A Comparison Study of Rule Space Method and Neural Network Model for Classifying Individuals and It's Applications

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Outline

- Educational Field
- Scoring Report
  - Score with guide for next learning steps
- Rule Space Method (RSM)
  - Clustering technique : Each mastering level
- Feed-Forward Neural Network Model (NNM)
- Comparison between RSM and NNM
- Science Reasoning Test (SR-Test)
  - Introduction
  - Experiment
    - Extraction of Attributes
- Conclusion and Discussion

Scoring Report

- Learning Diagnosis
  - Not only numerical score,
    But also guide of next learning steps
  - developing in USA
- Record of test :

  Numerical Score
  +
  guide of next learning steps
  ==> More effective
- “Next direction”、“Signpost”
  - Evaluation <===> Teaching

2. Rule Space Method

- A classification procedure
- Domain from educational statistics
- Conceptual framework of Psychmetrics
- Examinees ===> Knowledge States (KS)
  - Master/Learning level of each examinee
- Basic idea : Tatsuoka(1980's)
  - same total score ≠ same learning level
- in each Item : task analysis
  - Cognitive processes
  - Knowledge (named "Attribute")

Table 1

ADDITION TEST

	Item	Student Answer		
		*1	*2	*3
1)	$\frac{2}{3} + \frac{1}{3} = \frac{3}{3} = 1$	1	1	1
2)	$\frac{1}{3} + \frac{1}{4} = \frac{7}{12}$	$\frac{7}{12}$ U	$\frac{7}{12}$	$\frac{7}{12}$
3)	$\frac{2}{3} + \frac{5}{6} = 1\frac{1}{2}$	$\frac{1}{2}$ X	$1\frac{1}{2}$	$1\frac{1}{2}$ U
4)	$4\frac{1}{5} + 2\frac{1}{3} = 6\frac{8}{15}$	$6\frac{8}{15}$ U	$\frac{8}{15}$ X	$8\frac{6}{15} = 8\frac{2}{5}$ X
5)	$2\frac{2}{5} + 2\frac{2}{5} = 4\frac{4}{5}$	$4\frac{4}{5}$	$4\frac{4}{5}$	$4\frac{4}{5}$ U
6)	$1\frac{1}{6} + \frac{2}{3} = 1\frac{5}{6}$	$\frac{1}{2}$ X	$\frac{5}{6}$ X	$5\frac{1}{6}$ X
	Percent Correct	66.66%	66.66%	66.66%

X = incorrect response
U = correct response generated by "buggy" method

Student 1 : When denominators are different,
two denominators are add to numerator.

1) $\frac{2}{3} + \frac{1}{3} = \frac{2+1}{3} = \frac{3}{3} = 1$

w 2) $\frac{1}{3} + \frac{1}{4} = \frac{4+3}{12} = \frac{7}{12}$

× 3) $\frac{2}{3} + \frac{5}{6} \neq \frac{6+3}{18} = \frac{9}{18} = \frac{1}{2}$

w 4) $4\frac{1}{5} + 2\frac{1}{3} = 6\frac{8}{15}$

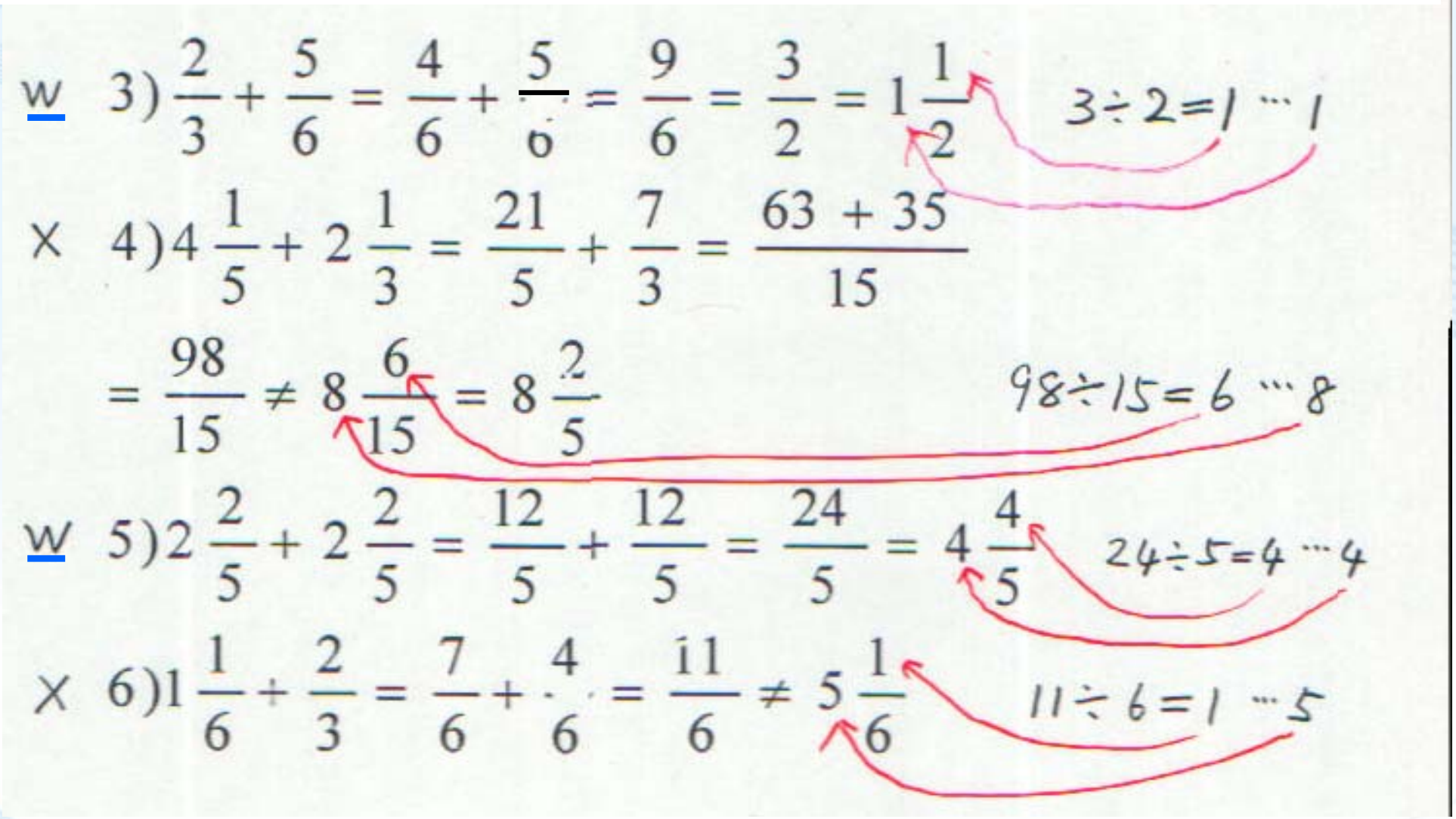
5) $2\frac{2}{5} + 2\frac{2}{5} = 4\frac{4}{5}$

× 6) $1\frac{1}{6} + \frac{2}{3} = \frac{7}{6} + \frac{2}{3} \neq \frac{9}{18} = \frac{1}{2}$

Student 2 : When denominators are different,
the whole part are forgotten.

× 4) $4\frac{1}{5} + 2\frac{1}{3} \neq \frac{3+5}{15} = \frac{8}{15}$

Student 3 : Wrong reducing method of an improper fraction.



Only if “quotient = remainder”

2.Rule Space Method

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- Domain from educational statistics
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- Basic idea : Tatsuoka(1980's)
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Rule Space Method

- Input Information
  - Incidence matrix : item-attribute matrix
  - item response pattern
- Output : Knowledge State (KS) : Cluster
  - mastered/non-mastered learning level
  - from item response patterns
- Results of examinees' performance on a test

  ▲ reported by total scores or scaled scores

  ◎ mastered or non-mastered、next directions
- more effective for learning

Simple Example of RSM

- Subject matter
  - fraction addition problems
  - 7 items and 5 Attributes
  - 595 Cases of Item Response Patterns

Items

1) $2\frac{8}{6} + 3\frac{10}{6} = (2+3)\frac{8+10}{6} = 5\frac{18}{6} = 5 + 3 = 8$

or $= (2+1)\frac{1}{3} + (3+1)\frac{2}{3} = (3+4)\frac{1+2}{3} = 7 + 1$

2) $2\frac{1}{2} + 4\frac{2}{4} = 2\frac{2}{4} + 4\frac{2}{4} = (2+4)\frac{2+2}{4} = 6\frac{4}{4} = 6 + 1 = 7$

3) $\frac{1}{2} + 1\frac{10}{7} = \frac{7}{14} + 1\frac{20}{14} = 1\frac{7+20}{14} = 1\frac{27}{14} = 2\frac{13}{14}$

4) $3\frac{5}{2} + 4\frac{6}{7} = 3\frac{35}{14} + 4\frac{12}{14} = (3+4)\frac{47}{14} = (7+3)\frac{5}{14} = 10\frac{5}{14}$

5) $1\frac{4}{7} + 1\frac{12}{7} = (1+1)\frac{4+12}{7} = 2\frac{16}{7} = (2+2)\frac{2}{7} = 4\frac{2}{7}$

6) $2\frac{5}{9} + 1\frac{1}{9} = (2+1)\frac{5+1}{9} = 3\frac{6}{9} = 3\frac{2}{3}$

7) $3\frac{1}{6} + 2\frac{3}{4} = 3\frac{2}{12} + 2\frac{9}{12} = (3+2)\frac{11}{12} = 5\frac{11}{12}$

Description of Items by Various Combinations of Attributes in Fraction Addition Problems, a(b/c)+d(e/f)

Attributes

A1 : Separate the whole part from the fraction part when a≠0 or d≠0
A2 : Get the common denominator(CD) when c≠f (公約数)
A3 : Convert the fraction part before getting CD
A4 : Reduce the fraction part before getting CD (約分)
A5 : Answer to be simplified

Incidence Matrix

	Items						
Attributes	I1	I2	I3	I4	I5	I6	I7
A1	1	1	0	1	1	1	1
A2	0	1	1	0	0	0	1
A3	1	0	1	0	1	0	0
A4	1	1	0	0	0	0	0
A5	1	1	1	1	1	1	0

Simple Example of RSM

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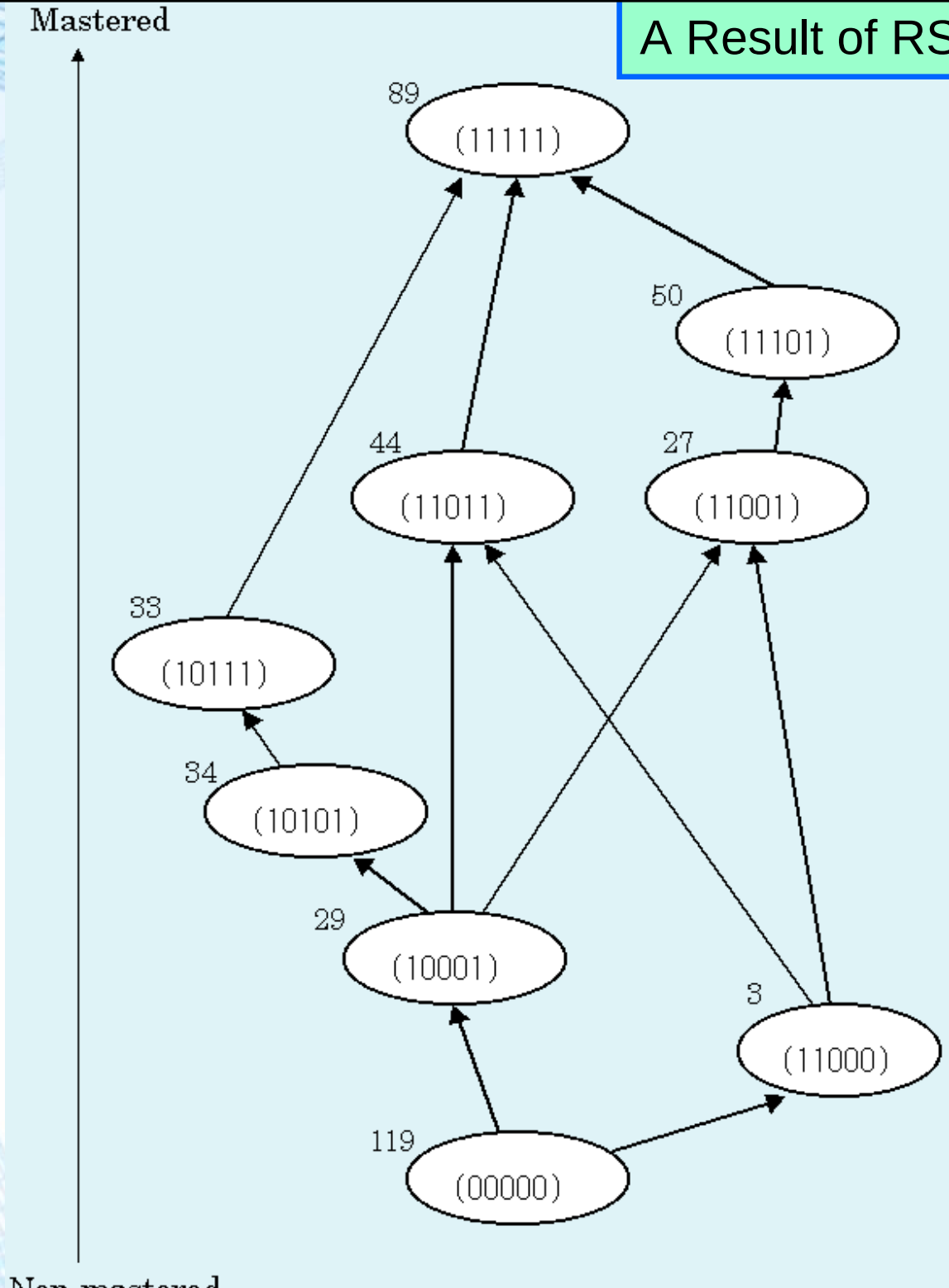
A Result of RSM



Attributes

A1 : Separate the whole part from the fraction part when a≠0 or
A2 : Get the common denominator(CD) when c≠f
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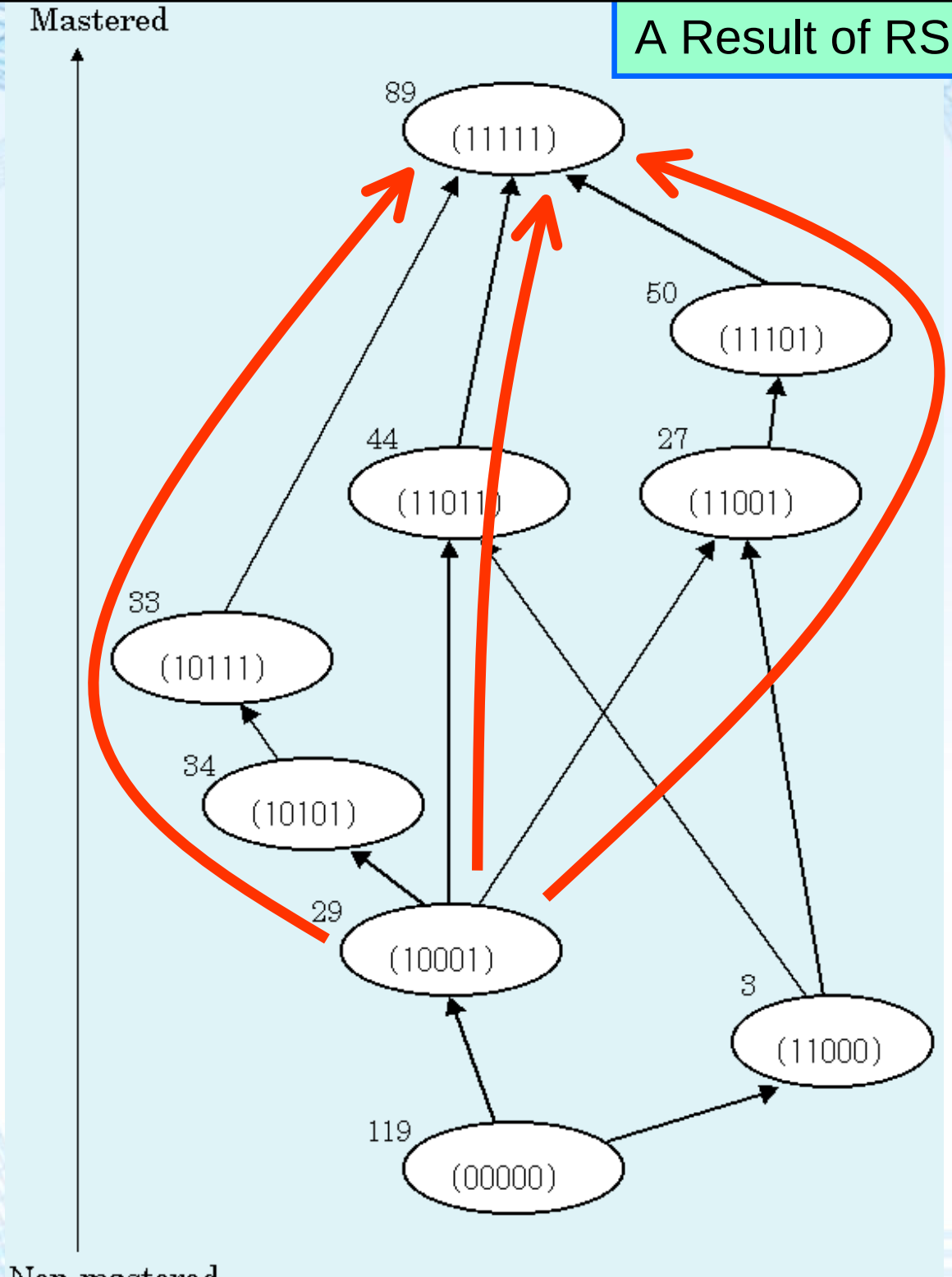
A Result of RSM



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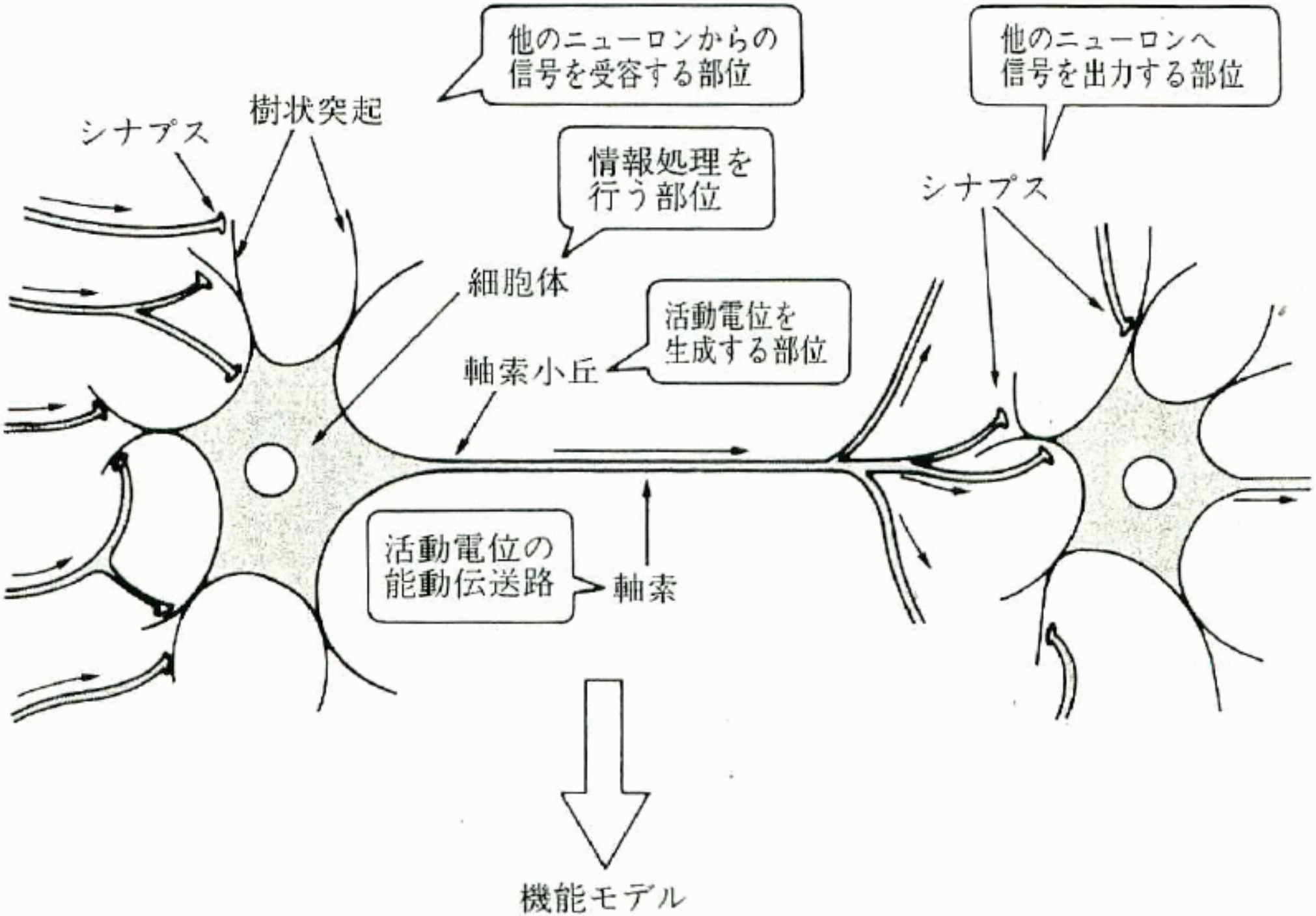
3.Feed-Forward NN Model

- Artificial NNM
  - McCullock & Pitts(1943) :
    - The model of neuron
  - Hebb(1949) :
    - Learning hypothesis :
      - Number of impulses = Learning
    - Formation of recognition and memory
- Connection type of neuron
  - Feed-Forward Type : simplex
  - Non-hierarchical Type (mutual link) : duplex
- From the statistical point of view :
  - One method of non-linear multivariate analysis or classification method
  - Parameter estimation <===> Learning


他のニューロンからの
信号を受容する部位
他のニューロンへ
信号を出力する部位
シナプス
樹状突起
情報処理を
行う部位
シナプス
細胞体
活動電位を
生成する部位
軸索小丘
活動電位の
能動伝送路
軸索
機能モデル

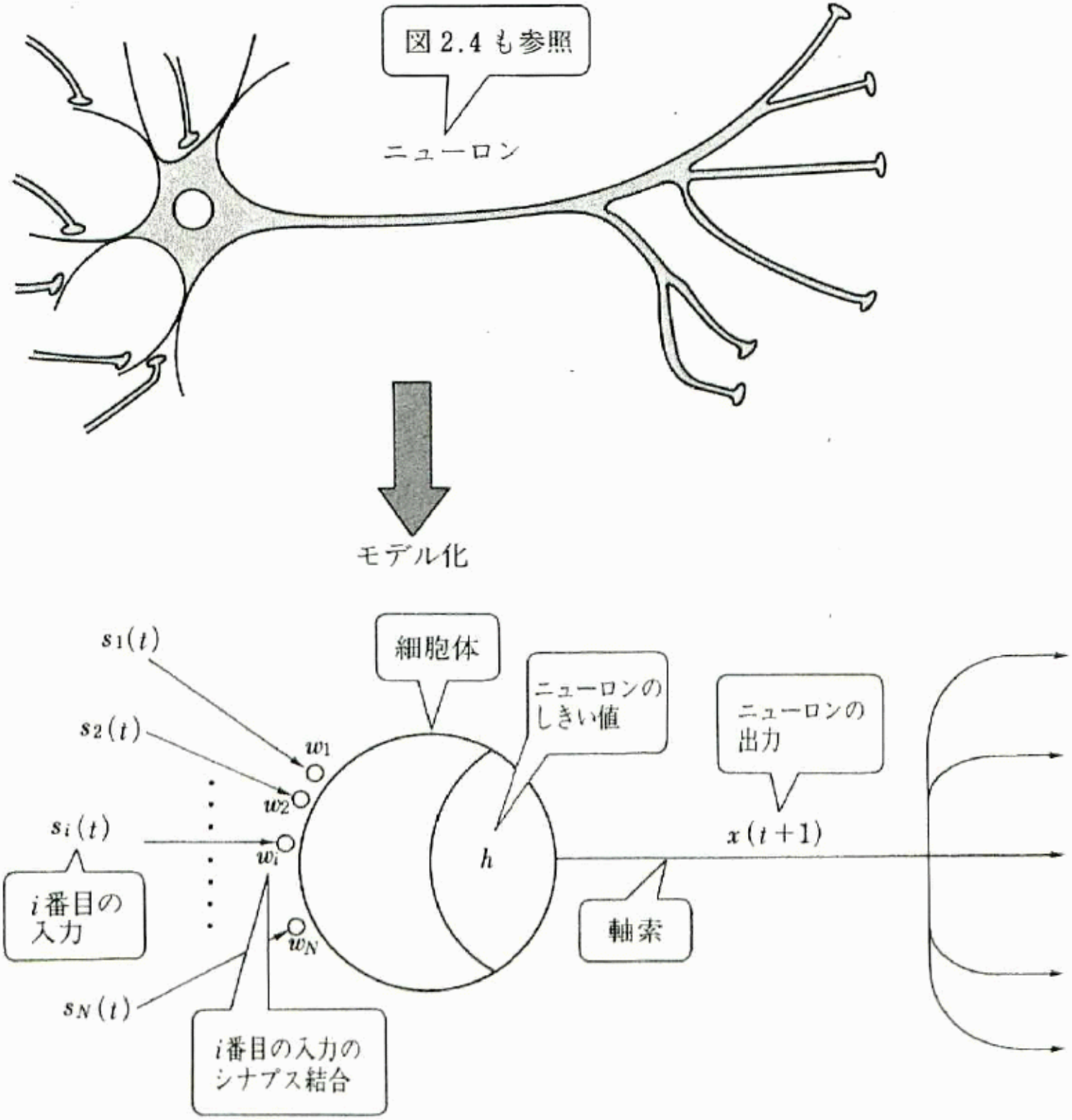


図 2.4 も参照
ニューロン
モデル化
$s_1(t)$
$s_2(t)$
$s_i(t)$
$s_N(t)$
w_1
w_2
w_i
w_N
細胞体
ニューロンの
しきい値
h
ニューロンの
出力
$x(t+1)$
軸索
i番目の
入力
i番目の入力の
シナプス結合

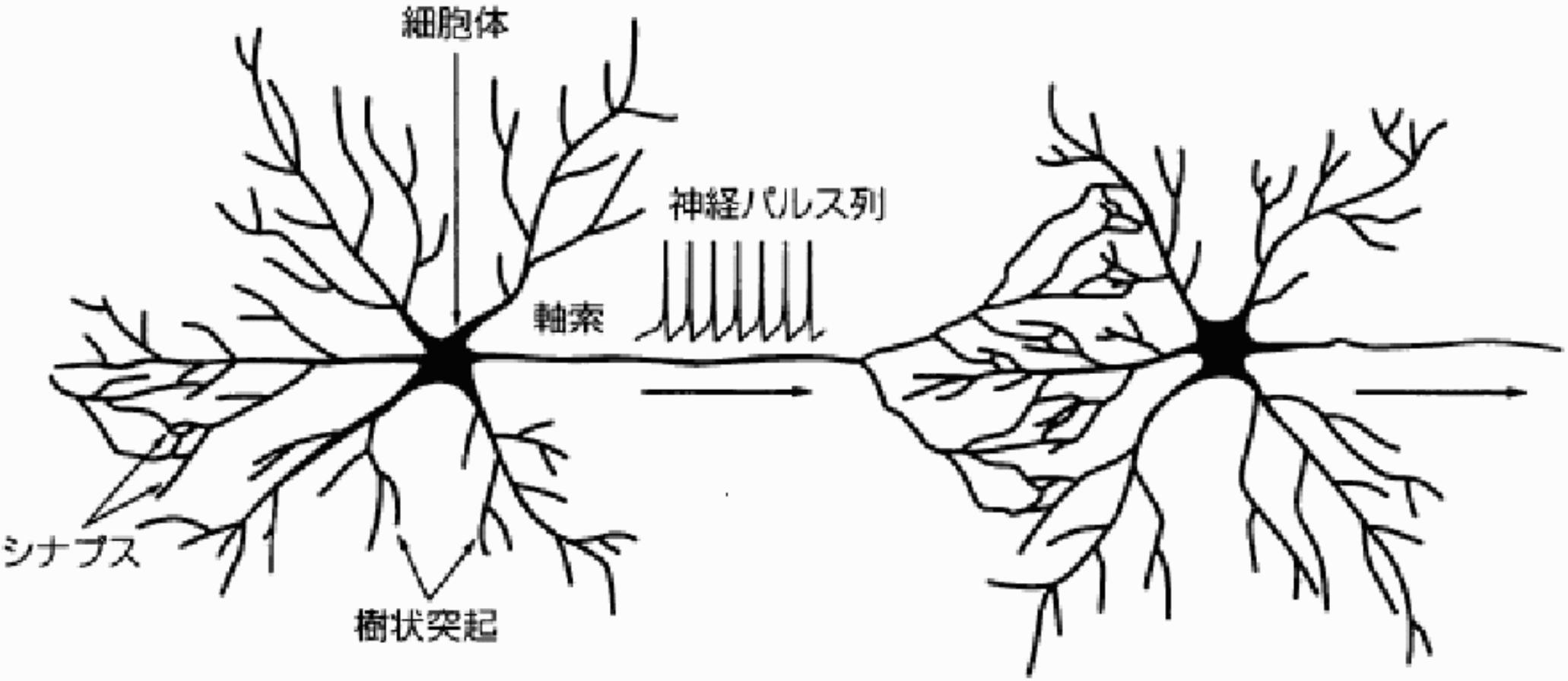


図１：単体ニューロンの概略図

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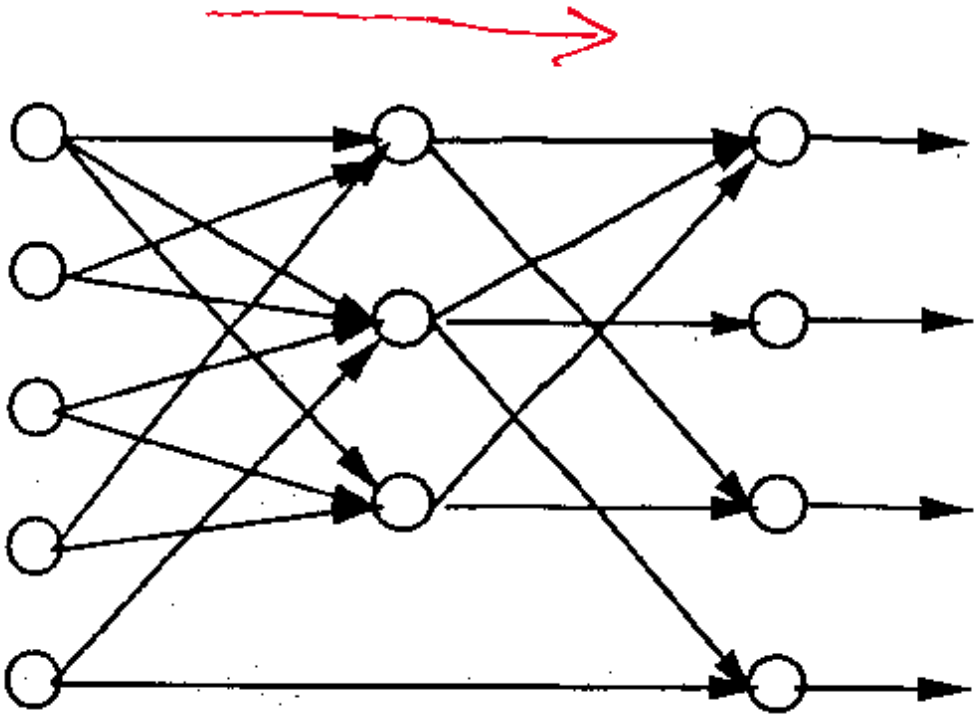
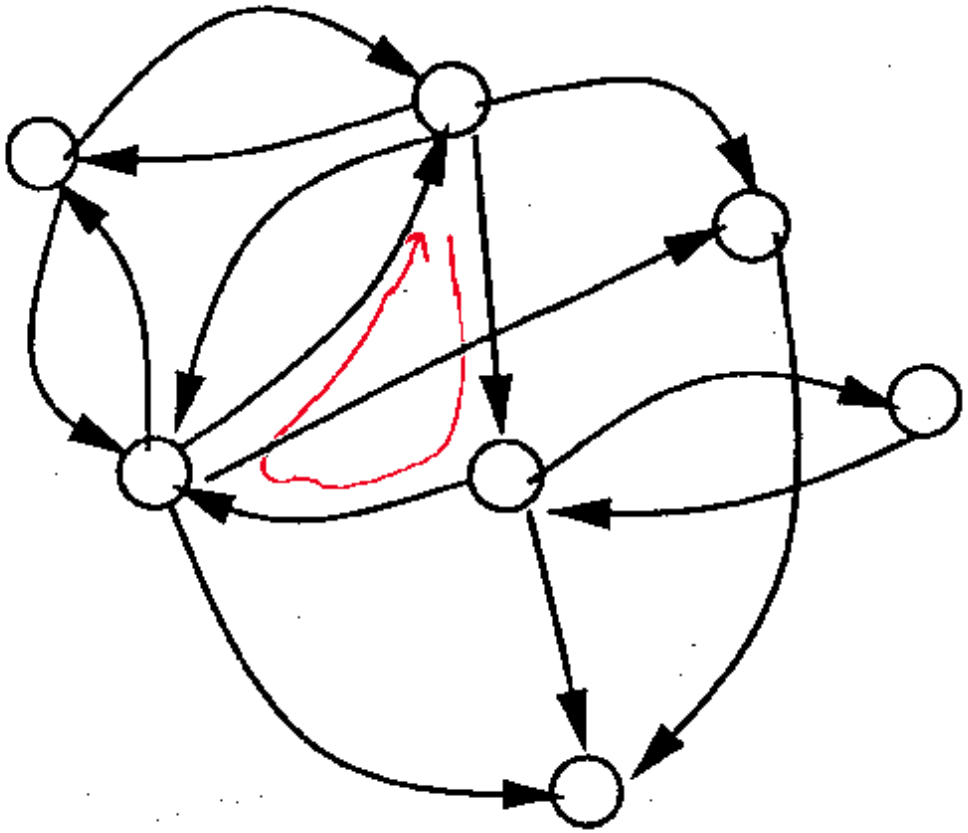


(a) 階層的ネットワーク

Feed-Forward Type



(b) 相互結合ネットワーク

Non-hierarchical Type

- Feed-Forward NNM
  - simple formula
  - can adapt non-linear relations
  - number of layers
  - linkage functions between units
  - search of optimal weights = learning
- Attractive points <== computers power
  - 「Simple formula but powerful expression」
  - 「Learning」
- Learning algorithm
  - Back Propagation(BP) method
  - A kinds of steepest descent method
  - Avoidance of Local convergence problems

3.Feed-Forward NN Model

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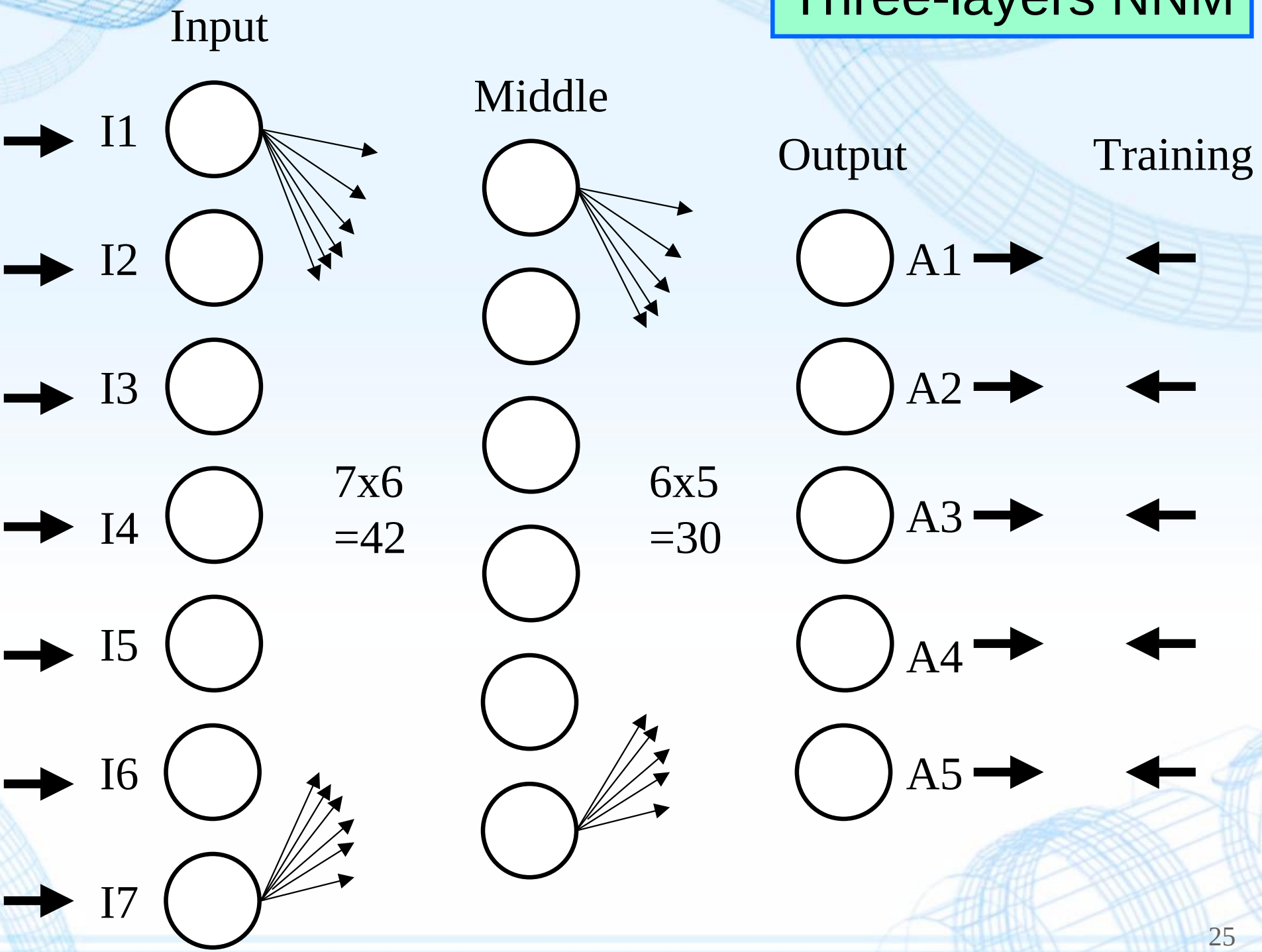
5.Comparison Study

- Subject matter
  - fraction addition problems
  - 7 items and 5 Attributes,
  - 595 Cases of Item Response Patterns
- Comparison
  - Focusing on the structure of NNM and Knowledge States in the RSM.
- Three-layers NNM <===> KS in RSM
  - input layer <=== items
  - output layer <=== Attributes
  - middle layer ===> KS?
- Several numerical examples

Three-layers NNM



- Step 1 : construct NN

  Item ==> Middle ==> Attribute
  - Number of units in middle layer : 5, 6, 7
  - Behavior of middle layer
  - Middle layer : Same structure with Incidence matrix

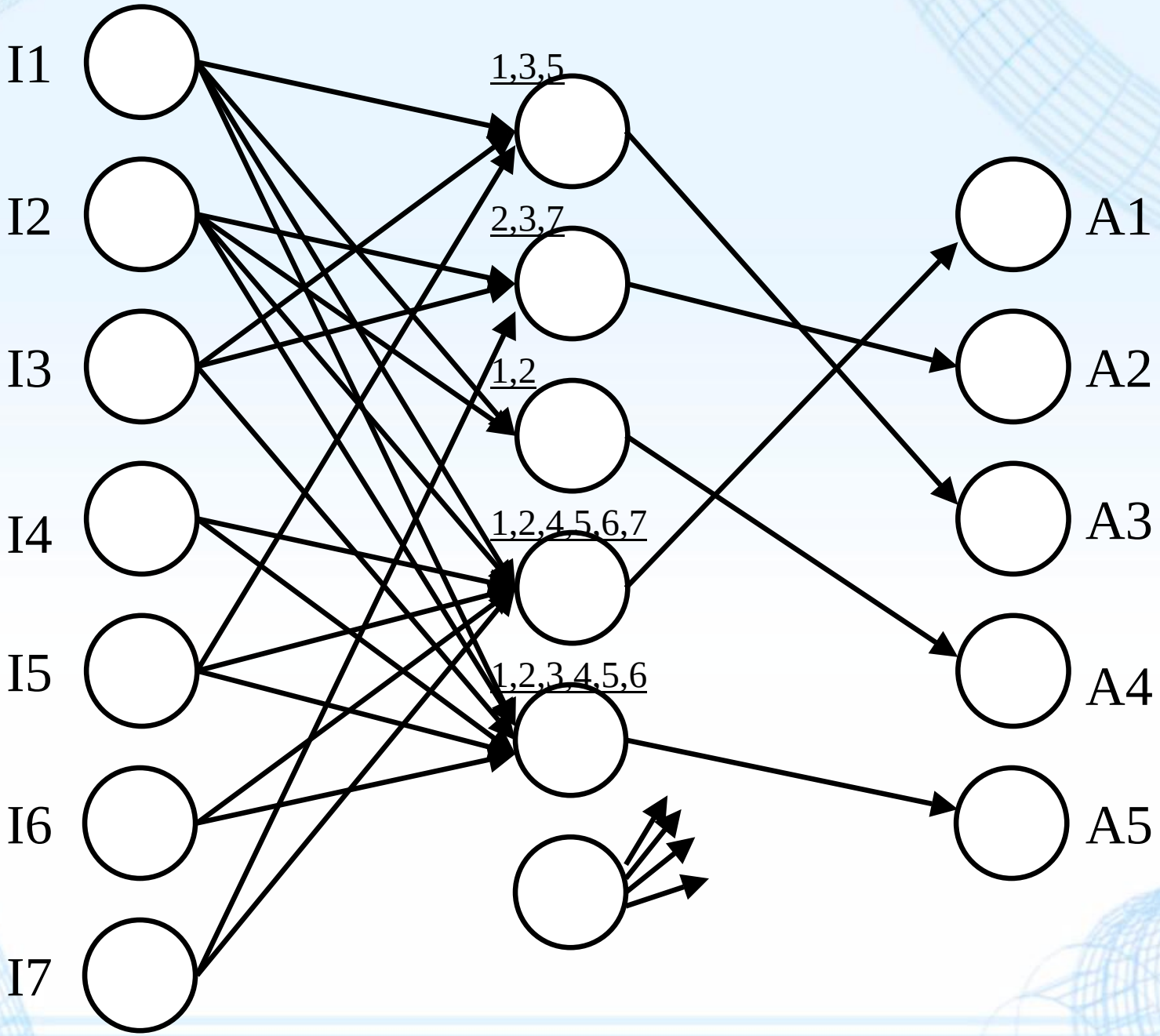
- Step 2 : validity check

  # of Training Set + # of Validation Set = 595 cases
  - High re-predictive structure
  - Stable

- Step 3 : KS for middle layer

  Item ==> Middle ==> Prob. of Attribute from RSM
  - Behavior of middle layer

  - found close similarities in their results
  - although they were not identical
  - can not find the clear relation


I1
I2
I3
I4
I5
I6
I7
1,3,5
2,3,7
1,2
1,2,4,5,6,7
1,2,3,4,5,6
A1
A2
A3
A4
A5

Incidence Matrix

Attributes	Items I1	I2	I3	I4	I5	I6	I7
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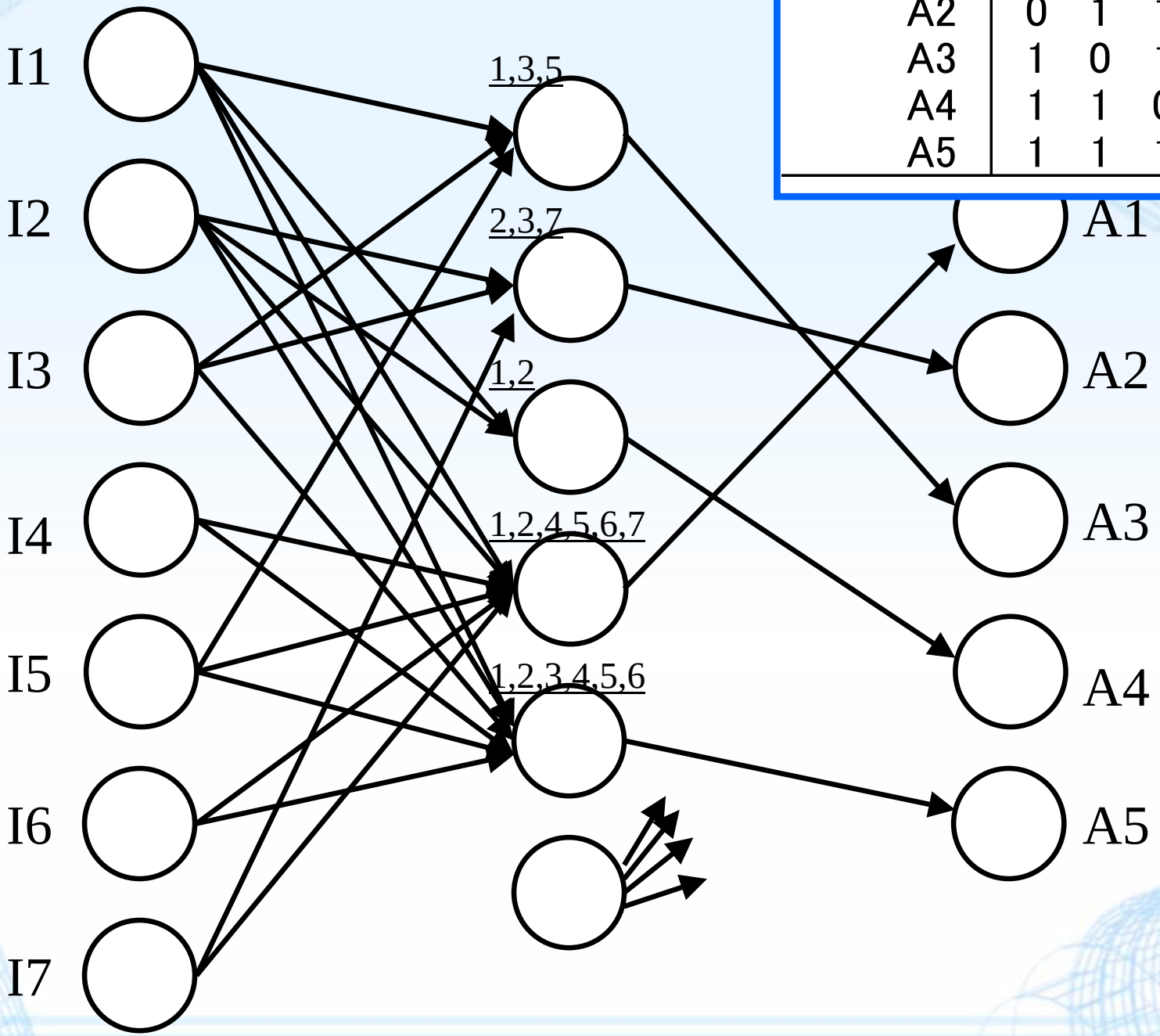

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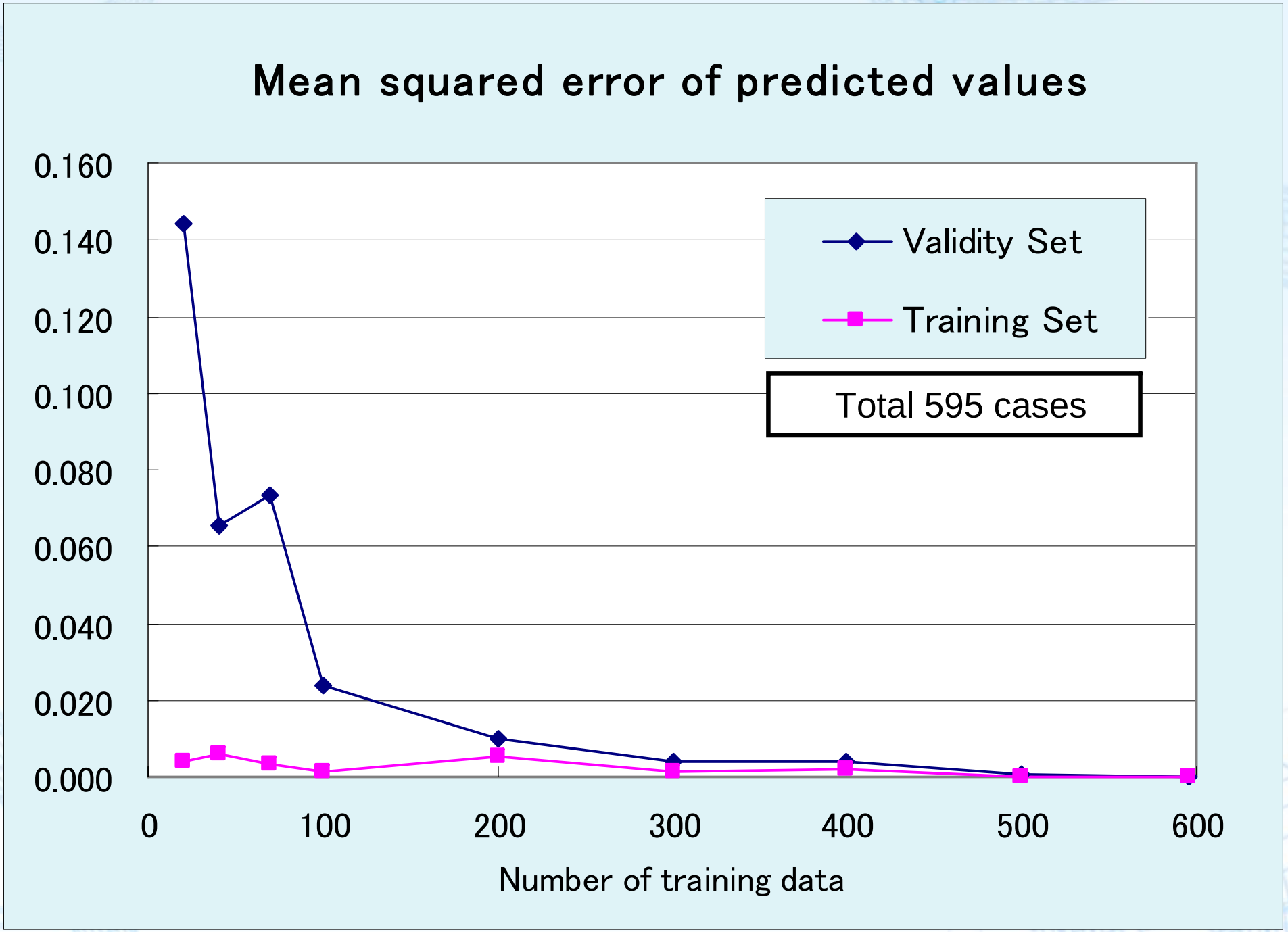
Mean squared error of predicted values
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
100
200
300
400
500
600
Number of training data
Validity Set
Training Set
Total 595 cases

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4.Science Reasoning Test (SR-Test)

- An entrance examination test
  - student's interpretation, analysis, evaluation, reasoning, and problem-solving skills
- A set of multiple choice questions
- Problem-solving skills from containing information <==> ordinary test
  - Do not need knowledge about it’s information
  - Pick out some from containing information
- Providing style of scientific information
  - 3types

ACTの試験

- AAP ： ACT Assessment Program
  - 非営利法人 ACT，Inc．が提供
    (American College Testing, Inc.)
  - 教科カリキュラムに基づくテスト
  - 英語 ： 70問(45分)
  - 数学 ： 60問(60分)
  - 読解 ： 40問(35分) (reading comprehension)
  - Science Reasoning Test ： 40問(35分)
- 多肢選択型設問

試験問題の特徴

- 自然科学分野の論理思考に関する能力
- 受験者の問題解決特性を把握する試験
- 自然科学に必要な判断能力、分析能力、評価能力、論理性、問題解決能力を測る
- 個々の Passage（大問）
  - 科学的な情報を提示する資料部分
  - それに続く幾つかの多肢選択式の設問群

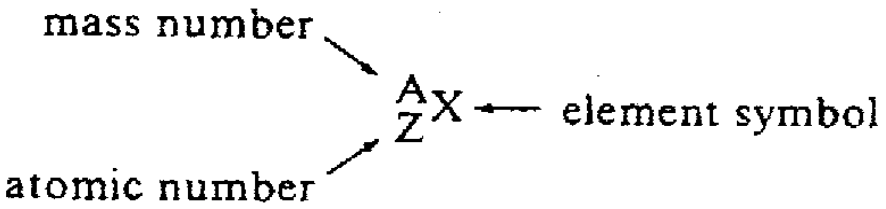
Scientific information

- Data representation
  - Graphic, tabular material
  - graph reading, interpretation of scatter plots, and interpretation of information
- Research summaries
  - one or more related experiments
  - interpretation of experimental results
- Conflicting viewpoints
  - several hypotheses or views
  - being based on differing premises or on incomplete data, are inconsistent with one another
  - understanding, analysis, and comparison of alternative viewpoints or hypotheses.

Data representation

Passage 1

All atoms of a given element have the same number of protons (positively charged particles) in the nucleus and electrons (negatively charged particles) in the surrounding space. This number is called the atomic number, symbolized by Z. The mass of an atom is the m number, symbolized by A. The mass number is found by adding the number of protons and neutrons (neutral, uncharged, particles) in the nucleus.



Isotopes are atoms of the same element having the same atomic number but different mass numbers. The stable isotopes of some common elements and their abundance are shown in the following table.

元素周期表：a periodic table

atomic number (Z)																
1	Hydrogen H	99.9 %	0.1 %													
2	Helium He				100 %											
3	Lithium Li					7.5 %	92.5 %									
4	Beryllium Be								100 %							
5	Boron B									20 %	80 %					
6	Carbon C											99 %	1 %			
7	Nitrogen N													99.6	0.4	

Passage 2

A scientist wanted to determine how sunshine and temperature influence the development of a tree branch.

Experiment 1

During the spring, a mature pine tree located on the south slope of a mountain was selected. One of its branches was tightly enclosed in a clear plastic bag. For a 24-hour period, air was drawn into the bag and exhausted hourly, so the carbon dioxide (CO_2) content of the air inside and outside the bag could be measured. A nearby device measured the sunlight intensity in Langleys per minute and air temperature in centigrade (°C). Temperatures ranged from a low of 2° C between 9 P.M. and 6 A.M. and rose to a maximum of 18° C between 11 A.M. and 2 P.M. It was noticed that the diameter of the branch decreased toward a minimum, which remained constant between 10 A.M. and 4 P.M., and increased to a maximum, which remained constant between 9 P.M. and 7 A.M. The sunlight intensity readings are shown in Figure 1 and the CO_2 exchange readings in Figure 2.

(Note: Positive CO_2 readings indicate emission; negative readings indicate absorption.)

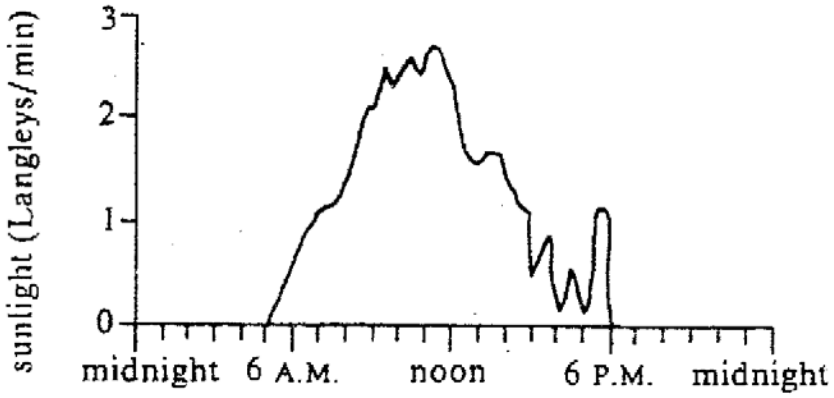


Figure 1

Experiment 2

Experiment 1 was repeated on the same tree branch, except the readings were taken during a 24-hour period during autumn. The temperature ranged from a low of −1° C between 6 P.M. and 6 A.M., to a high of 17° C between 9 A.M. and 2 P.M. The diameter of the tree branch decreased to a minimum value, which remained constant between 1 P.M. and 5 P.M., then increased to a maximum, which remained constant between 10 P.M. and 8 A.M. The sunlight intensity readings are shown in Figure 3 and the CO_2 readings in Figure 4.

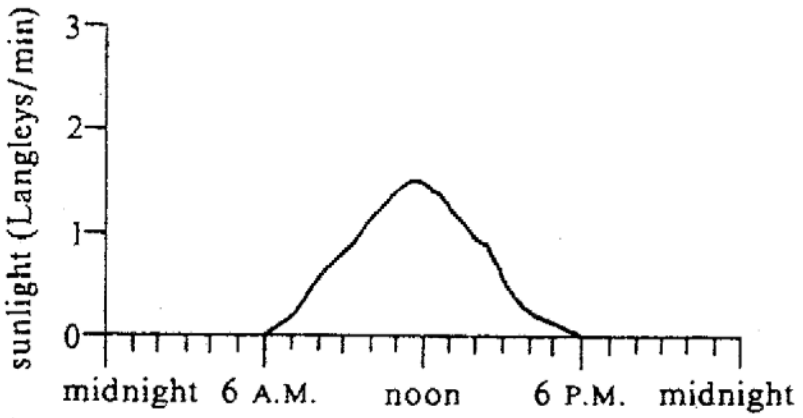


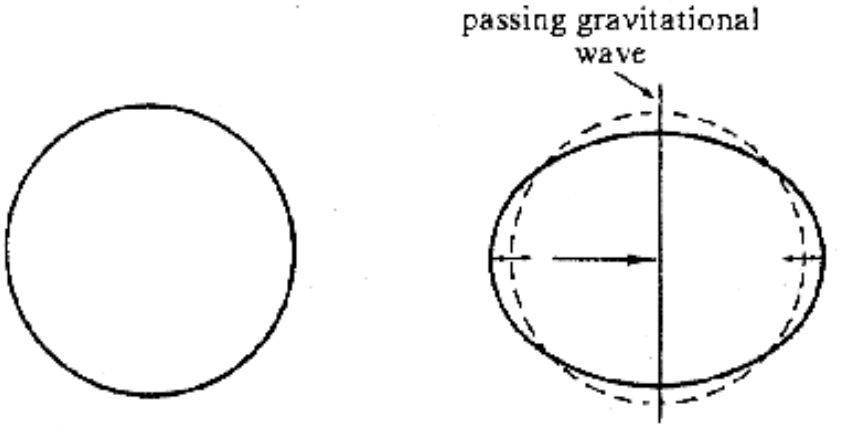
Figure 3

Conflicting viewpoints

Passage 4

Gravitation is the attractive force that all masses exert on other masses. It increases as the masses of the attracting objects increase. However, when large stars explode or undergo rapid changes in motion, gravitational radiation is emitted. Gravitational radiation moves away from its source at the speed of light (3×10^5 km/sec) as ripples or waves traveling through the otherwise smooth gravitational field of space. This is similar in concept to the way water waves travel along the otherwise smooth liquid surface.

However, gravitational waves are special because as they pass, they cause matter to distort as shown below.

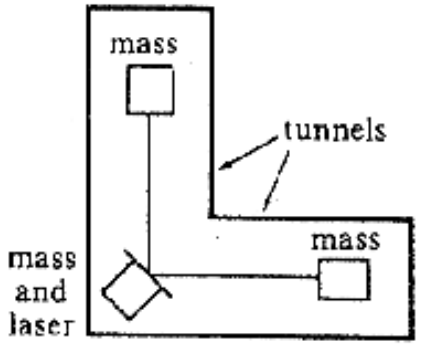


Since gravitational waves are extremely weak and therefore hard to detect, two physicists discuss alternative methods of detecting them.

Physicist 1

Physicist 2

Since the energy in traveling gravitational waves is so low, a very long antenna is needed to detect them. Lasers will be used to detect the changes in distance between locations in an L-shaped antenna, as shown below. Detection of gravitational waves will be possible because as they pass through the antenna, the lengths of the tunnels will change by different amounts.



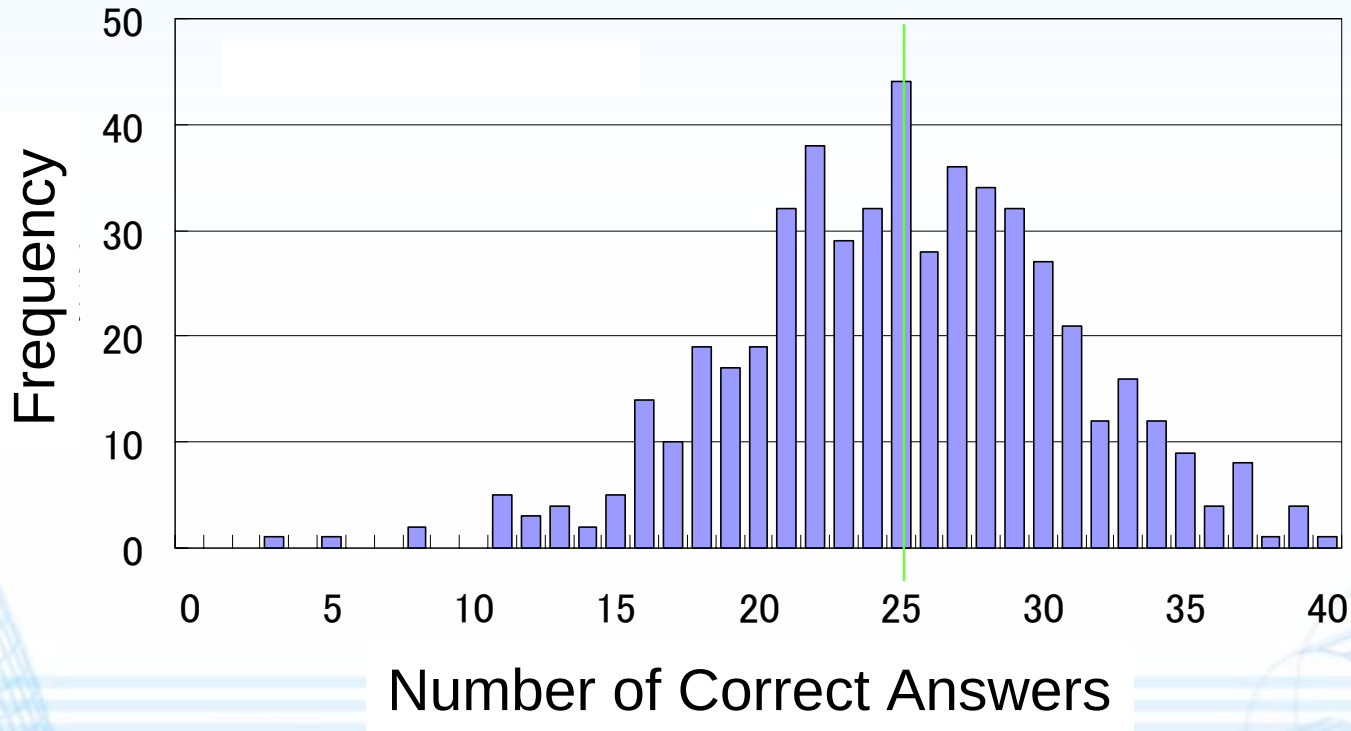
Because this antenna is not a vibrating cylinder, it will be 1,000 times more sensitive than Physicist 1's antennas. In addition, like water waves, different gravitational waves have different wavelengths. Physicist 1's vibrating cylinder antennas can only detect gravitational waves that have a few specific wavelengths. The antenna will be able to detect gravitational waves with a wide range of wavelengths.

D1. According to Physicist 2, Physicist 1's antenna is ineffective because it is:

F. not properly shielded from Earth vibrations.
G. not sensitive enough.

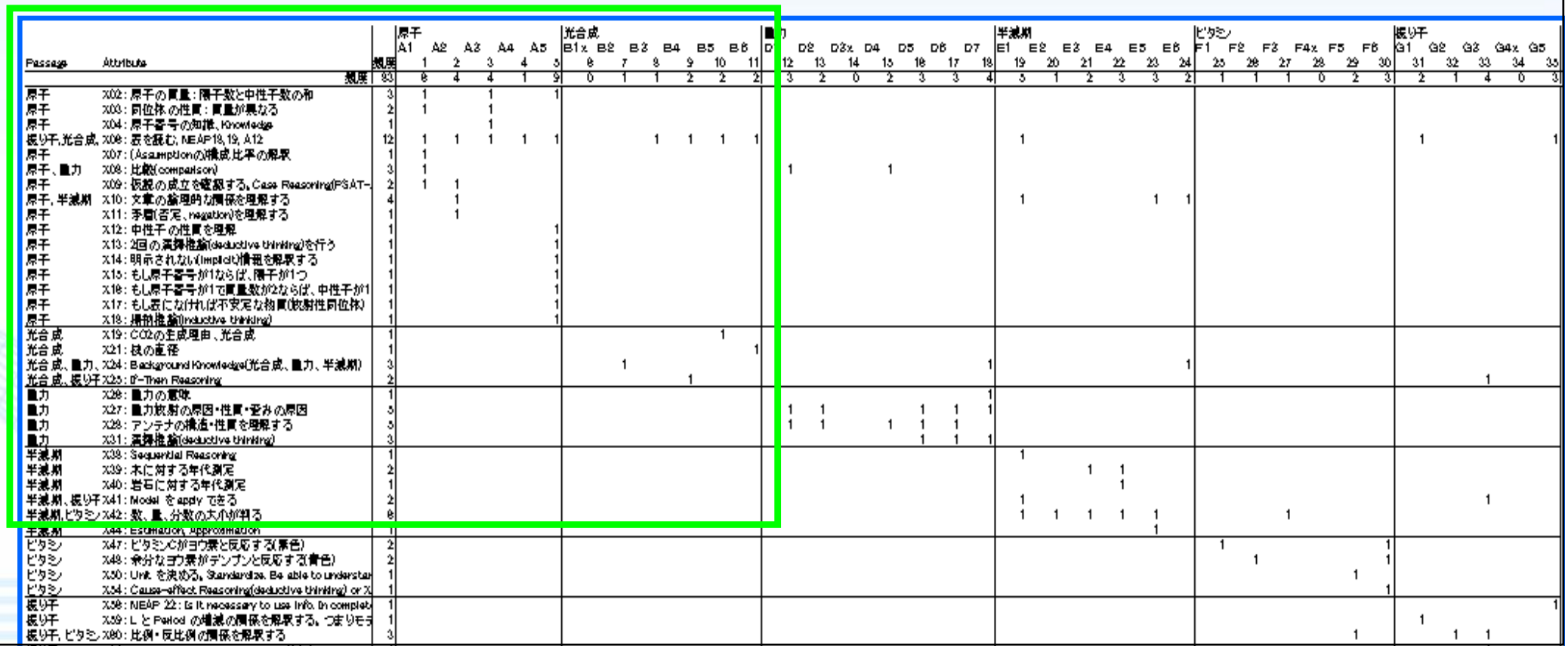
5. Numerical Example

- **7 Passages (Total 40 Items)**
- **286** first-year students of Univ.
- **45 minutes**
- **Distribution Of Correct Answers**
  - **Almost Symmetrical Distribution**



An example of Incidence Matrix

- Task Analysis :
  - Extraction of Attribute, refining
  - Domain Expert of these subject, teacher
- Reducing : Number of Attributes : 80 → 39



Passage	Attribute	頻度	原子 A1	A2	A3	A4	A5	光合成 B1x	B2	B3	B4	B5	B6	重力 D	D2	D3x	D4	D5	D6	D7	半減期 E1	E2	E3	E4	E5	E6	ビタミン F1	F2	F3	F4x	F5	F6	振り子 G1	G2	G3	G4x	G5
	頻度	93	6	4	4	1	9	0	1	1	2	2	2	3	2	0	2	3	3	4	5	1	2	3	3	2	1	1	1	0	2	3	2	1	4	0	3
原子	X02：原子の質量：陽子数と中性子数の和	3	1		1		1																														
原子	X03：同位体の性質：質量が異なる	2	1		1																																
原子	X04：原子番号の知識、Knowledge	1			1																																
振り子,光合成,	X06：図を読む, NEAP 18, 19, A12	12	1	1	1	1	1			1	1	1	1								1												1				1
原子	X07：(Assumptionの)構成比率の解釈	1	1																																		
原子、重力	X08：比較(comparison)	3	1												1			1																				
原子	X09：仮説の成立を確認する, Case Reasoning(PSAT-	2	1	1																																	
原子, 半減期	X10：文章の論理的な関係を理解する	4		1																	1				1	1											
原子	X11：手順(否定、negation)を理解する	1		1																																	
原子	X12：中性子の性質を理解	1					1																														
原子	X13：2回の演繹推論(deductive thinking)を行う	1					1																														
原子	X14：明示されない(implicit)情報を解釈する	1					1																														
原子	X15：もし原子番号が1ならば、陽子が1つ	1					1																														
原子	X16：もし原子番号が1で質量数が2ならば、中性子が1	1					1																														
原子	X17：もし炭になければ不安定な物質(放射性同位体)	1					1																														
原子	X18：帰納推論(inductive thinking)	1					1																														
光合成	X19：CO2の生成理由、光合成	1										1																									
光合成	X21：枝の直径	1											1																								
光合成、重力、	X24：Background Knowledge(光合成、重力、半減期)	3							1											1						1										
光合成、振り子	X25：If-Then Reasoning	2									1																								1		
重力	X26：重力の意味	1																		1																	
重力	X27：重力放射の原因・性質・歪みの原因	5													1	1			1	1	1																
重力	X29：アンテナの構造・性質を理解する	5													1	1		1	1	1																
重力	X31：演繹推論(deductive thinking)	3																	1	1	1																
半減期	X38：Sequential Reasoning	1																			1																
半減期	X39：木に対する年代測定	2																					1	1													
半減期	X40：岩石に対する年代測定	1																						1													
半減期、振り子	X41：Model を apply できる	2																			1														1		
半減期,ビタミン	X42：数、量、分数の大小が判る	6																			1	1	1	1	1				1								
半減期	X44：Estimation, Approximation	1																							1												
ビタミン	X47：ビタミンCがヨウ素と反応する(黒色)	2																									1					1					
ビタミン	X48：余分なヨウ素がデンプンと反応する(青色)	2																										1				1					
ビタミン	X50：Unit を決める, Standardize, B4 able to understar	1																													1						
ビタミン	X54：Cause-effect Reasoning(deductive thinking) or X	1																														1					
振り子	X58：NEAP 22：Is it necessary to use Info. in complet	1																																			1
振り子	X59：L と Period の増減の関係を解釈する。つまりモ	1																															1				
振り子, ビタミン	X60：比例・反比例の関係を解釈する	3																													1			1	1		

Passage	Attribute	頻度	原子 A1		A2		A3		A4		A5	光合成 B1x		B2		B3		B4		B5		B6		重力 D1	D
			1		2		3		4		5	6		7		8		9		10		11		12	
	頻度	83	6		4		4		1		9	0		1		1		2		2		2		3	
原子	X02：原子の質量：陽子数と中性子数の和	3	1				1				1														
原子	X03：同位体の性質：質量が異なる	2	1				1																		
原子	X04：原子番号の知識、Knowledge	1					1																		
振り子,光合成,	X06●表を読む, NE18,19, A12	12	1		1		1		1		1					1		1		1		1			
原子	X07：(Assumptionの)構成比率の解釈	1	1																						
原子、重力	X08：比較(comparison)	3	1																				1		
原子	X09：仮説の成立を確認する。Case Reasoning(P	2	1		1																				
原子, 半減期	X10●文章の論理的な関係を理解する	4			1																				
原子	X11：矛盾(否定、negation)を理解する	1			1																				
原子	X12：中性子の性質を理解	1									1														
原子	X13：2回の演繹推論(deductive thinking)を行う	1									1														
原子	X14：明示されない(implicit)情報を解釈する	1									1														
原子	X15：もし原子番号が1ならば、陽子が1つ	1									1														
原子	X16：もし原子番号が1で質量数が2ならば、中性	1									1														
原子	X17：もし表になければ不安定な物質(放射性同	1									1														
原子	X18：帰納推論(inductive thinking)	1									1														
光合成	X19：CO2の生成理由、光合成	1																	1						
光合成	X21：枝の直径	1																			1				
光合成、重力、	X24：Background Knowledge(光合成、重力、半減	3												1											
光合成、振り子	X25：If-Then Reasoning	2																1							
重力	X26：重力の意味	1																							
重力	X27：重力放射の原因・性質・歪みの原因	5																					1		
重力	X28：アンテナの構造・性質を理解する	5																					1		
重力	X31●演繹推論(deductive thinking)	3																							
半減期	X38：Sequential Reasoning	1																							
半減期	X39：木に対する年代測定	2																							
半減期	X40：岩石に対する年代測定	1																							
半減期、振り子	X41：Modelを applyできる	2																							
半減期,ビタミン	X42：数、量、分数の大小が判る	6																							
半減期	X44：Estimation, Approximation	1																							
ビタミン	X47：ビタミンCがヨウ素と反応する(無色)	2																							
ビタミン	X48：余分なヨウ素がデンプンと反応する(青色)	2																							
ビタミン	X50：Unitを決める。Standardize. Be able to und	1																							
ビタミン	X54：Cause-effect Reasoning(deductive thinking	1																							
振り子	X56：NE 22：Is it necessary to use info. In comp	1																							
振り子	X59：Lと Periodの増減の関係を解釈する。つま	1																							
振り子,ビタミン	X60：比例・反比例の関係を解釈する	3																							
振り子	X64：Quantitative and logical reading(A15)	1																							
振り子	X65：Executive Control or Management(A17)	1																							

Passage	Attribute	頻度	原子 A1 1	A2 2	A3 3	A4 4	A5 5	光合成 B1x 6	B2 7	B3 8
	頻度	83	6	4	4	1	9	0	1	1
原子	X02：原子の質量：陽子数と中性子数の和	3	1		1		1			
原子	X03：同位体の性質：質量が異なる	2	1		1					
原子	X04：原子番号の知識、Knowledge	1			1					
振り子,光合成,	X06：表を読む, NE18,19, A12	12	1	1	1	1	1			1
原子	X07：(Assumptionの)構成比率の解釈	1	1							
原子、重力	X08：比較(comparison)	3	1							
原子	X09：仮説の成立を確認する。Case Reasoning(P	2	1	1						
原子, 半減期	X10：文章の論理的な関係を理解する	4								
原子	X11：矛盾(否定、negation)を理解する	1								
原子	X12：中性子の性質を理解	1								
原子	X13：2回の演繹推論(deductive thinking)を行う	1								
原子	X14：明示されない(implicit)情報を解釈する	1								
原子	X15：もし原子番号が1ならば、陽子が1つ	1					1			
原子	X16：もし原子番号が1で質量数が2ならば、中性	1								
原子	X17：もし表になければ不安定な物質(放射性同位	1								
原子	X18：帰納推論(inductive thinking)	1					1			
光合成	X19：CO2の生成理由、光合成	1								
光合成	X21：枝の直径	1								
光合成、重力、	X24：Background Knowledge(光合成、重力、半減	3								
光合成、振り子	X25：If-Then Reasoning	2								
重力	X26：重力の意味	1								
重力	X27：重力放射の原因・性質・歪みの原因	5								
重力	X28：アンテナの構造・性質を理解する	5								
重力	X31：演繹推論(deductive thinking)	3								
半減期	X38：Sequential Reasoning	1								
半減期	X39：木に対する年代測定	2								
半減期	X40：岩石に対する年代測定	1								
半減期、振り子	X41：Model を apply できる	2								
半減期,ビタミン	X42：数、量、分数の大小が判る	6								
半減期	X44：Estimation, Approximation	1								
ビタミン	X47：ビタミンCがヨウ素と反応する(無色)	2								

Working with figures, tables and graphs

Case reasoning

Logical relation in sentences

Deductive thinking

A Result of RSM for SR-Test

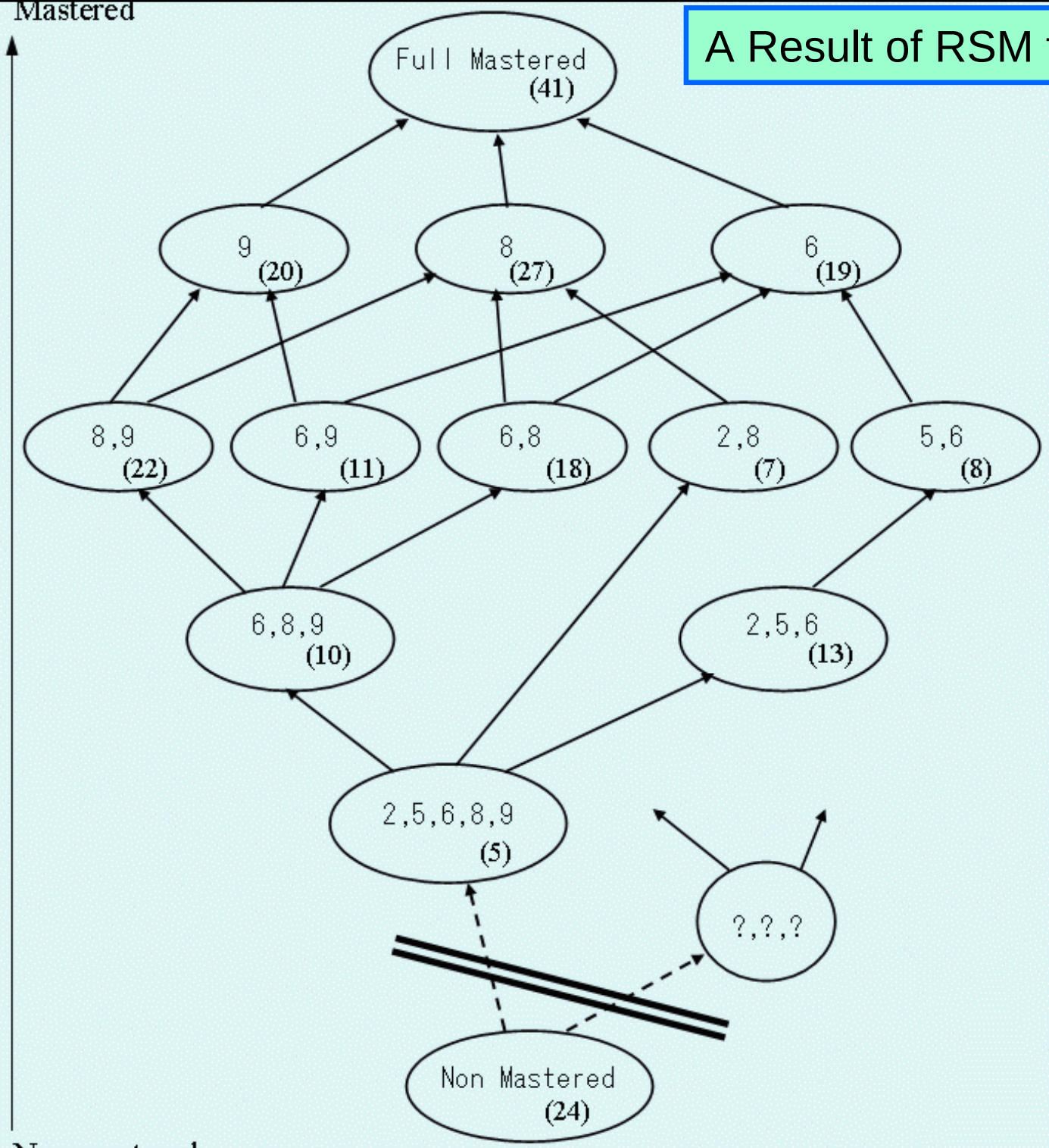


Figure 1 : A tree representation of Knowledge States for the SR-Test data

286名中225名(78.7%)

A Result of RSM for SR-Test

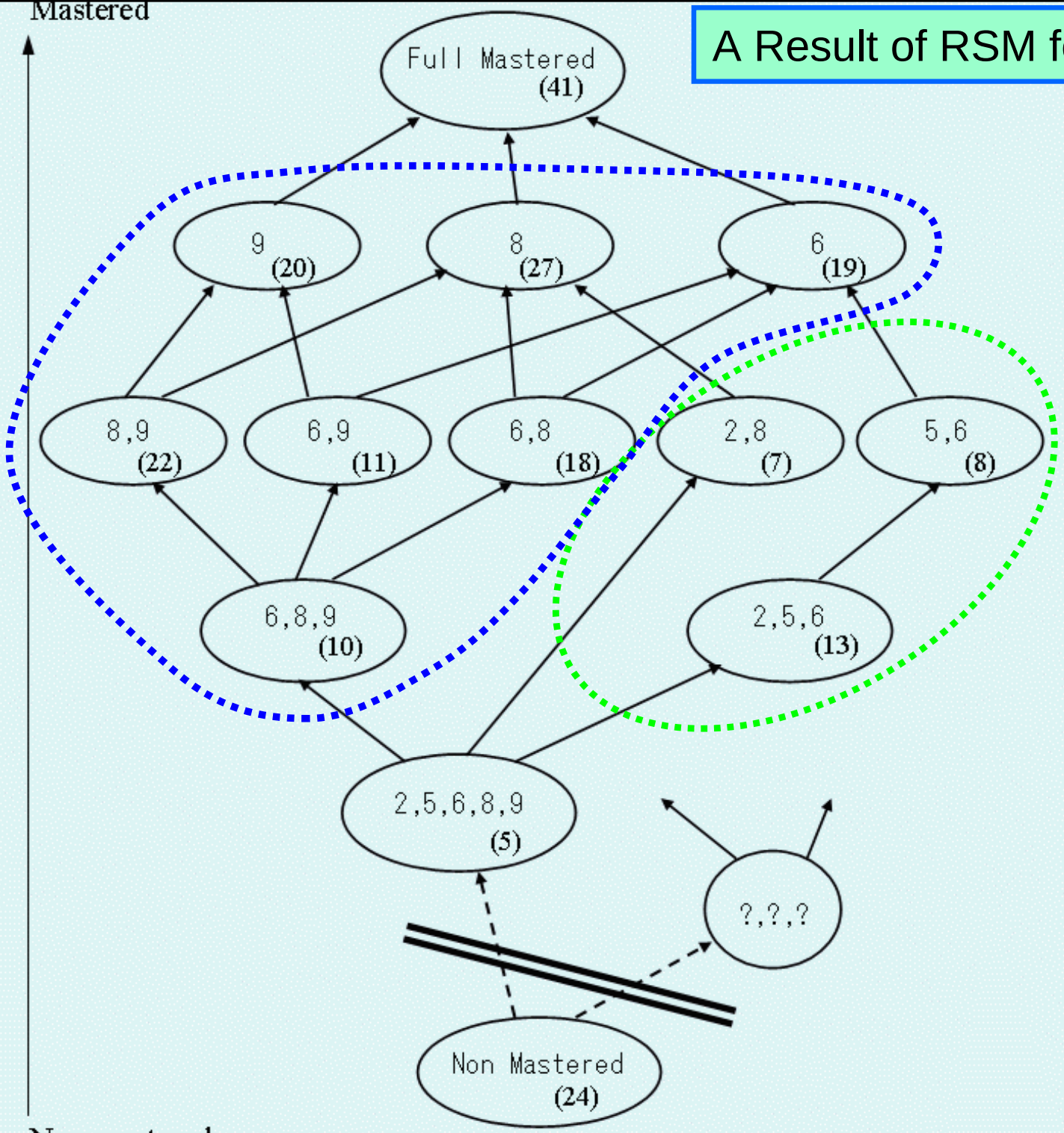


Figure 1 : A tree representation of Knowledge States for the SR-Test data

286名中225名(78.7%)

A Result of RSM for SR-Test

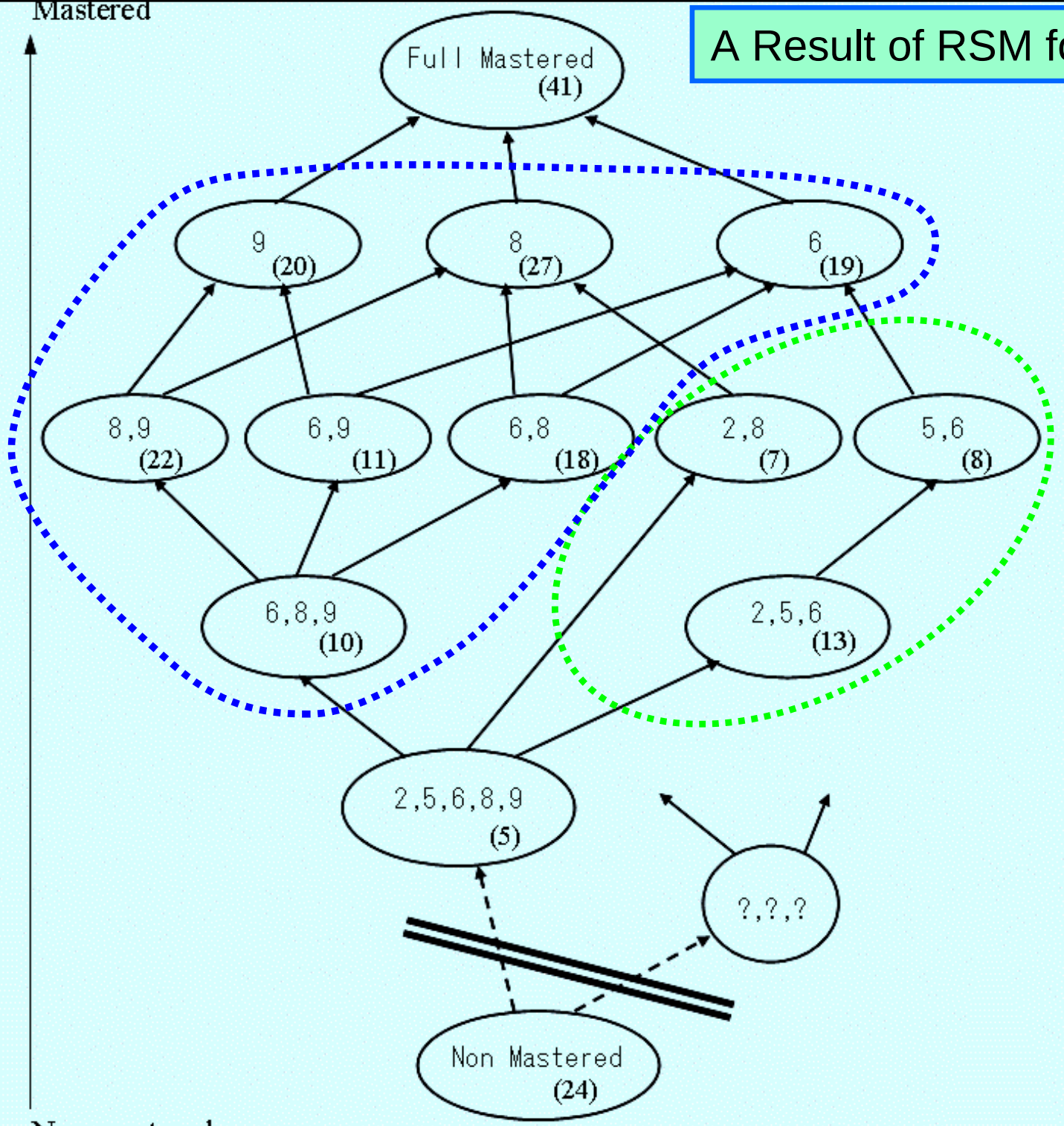


Figure 1 : A tree representation of Knowledge States for the SR-Test data

6: Logical relations in sentences : Consideration
8: If-Then Reasoning : Consideration
9: Understanding about gravitation : Fact

5 : Case reasoning : Consideration
2 : Understanding about isotope : Fact

286名中225名(78.7%)

Rule Space Method

- SR-Test example
  - 3 Key points
    - Logical relations in sentences [6] : Consideration
    - If-Then Reasoning [8] : Consideration
    - Understanding about gravitation [9] : Fact
  - 2 sub-key points
    - Case reasoning [5] : Consideration
    - Understanding about isotope [2] : Fact
- Validation of classification
  - Characteristics in each KS (cluster)
  - Item Response Pattern

Another Application

- **Experimental Project:**
  基礎総合試験（Integrated-type examination）
- **英語、数学、国語(日本語)**
- **60 minutes each**
- **Easier than NCUEE Test**
- **For junior college ===> X**
- **For entered students in University**
- **In 数学 : 3 booklets : J冊子、K冊子、C冊子**

1

小問１　次の計算をせよ。

1. $\{(-3)^2+(-1)^3\}\div(-2)=$ アイ

2. $4\times(0.25-1)^2-(-3)^3\times(1-0.5)^2=$ ウ

3. $-2\times\left(\frac{1}{4}\right)^2\div\left\{(-0.5)^3-\frac{1}{5}\times\left(-\frac{5}{4}\right)^2\right\}=\frac{\text{エ}}{\text{オ}}$

4. $\left(\frac{25}{9}a^3b^3-2a^2b^4\right)\div\left(-\frac{5}{3}a^2b^3\right)=\frac{\text{カキ}}{\text{ク}}a+\frac{\text{ケ}}{\text{コ}}b$

小問2　次の問いに答えよ。

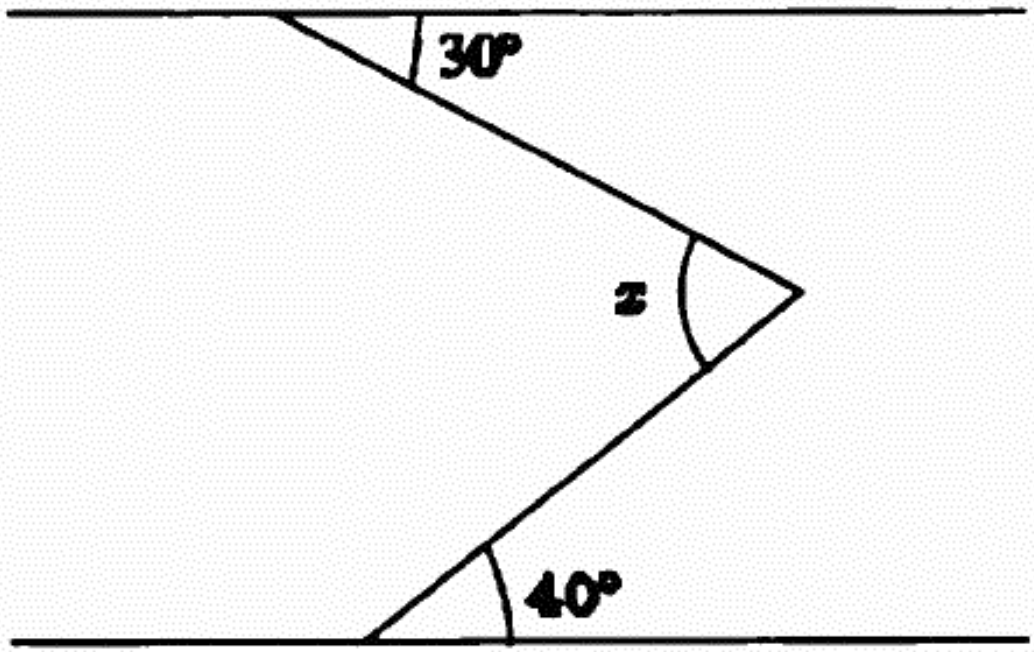
1. 一辺の長さが 1 の正方形 ABCD の対角線の長さ a は $a = \sqrt{\boxed{\text{サ}}}$ である。また、2 次方程式 $8x^2 - 22x + 15 = 0$ の解を $\alpha, \beta(\alpha < \beta)$ とするとき、a と α, β の大小関係は、$\boxed{\text{シ}}$ である。ただし、$\boxed{\text{シ}}$ は以下の選択肢から選択せよ。

① $a < \alpha < \beta$　② $a = \alpha < \beta$　③ $\alpha < a < \beta$　④ $\alpha < \beta = a$　⑤ $\alpha < \beta < a$

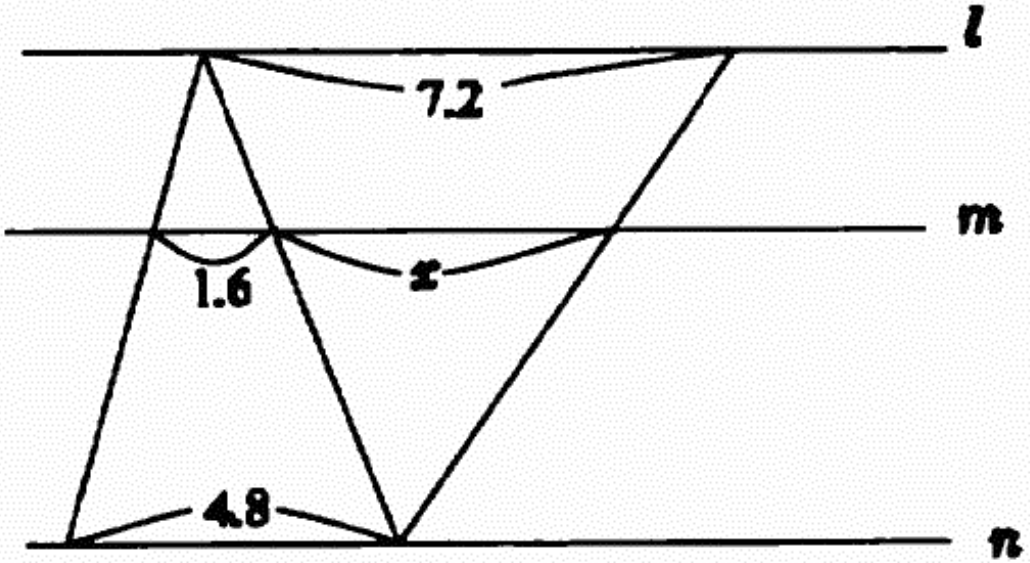
2. $\boxed{\text{ス}}$、$\boxed{\text{セ}}$ の中に、0 から 9 までの整数を入れて次の計算を完成させよ。ただし、同じカタカナは同じ数字を表すものとする。

$$\begin{array}{cccc} & 1 & \boxed{\text{ス}} \\ \times & 4 & \boxed{\text{ス}} \\ \hline \boxed{\text{ス}} & \boxed{\text{セ}} & 9 \end{array}$$

3. 下図の 2 直線は平行である．角 x は［キク］度である．



4. 下図の 3 直線 l, m, n が平行なとき，x の長さは［ケコサ］である．



Attribute（基礎総合試験）
==========

C1 : Basic concepts, properties and operations in whole numbers and integers
C2 : Basic concepts, properties and operations in fractions and decimals
C2' : 無理数 : irrational number
C3 : Basic concepts, properties and operations in elementary algebra
C3' : 根と係数の関係, ルートの値の概数 : advanced algebra
C4 : Basic concepts, properties of two-dimensional Geometry
C4' : 三角法 : trigonometry
C5 : Data and basic statistics
C5' : combinatrix and probability
C6 : Using tools to measure (or estimating) length, time, angle, temperature

P1 : Translate/formulate equations and expression to solve a program
P2 : Computational applications of knowledge in arithmetic and geometry
P3 : Judgmental applications of knowledge in arithmetic and geometry
P4 : Applying rules in algebra
P5 : Logical reasoning -- includes case reasoning, deductive thinking skills, if-then, necessary and s
P5' : Case reasoning
P6 : Problem Search; Analytic Thinking, Problem Restructuring and Inductive Thinking
P7 : Generating, visualizing, and reading Figures and Graphs
P9 : Management of Data and Procedures
P10 : Quantitative and Logical Reading such as "at least", "must" or "less than", "more than", "negativ
P91 : Interpretation : 言い換え

S1' : Number Conversion
S2 : Apply number properties and relationship; number sense/number line
S2' : べキの計算 Exponent : Computaion of Exponent or Logarithm
S3 : Using figures, tables, charts and graphs
S4 : Approximation/Estimation
S5 : Evaluate/Verify/Check Options
S6 : Patterns and relationship (be able to apply inductive thinking skills)
S7 : Using proportional reasoning
S11 : Using words to communicate questions (word problem)

＊ Attribute：基礎総合試験

冊子	J冊子																								K冊子																								C冊子																							
大問	1A				1B			2						3							4				1A					1B			2						4					1							2				3	
設問	1	2	3	4	1a	1b	2	1	2a	2b	2c	3	1	2a	2b	3a	3b	4	1a	1b	2a	2b	3	1	2	3	4	1a	1b	2	1a	1b	2	3	4	5	1a	1b	2a	2b	3	1	2	3	4	5	6	7	1	2	3	4	1	2
C1	1																							1																																			
C2		1	1	1																					1	1																								1	1									
C2’																																																							1					
C3									1																																													1		1	1		
C3’				1		1																				1	1		1																														1
C4					1														1			1						1			1						1			1									1	1		1					
C4’					1																							1																													
C5’								1																																																			
C6																															1																												
P1							1	1					1										1																																					
P2						1				1				1	1	1	1	1			1		1					1	1												1		1		1								1		1						
P3																				1		1																					1		1															
P4				1			1																			1	1		1	1																								1		1	1	1	1
P5							1												1			1				1		1	1						1	1			1																	
P5’											1																																																
P6						1																				1																																
P7																			1						1										1																						
P9							1				1		1									1			1	1														1																	
P10																											1	1																													
P91												1															1	1	1	1																										
S1’		1	1																						1																										1								
S2							1																		1																										1								
S2’	1	1	1																					1	1																											1							
S3							1																								1			1																							
S4																																1																										
S5						1																																																						
S6																		1														1																										
S7													1	1	1	1	1	1				1																																						
S11																			1						1														1																			
Sum	2	3	3	3	2	4	6	2	1	1	2	1	3	2	2	2	2	3	4	1	1	5	1	2	3	3	4	3	4	6	5	5	2	2	1	2	4	1	1	5	1	3	2	4	4	4	4	6	2	2	4	3	4	3

Result: ?

Rule Space Method

- Task Analysis <=== Key point
  - Extraction of Incidence matrix is a very laborious work
  - need experts' intense cooperation
  - require careful investigation
  - solution strategies for each item
- NNM may help the Task Analysis in RSM
  - complementary characteristics

6.Discussion and Conclusions

- relationship
  - the middle layer of NNM
  - the Knowledge States in the RSM
- from the results of these experiments
  - not always same behaviors
    - sometime different
  - But predicted values are close : Validity
  - complementary characteristics
    - each other
- meaning of middle layer in NNM ≠ KS

- Step 4(future) : search new attributes
  - similarities and usefulness
  - supplements weaknesses existing in the RSM
  - for replacing a task analysis required in making Incidence matrixes
  - Assist with NNM?

- Realize the better Scoring Report
- Good educational environment

- Some open problems
  - number of units in middle layer
  - initial values of weight wi and threshold θ
  - local convergence problems in training step
  - interpretation of each parameters and each layers in non-linear relation
  - relation between number of units and time of iteration in training
  - improve of convergence speed
- Some related topics
  - Facet Theory
  - POSA (Partial Order Scalogram Analysis)

End of this Presentation