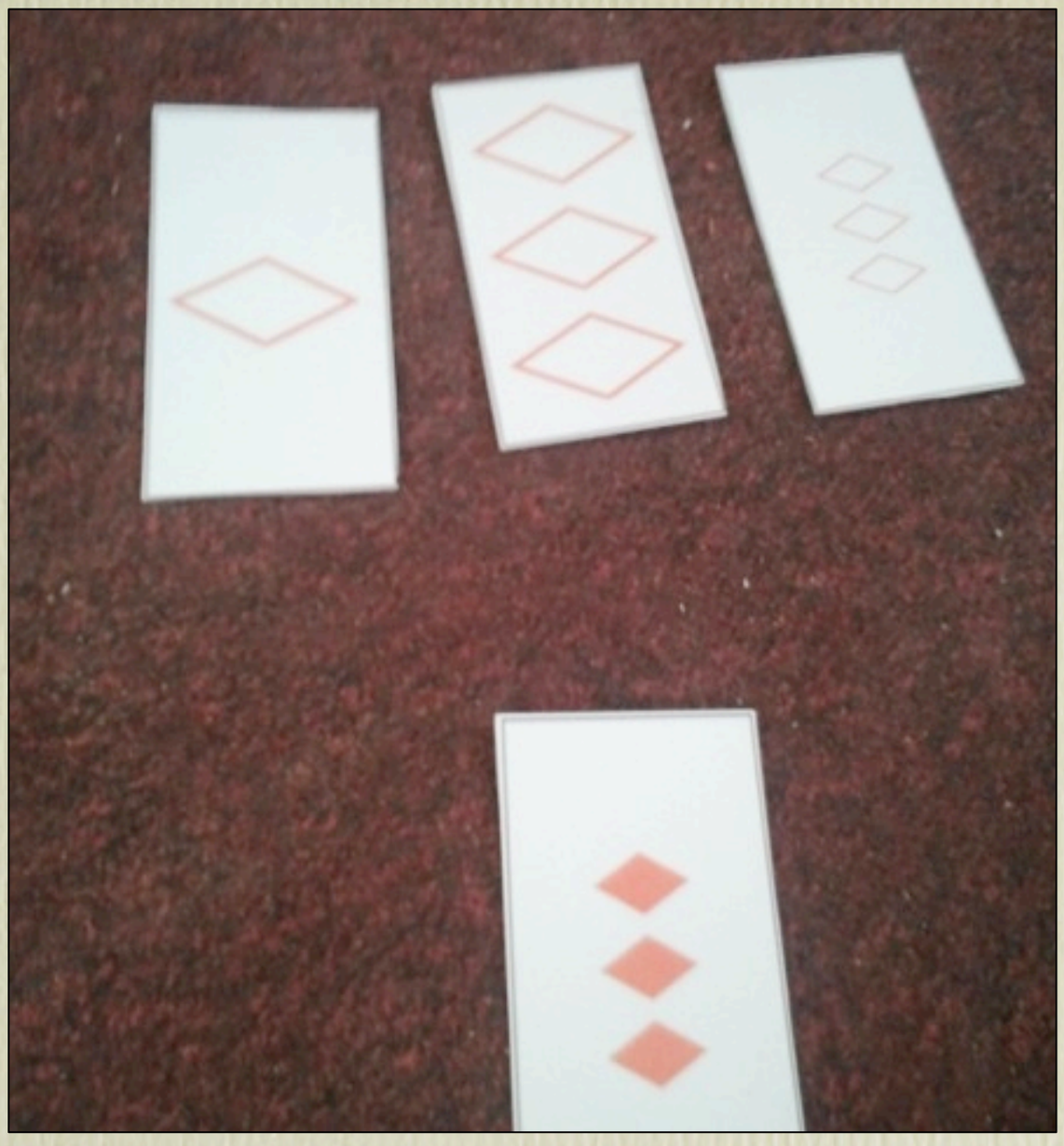
3x3 matrix of cards for Set game



Pre-test

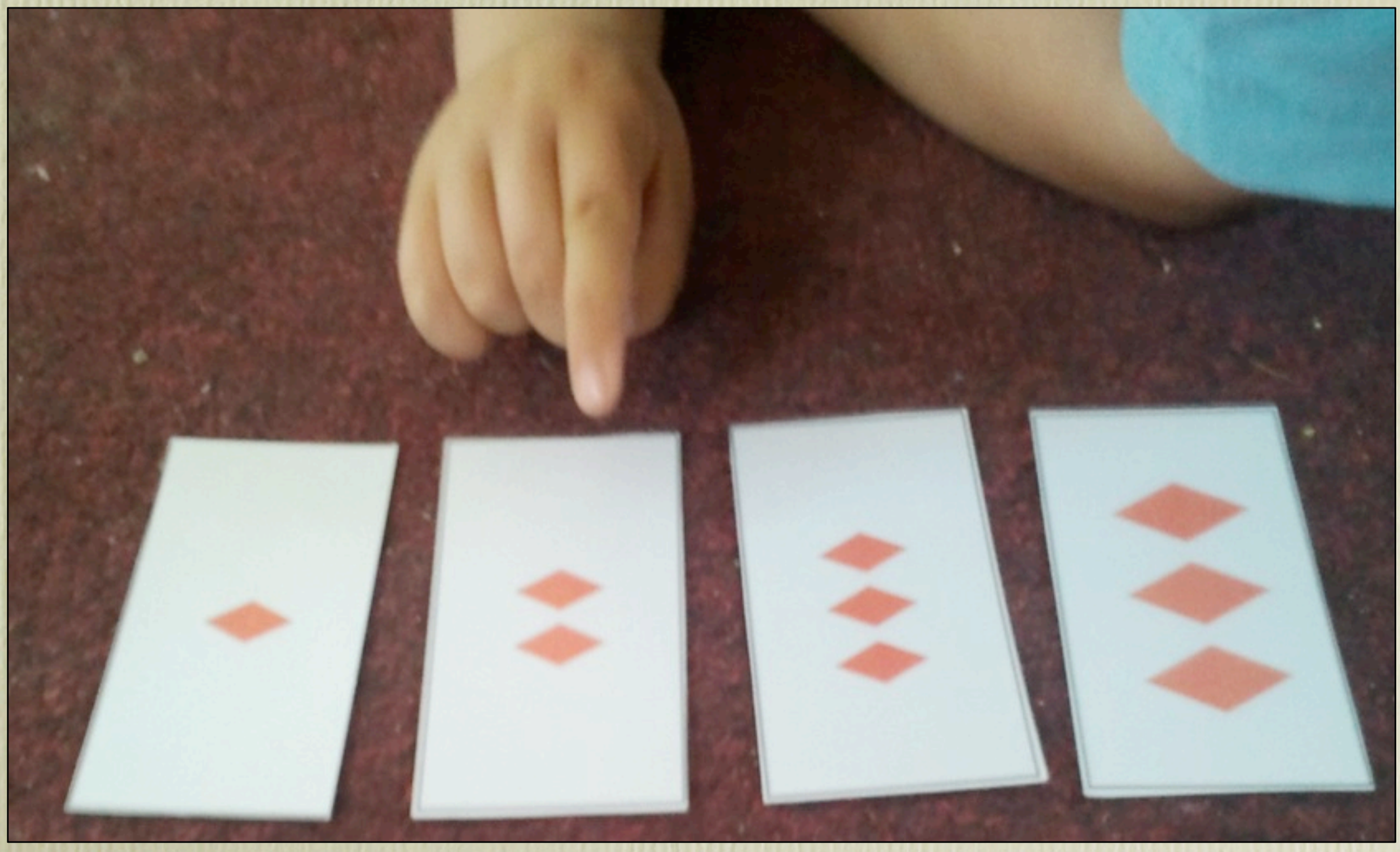
Student prefer fill as a main characteristic up on number





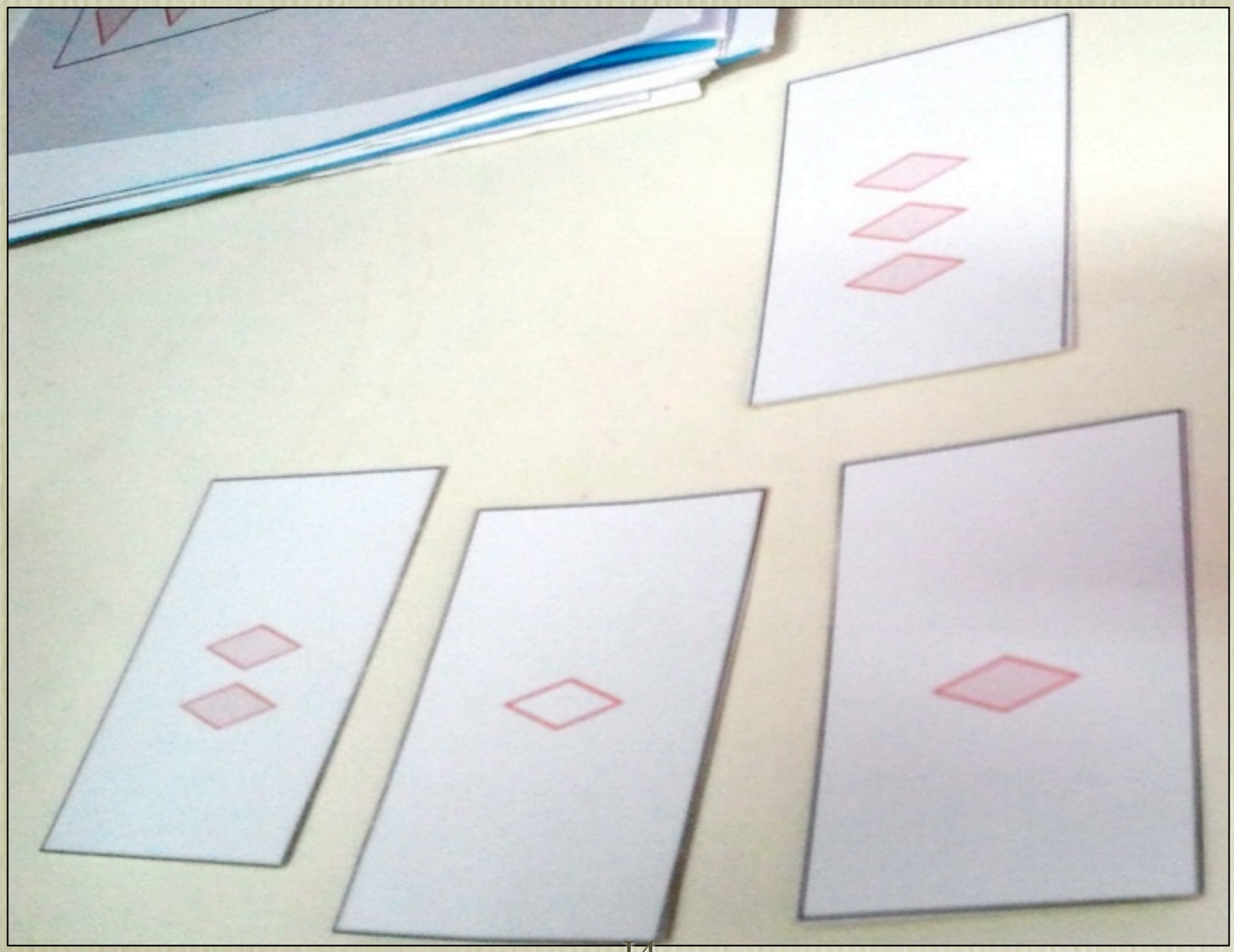
Pre-test

Student prefer size (big or small) as a main characteristic up on number: “When it big it looks more…”



Pre-test

Student regarded number three as different from to two smaller numbers: “Three is different because it’s a lot”



Research Methodology

- We propose a specific regularity function that measures the cognitive complexity of the task

- We study experimentally how children recognize regularity within the shapes' characteristics and how this recognition supports children in solving logic problems

- Our research hypothesis was that despite of high Feldman's complexity, children are able to solve logic successfully by recognizing some regularities in tasks

Set cards characteristics

- Size
- Fill
- Number

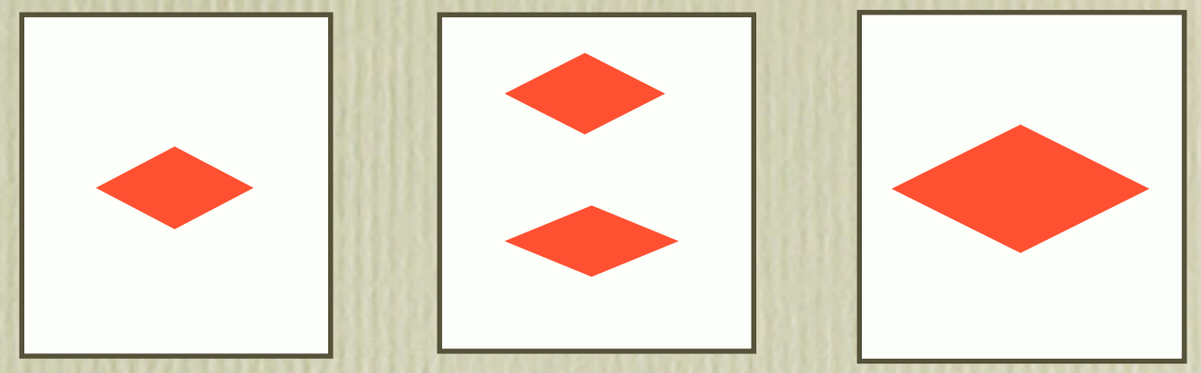
Set cards regularities

- Homogeneity
- Difference
- Monotony
- Symmetry

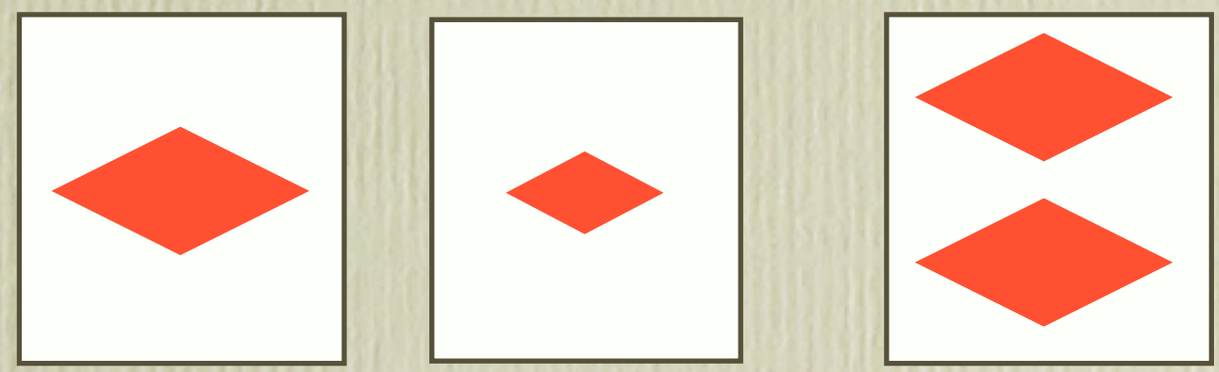
The regularities can be recognized in each of the characteristics

Example: regularities of Size

Monotony



Symmetry



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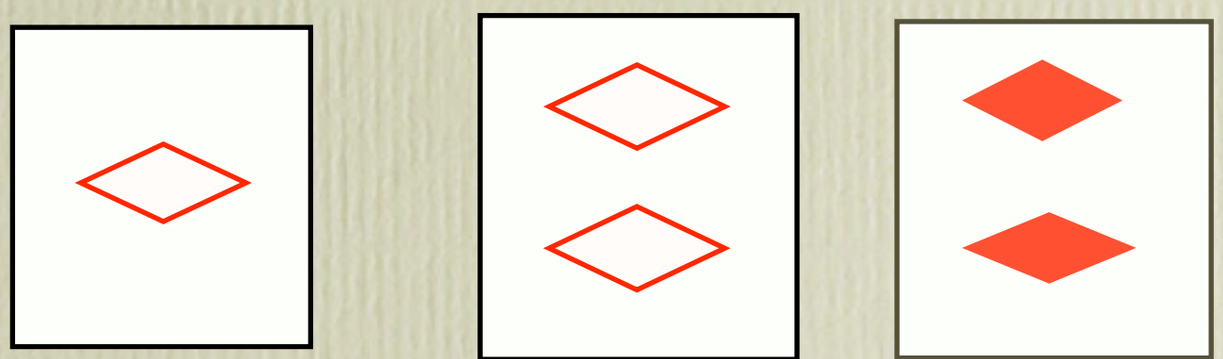
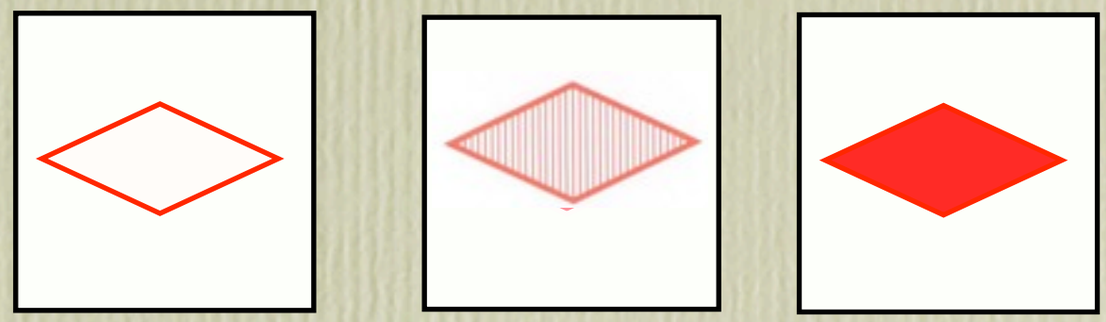
Homogeneity

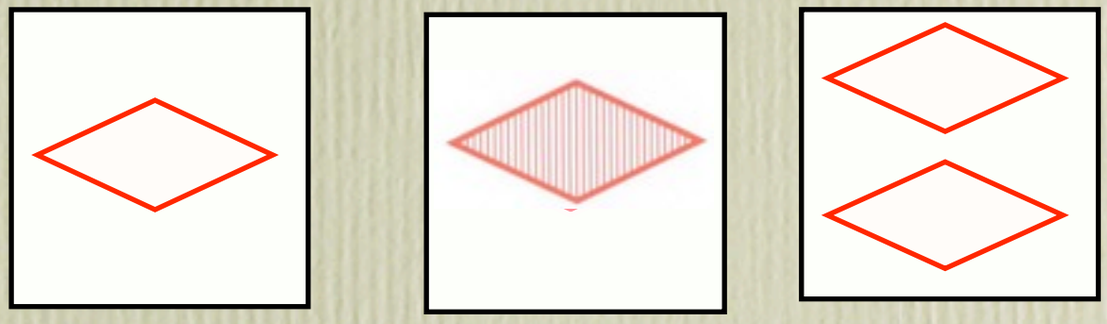


Example: of regularities of Fill

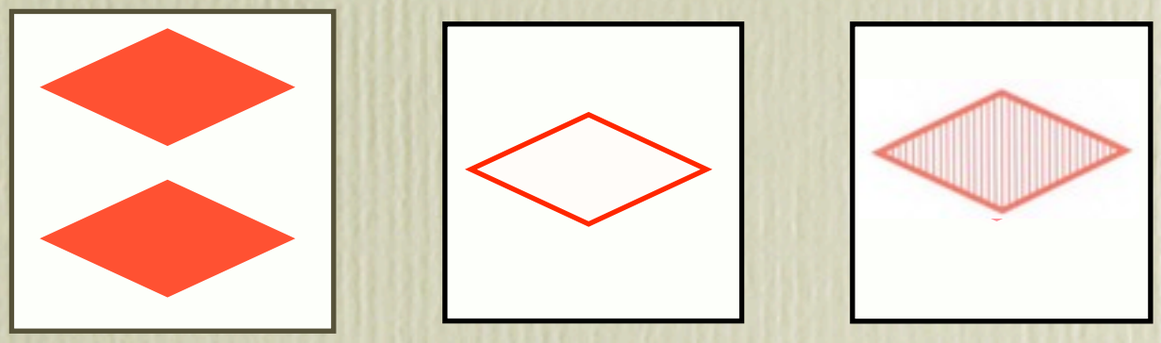
Monotony



Symmetry



Difference



Function of regularity

- Function of regularity R measures the level of regularity of the sequence of cards in cases when a specific card is chosen from a set of cards-candidates

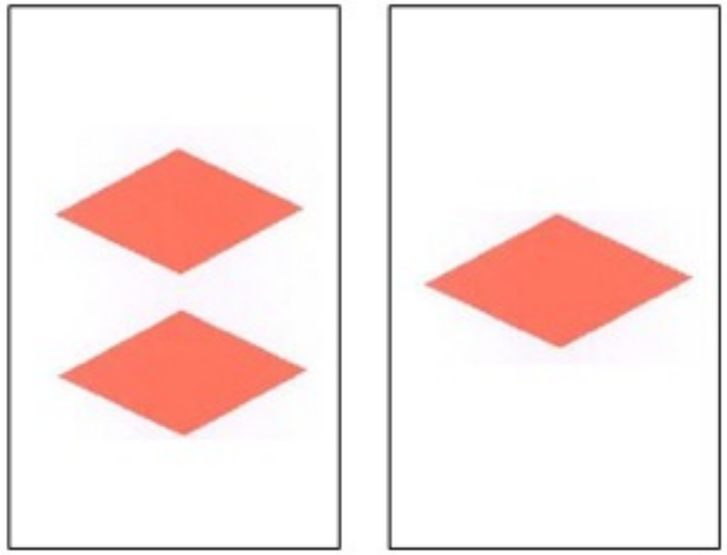
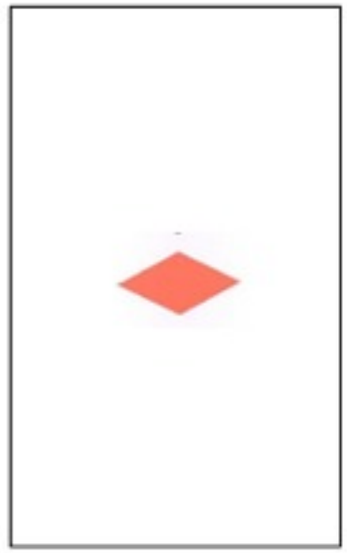
- The regularity of a specific characteristic of a card is a vector comprising values of all the regularities.

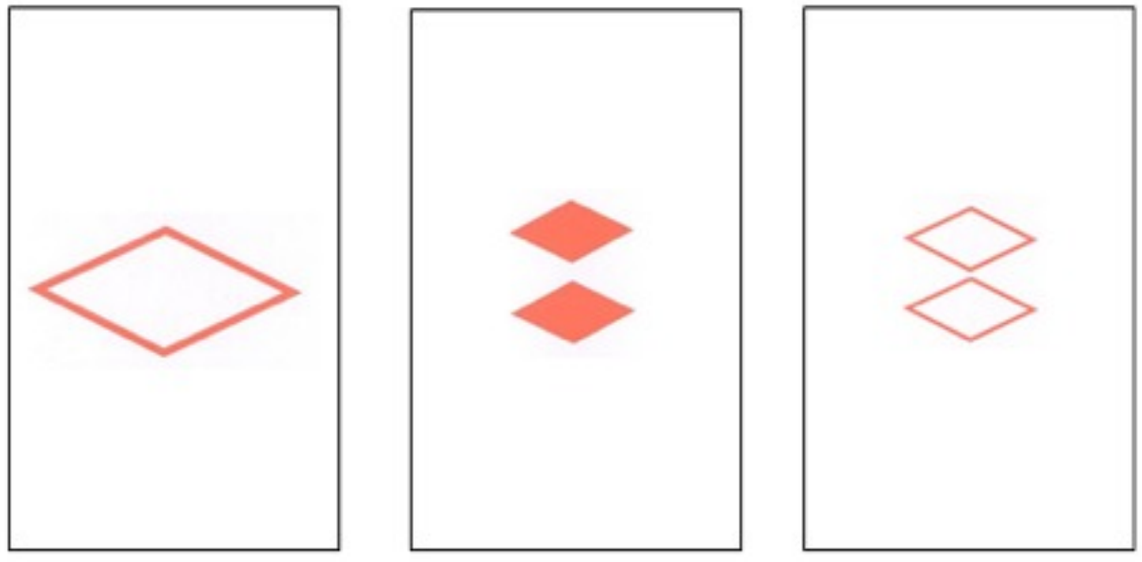
8

$$R_S = \sqrt{w_h r_{Sh}^2 + w_d r_{Sd}^2 + w_m r_{Sm}^2 + w_s r_{Ss}^2}$$

$$R = \sqrt{w_S R_S^2 + w_N R_N^2 + w_F R_F^2}$$

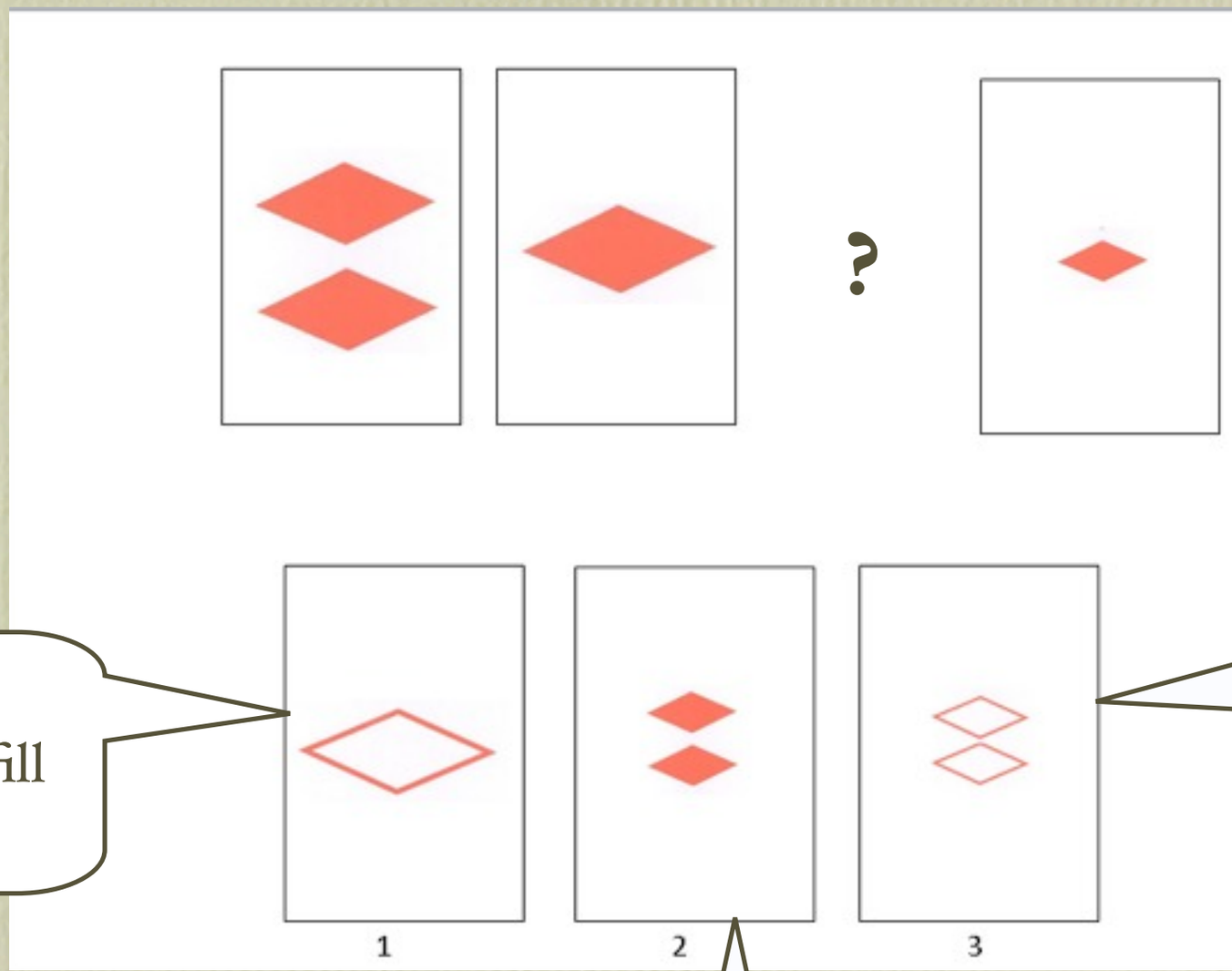
Logic problem: to complete the set

The set  ? 

Candidates 

1 2 3

Possible Choices

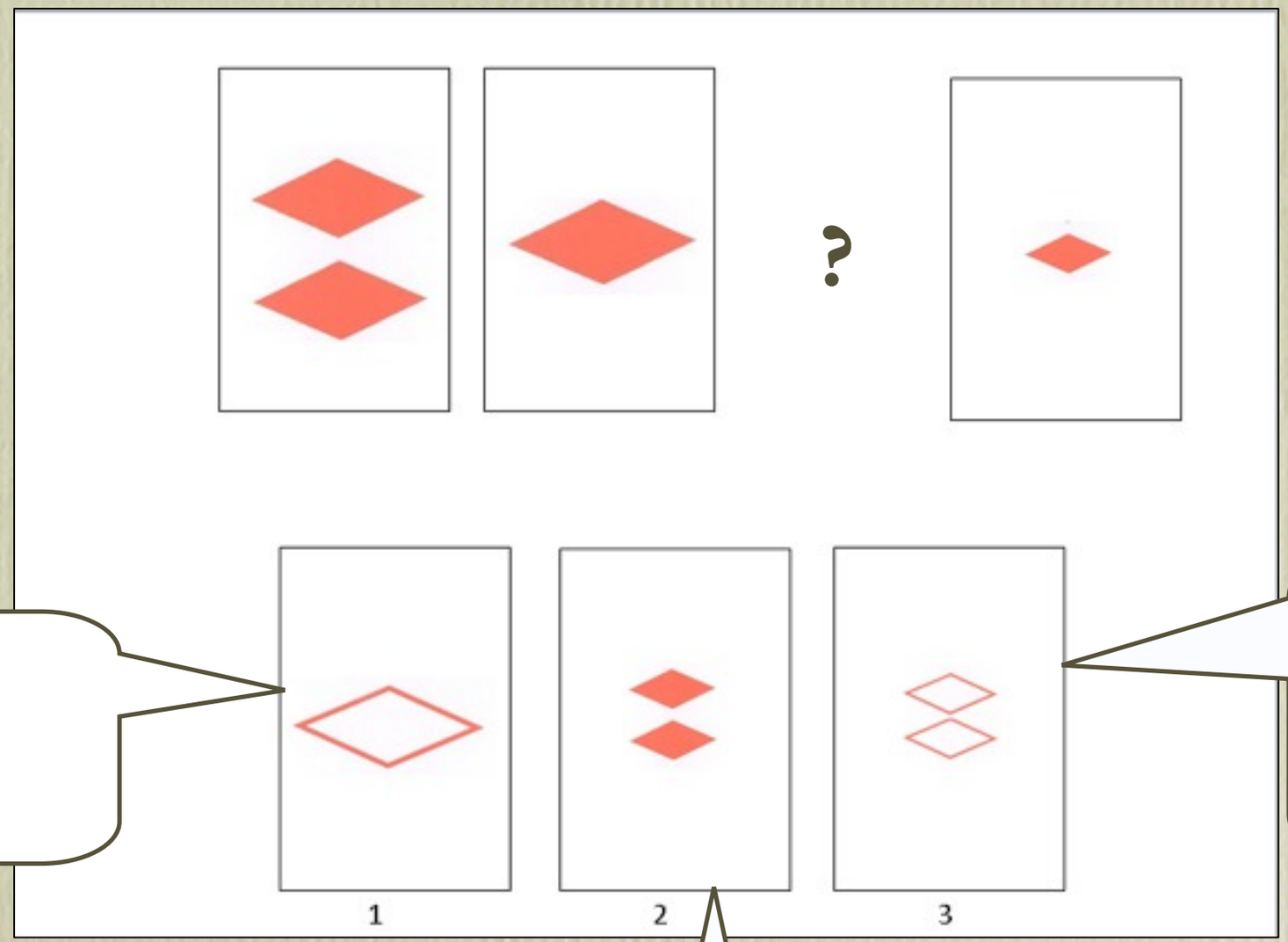


difference in fill

difference in fill

symmetry in number, homogeneity in fill

Possible Choices

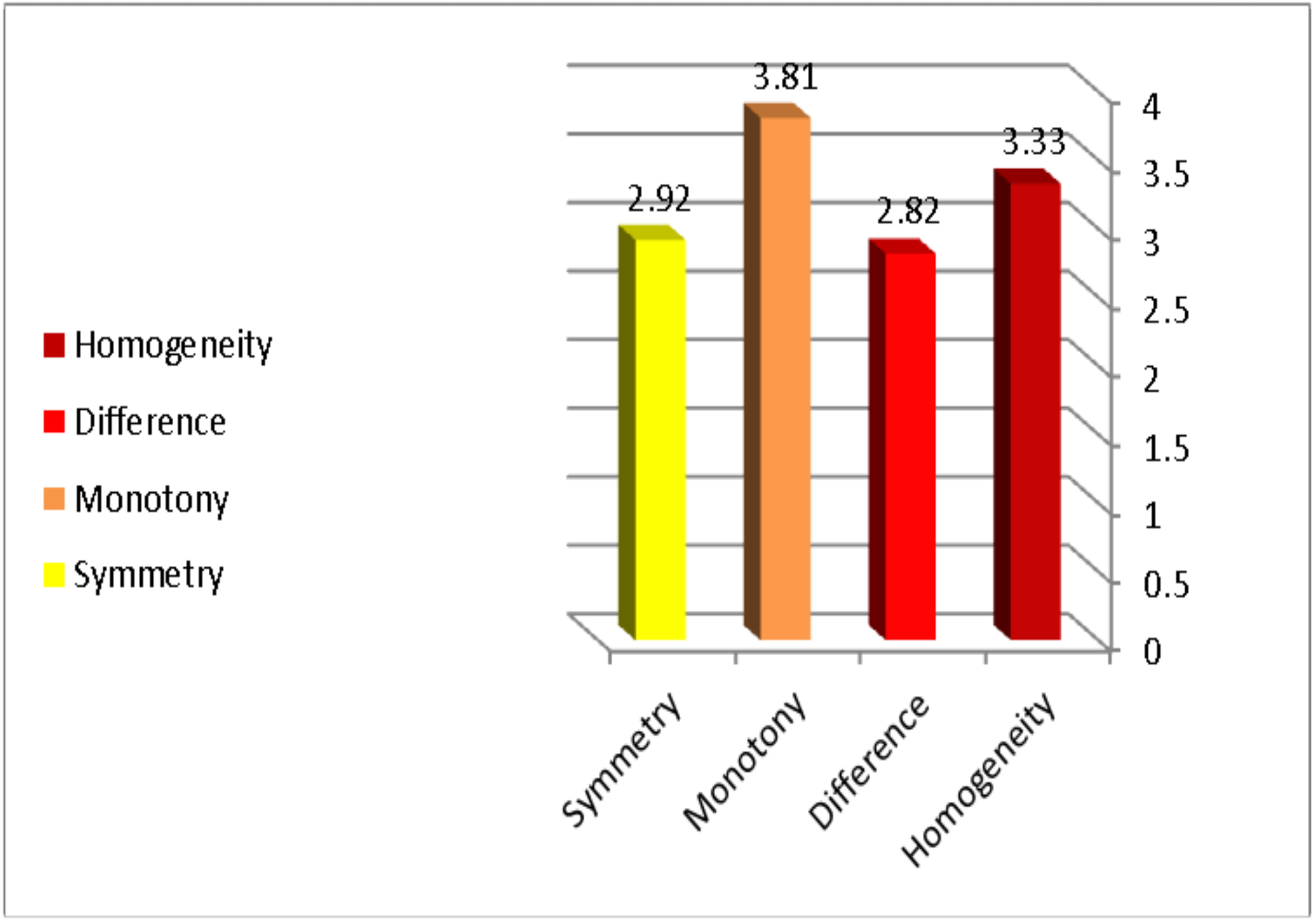


R=1

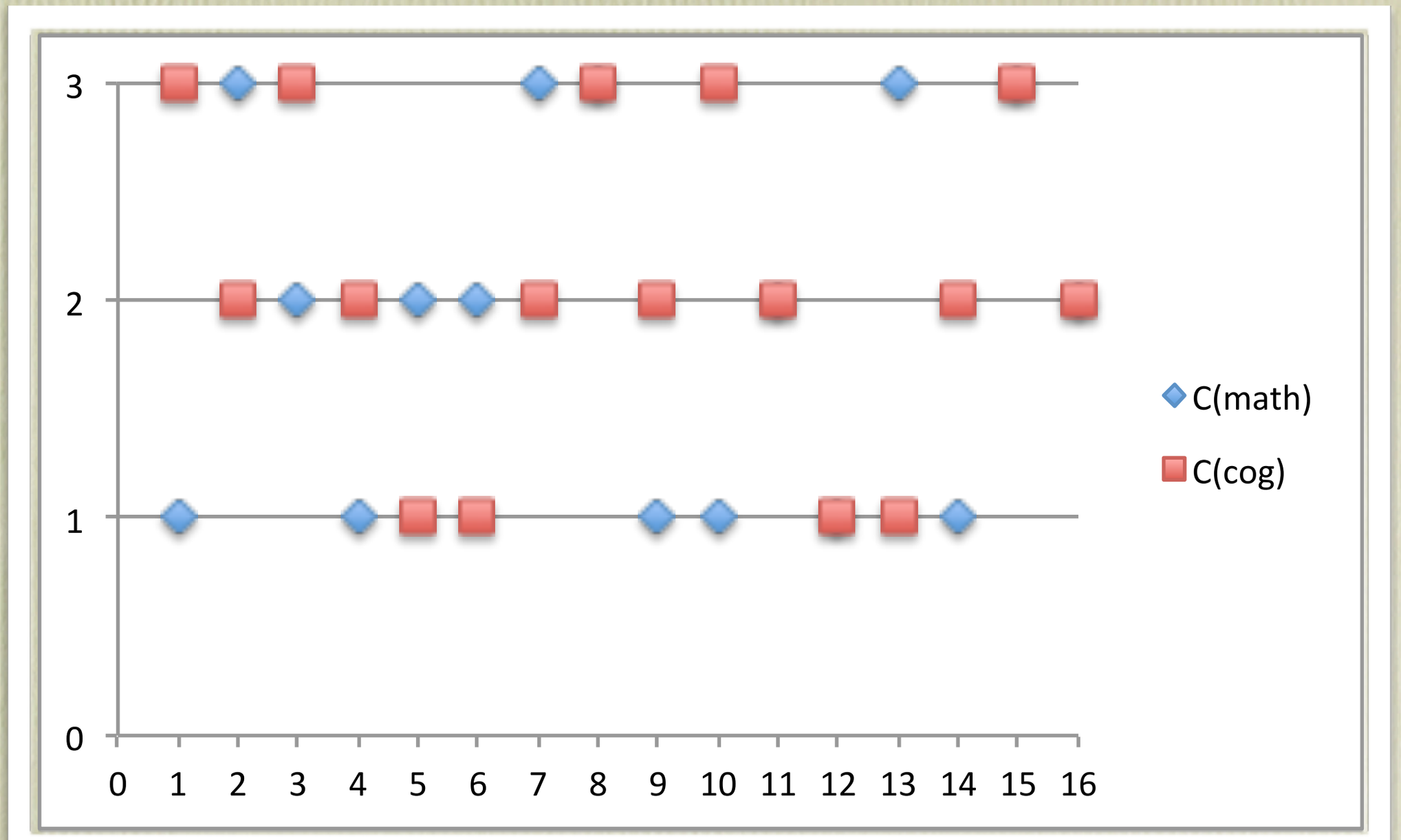
R=1.4

R=2.3

Recognizing Regularities



Cognitive vs. Math Complexities



C(math) - choice according to the Feldman's complexity

C(cog) - choice according to the cognitive complexity $\left(1/R_{\max}\right)$

Conclusions

- We study ways students solve logic problems by comparing math and cognitive complexities of logic problems
- The specific function of regularity as a measure of cognitive was proposed
- The main findings of the study:
  - Recognizing of regularities support problem solving
  - The most recognized type of regularity was symmetry
  - The most recognized characteristic of set cards was the number
  - No correlation has been indicated between the math complexity the cognitive complexity in a considerable number of logic problems