香港中文大學研究院教育學部
THE CHINESE UNIVERSITY OF HONG KONG
GRADUATE SCHOOL . DIVISION OF EDUCATION

哲學教育碩士論文
Master of Philosophy in Education Thesis

論文題目 Thesis Title: EFFECT OF PRACTICE SCHEDULES ON PROBLEM-SOLVING PERFORMANCE IN GENETIC KNOWLEDGE
訓練程序對遺傳問題解難的效應

撰作語言 Language Used: 英文 English

研究生姓名 Name of Student: 陳慧瑜 Chan Wai Yu

專修範圍 Specialization: 教育心理學 Educational Psychology

論文考試委員會
Thesis Examination Committee

論文導師 Thesis Supervisor	Dr. SIU Ping Kee	蕭炳基 教授
校內委員 Internal Examiner	Dr. LO Lam Fat	盧林發 博士
校內委員 Internal Examiner	Dr. CHAN Wai Ock	陳維鄂 博士
校外委員 External Examiner	Prof. LEONG Che Kan	梁子勤 教授
學部主任 Division Head	Dr. CHUNG Yue Ping	鍾宇平 博士

論文通過日期
Date of Approval: September 2, 1994

EFFECT OF PRACTICE SCHEDULES
ON PROBLEM-SOLVING PERFORMANCE
IN GENETIC KNOWLEDGE

A THESIS

SUBMITTED TO THE FACULTY OF EDUCATION

THE CHINESE UNIVERSITY OF HONG KONG

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF PHILOSOPHY IN EDUCATION PSYCHOLOGY

By

Chan Wai Yu

under the Supervision of

Dr. Siu Ping-Kee

June 1994

THE CHINESE UNIVERSITY OF HONG KONG

GRADUATE SCHOOL - FACULTY OF EDUCATION

Master of Philosophy in education Psychology Thesis

Thesis Title	Effect of Practice Schedules on Problem-Solving Performance in Genetic Knowledge
Language Used	English
Name of Student	Chan Wai Yu
Specialization	Educational Psychology

Thesis Examination Committee

Thesis Supervisor	Dr. Siu Ping-kee
Internal Examiner	Dr. Chan David W.O.
Internal Examiner	Dr. Lo Lam Fat
External Examiner	
Faculty Head	Dr. Lo Leslie

Date of Approval

Acknowledgements

My particular thanks must go to Dr. Siu Ping-Kee, my supervisor, who has been very supportive and encouraging throughout the course of my study. I have learnt from his stimulating ideas and insights. I must gratefully thank him for shaping my thoughts throughout the project. His detailed comments upon every draft of the work have saved me from making mistakes.

I owe a great deal to all my teachers. Any list of debts will necessarily be incomplete, but I would be remiss in failing to thank Dr. David Chan for his comments on the research proposal and the thesis, Dr. Lo Lam Fat for his comments on the thesis, Dr. Rex M. Heyworth for his kindness in sharing his experience and ideas and Mr. Chung Choi Man and Dr. Yau Chan Yuk-ping for their advice on the research proposal.

Finally, I must thank Mr. Wong Chi Fai, Miss Kong Choi Fung, Ms. Wu Lai Mee, Ms. Chiu Yin Mei, Mr. Yip Shu Wing and Mr. Cheung Wai Hung for participating in the research. Very special mention has to be made of the encouragement and help of my brothers Ka Yin and Wai Yin. Besides, the nuture of friendship from Ms. Chung Sin Ling and Ms. Law Yin Kum has also made this intellectual journey an enjoyable experience.

Abstract

The literature review shows that practice schedules may affect problem-solving performances such as acquisition, retention and transfer. In this study, the effect of two practice schedules on the problem-solving performance in high school genetic knowledge was examined. Null hypotheses were set in view of contrasting view points in the literature review. Methodology of cognitive research such as protocol analysis was adopted to investigate the problem-solving procedure in acquisition performance and the problems subjects met in transfer problems.

Two pilot studies which involved the development of practice schedules exercises and written tests were conducted. Seven Form 5 classes from five schools participated in the main study. Half of the students in each class had block practice (practising the same type of problems in each practice session) and the remaining half had random practice (practising two different types of problems randomly appeared in each practice session).

It was found that the block practice group performed better in the immediate acquisition posttests while the random practice group performed better in the immediate and delayed transfer posttest as well as the delayed acquisition posttest. A pretest had been conducted before the practice schedule experiment and the pretest scores had been used to control initial differences among the subjects statistically. The results of statistical analysis indicated that block practice facilitated learning while random practice enhanced retention and transfer.

Protocol analysis in this study revealed that chunking of productions into macroproduction occurred in subjects of both practice groups. Higher level consistency such as consistency in "hierarchical goal structure" (Anderson, 1987) might be enough to produce learning effects that match the ACT* theory.

In this study, as revealed in the protocol, poor performance in lateral transfer was due to the fact the subjects were confined by the typical conditions they learnt during the practice. In problems for lateral transfer, Einstellung effect/ set effect (appling productions learnt in unsuitable situation) was observed in the subjects of the block group.

Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

1. Background to the study

Studies in cognitive psychology in the last century lead to numerous educational reforms (Glaser, 1976; White & Tisher, 1986). There are many prominent examples, like the contribution of the learning taxonomy of Benjamin Bloom to the improvement in the areas of learning curriculum, textbook design and evaluation (Bransford & Vye, 1989; Resnick & Klopfer, 1989). Research focus has been on metacognition and learning strategies. Teachers are now more aware that teaching students how to learn and their instructional methods are equally important (Ahn, Brewer & Mooney, 1992; Ayres, 1993; Barba & Merchant, 1990; Briscoe & LaMaster, 1991; Gagne, 1966; German, 1991; Ploger, 1991; Semb, Ellis & Araujo, 1993; Solso, 1988; Weinstein & Mayer, 1986; White, 1988). Recently, cognitive psychologists are concerned about how students solve problem (e.g. Anderson, 1987; Lavoie, 1991; Palmer & Kimchi, 1986; Tallent, 1993; Wenestam. 1993).

Problem-solving research started with artificial tasks like Tower of Hanoi and games like chess playing (DeGroot, 1965; Ernst & Newell, 1969; Simon & Gilmartin, 1973). Domain general problem-solving strategies such as means-ends analysis, working backward and solving by analogy were discovered. Then domain specific thinking skills, especially in areas of mathematics and physics, have received much attention (e.g. Cratsley, 1991; Gayford, 1989; Gick, 1986; Lock, 1991; Nolan, 1990; Perkins & Salomon, 1989; Resnick & Klopfer, 1989; Stencel, 1991). Cognitive psychologists are trying to explain the learning behaviour during the process of problem solving and there are divided viewpoints (e.g Anderson 1989; Carlson, Sullivan and Schneider, 1989b, 1989c).

In the study of problem solving, learning how to solve a problem (acquisition), remembering the skill and using it again in similar situations (retention) as well as using the skill to solve new problems (transfer) are equally important (Ennals, 1988). Researchers persist in their efforts to identify conditions that allow flexible transfer of learning. A lot of the findings were, however, very disappointing (Bassok, 1990). It was discovered that learning situations (acquisition context) can affect retention and transfer. Although there were a number of studies probing into factors facilitating acquisition as well as retention and transfer (e.g. Catrambone & Holyoak, 1989; Kotovsky & Fallside, 1989; Perkins & Salomon, 1989), much research focused on the learning of motor skills (Shea & Kohl, 1990; Shea & Zimny, 1983); domain general area such as critical thinking skill (e.g. Riesenmy, Mitchell & Hudgins, 1991) or artificial cognitive tasks (Carlson & Lundy, 1992). Still, the most suitable acquisition context, such as the level of consistency during practice, in many domains awaits to be explored (Kramer, Strayer & Buckley, 1990).

In high school biology, students' performance in problem-solving is unsatisfactory, especially in the area of genetics. In A-level Biology, students find genetics the most difficult topic (Johnstone & Mahmound, 1980). Concepts and adequate use of methods were essential in solving genetic problems (Steward & Dale, 1981). Studies of the learning in genetics still focus on two areas: (1) Identifying students' misconcepts and finding instructional methods to correct or avoid them (Brown, 1990; Browning & Lehman, 1988; 1991; Kindfield, 1991; Lawson & Weser, 1990; Macnab, Hansell & Johnstone, 1991; Shemesh & Lazarowitz, 1989; Smith, 1991; Stewart & Maclin, 1990) and (2) developing a model for instruction through distinguishing the differences in thinking processes between successful and unsuccessful genetic problem-solving (Smith, 1988; Smith & Good, 1984; Thomson & Stewart, 1985).

2. Purpose of the study

The purpose of this study was two-fold. First, this study investigates how different levels of consistency in genetic problem-solving practice influence the process of skill acquisition and the process of retention and transfer as measured by achievement tests. Second, it investigates the thinking processes subjects employed in solving different genetic problems.

3. Limitations of the study

This study has the following limitations:

(i) The sample size (264 subjects) was not sufficient for generalization of findings beyond the target sample.

(ii) Random sampling was not possible and intact classes were used. However, subjects in each intact class were randomly assigned into the two experimental groups.

(iii) As typical among the science classes in Hong Kong high schools, it was found that 70% of the subjects were students of the high ability group and only 30% of the subjects were students of the medium and low ability groups. However, subjects in each class were similar in their learning ability.

(iv) Subjects in the protocol interviews were all girls. This further limits the generalization of findings.

(v) With regard to transfer, this study aimed to compare the transfer performance between two practice conditions. Transfer problems did not appear on the pretest of this study. There was no record on the problem solving ability about the transfer problems before the practice schedules. Analysis could not be made on the extent to which the practice affect the transfer.

(vi) Protocol interviews were performed after the practice schedules and the immediate posttest were carried out. Subjects' performance in their first trial of the problem was not known.

4. Significance of the study

High school biology students have a lot of practice on genetic problem-solving before they sit for public examinations. It is reviewed that consistent practice facilitates acquisition and random practice enhances retention and transfer. Yet, the best practice schedule for each ability group is still unknown in genetic problem-solving. This area needs exploration. In order to improve on instructional methods in genetic problem-solving, understanding how students solve genetic problems and what their problems are, will certainly be of help.

At present, the theoretical explanation with respect to the processes in the brain that bring about problem solving behaviour is still debatable. Findings of this research, though limiting in its generalization, may be of help in enriching behaviourial data for further investigations and interpretations.

Chapter II

Review of related literature

1. Definitions of problem and major approaches in problem-solving research

Psychologists have commonly agreed that problems exist in relation to the problem solver's point of view. If a person has a goal and has some obstacles to attain the goal, he is said to have a problem (Duncker, 1945; Gagne, 1985; Newell & Simon, 1972). A problem also exists when someone figures that situation to be in a different state and has not yet found a way to change it (Mayer, 1989). If the human brain is viewed as an information-processing system, a problem can be said to exist when a goal condition in the system cannot be attained without a search process (Gilhooly, 1989). Therefore, it is all agreed that adding one to one is not a problem to a normal adult as the solution can be accessed easily. However, a little child requires cognitive search to find the solution to a simple addition question, so it is a problem to him.

In the studies of problem-solving, four major approaches have been attempted by psychologists. They are: the Gestalt approach, the behavioral (associationist) approach, the psychometric approach and the information processing approach (Greeno, 1978; Mayer, 1983; Rowe, 1985).

Gestalt psychologists like Dunker(1945), Kohler(1927) and Wertheimer(1959) are the pioneers in this area. A problem exists when cognitive representation has gaps and problem solving is the process of cognitive organization to restructure the elements in the problem situation in order to attain the goal. Their studies provide insightful analysis of thinking processes to successors. Behavioral and associationist psychologists, on the other hand, emphasize the need for the problem solver to perform a variety of responses before the problem could be solved. Although problem solving is taken as trial-and-error activities and the behavioral approaches rarely analyze the component structure of the problem-solving performance, (see e.g., Skinner, 1966) conditions that facilitate or hinder problem solving behaviours have been identified (Greeno, 1978).

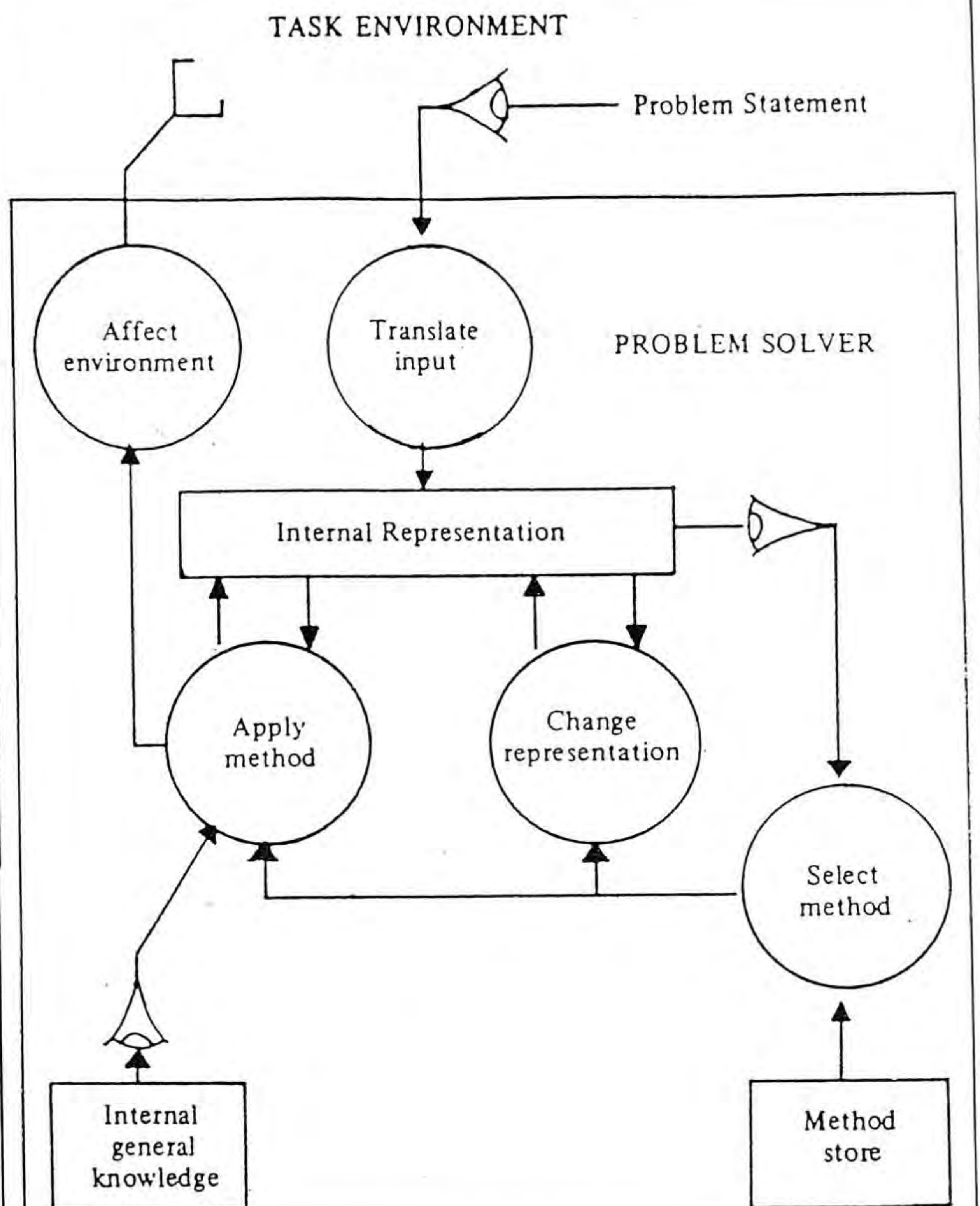
The psychometric research links problem solving behaviour to intelligence factors through correlation models (see e.g. Rowe, 1985). The information processing approach is of more recent origin. It believes that the human mind behaves as an information-processing system when engaged in problem solving. The human brain is conceptualized as capable of manipulating symbols, switching methods and representations, and making decisions (Newell & Simon, 1972). Information-processing psychologists have taken up the detailed analysis of problem solving process that has been originated by Gestalt psychologists in a more vigorous and systemic way. Theories have been put forth in explaining the problem solving performance (Greeno, 1978).

2. Information-processing theory of problem solving

Human information-processing system is subdivided into sensory input unit, central processing unit, motor output unit and memory or storage unit which encompasses a small capacity of short-term memory for input and output and an essentially unlimited capacity of long term memory (Plamer and Kimchi, 1986). Except for the sensory inputs, the system operates serially (Simon, 1978). The problem solving processes are described as an interaction between the information processing system of the problem solver and the task environment. Problem solving processes consist of two major phases: (1) Understanding and representing the problem and (2) solving the problem. First the problem solver tries to understand the problem. This is to encode and translate the structure of the task environment into internal representations which are called problem space. The problem solver then searches for a solution from within this system. Knowledge and procedures are selected and applied adequately toward the goal of solving the problem (Simon, 1978; Mayer, 1989).

Problem space can be analyzed into three components: (1) the initial state which is the starting situation conceived by the problem solver, (2) the operators which are the methods applied in the way of removing the obstacles, and (3) finally the goal state which is the problem solver's desired condition. New problem states which are also called intermediate states may be created before reaching the goal state (Gagne, 1985; Mayer, 1989). Problem solving is a cognitive process which constructs the problem space and searches for possible solution paths by converting the initial state to the goal state (Mayer, 1989; Newell and Simon, 1972).

Studies in problem solving have revealed that the internal representation is very important in determining the possibility of success as the internal representation influences the selection of operators. It is generally agreed that formation of internal representation and application of knowledge are not single direction processes . Each of them is an interactive process in which both the internal representation and application process are evaluated after each trial. Internal representation will be modified or rebuilt or new operations will be selected if necessary (Gagne, 1985; Mayer, 1989; Simon, 1978). Though details and steps have changed as knowledge of problem solving processes increases, the overall organization of the problem solving process is much the same as depicted in Figure 1 by Newell & Simon in 1972.



Note: the eye indicates that input representation is not under control of inputting process.

Figure 1. General organization of problem solving with reference to the information processing model of Newell & Simon (1972).

3. Cognitive theories and the acquisition of procedural knowledge in problem solving

In developing a learning theory to explain the acquisition of cognitive skills, psychologists observe and compare the problem solving processes of novices and experts in areas such as decision making, mathematics problem solving, computer programming and language generation.

Fitts (1964) distinguished three stages in skill acquisition: cognitive stage, associative stage and autonomous stage. A problem solver is in the cognitive stage when he/she encodes facts needed for solving the problem and tries to solve it when first encountering it. The associative stage designates the smoothing out of problem solving performance by practice. The problem solver detects and eliminates errors and successfully finds the way to solve the problem. At this stage, verbal rehearsal also disappears gradually. The autonomous stage denotes the continuous improvement in speed and accuracy with further practice performed by the problem solver as developed from the associative stage. Through extensive practice, direct and immediate retrieval of solution may occur (Fitts, 1964; Fitts & Posner, 1967).

Though Fitts and Posner's interpretation is generally agreed by cognitive psychologists, arguments exist in theoretical explanation. There are different positions about the cognitive structure, in explanation for cognitive processes that bring about problem solving behaviour as well as the gradual reaching of the autonomous stage (e.g Baddley, 1986; Clark, 1990; Fish, Oransky & Skedsvold, 1988; Just & Carpenter, 1992; Klapp, Marshburn & Lester, 1983; Knapp & Robertson, 1986; Logan, 1988, 1990; Mackay, 1982; McClelland, 1986; McClelland & Rumelhart, 1986; Monsell, 1984). However, few have developed explanations for the complex cognitive skill of problem solving processes (Kramer et al, 1990).

Among them, Anderson's ACT* theory (1983; 1987; 1990a) and Schneider & Detweiler's explanation of how automatic processing developed has received much attention. Anderson has put forth the ACT* theory to explain acquisition of cognitive skill. It tries to explain high level cognitive activities by sets of condition-action pairs called productions (Anderson, 1983; 1987; 1990a). Schneider & Detweiler (1987: 1988) have been developing a skill acquisition theory to explain performance of single task as well as dual tasks.

(i) Anderson's ACT* theory

ACT* is a theory of cognitive architecture where ACT stands for Adaptive Control of Thought (Anderson, 1983; 1987). According to ACT* theory, memory can be classified into declarative memory and procedural memory (Anderson, 1983; 1990a). Besides, memory can also be classified into working memory and long term memory by two concepts: activation and strength. Activation is the transient factor that determines the momentary availability of the memory trace.

Memory in high activation can be accessed quickly and reliably. Strength is the long-term durability of the memory trace. Activation and strength have great difference in their durability. Activation can decay from high level to low level in a second while strength takes some memory years to decay. Working memory are memories that are currently active and so the knowledge can currently be worked with. Long term memory are memories which have sufficiently strong encodings that they can be reactivated or can be recalled at long delays (Anderson, 1990a; Anderson & Pirolli, 1984).

Anderson (1987) uses ACT* production system as the framework for explaining cognitive performance. Knowledge stored in our memory is classified into declarative knowledge and procedural knowledge. Declarative knowledge is the knowledge about facts and things. For example, the knowledge about the different inheritance patterns in genetics. It can be represented in the form of temporal string, spatial image or abstract proposition. ACT* theory is based mostly on propositions. Procedural knowledge is the knowledge about how to perform cognitive activities and how to represent them in rules called productions. In the ACT* theory, cognitive processing occurs as a result of firing of production. For example, Smith (1988) also thought that students had to recognize common genetic patterns or other critical cues (i.e. conditions in production rule) from the problems and make appropriate genetic inferences (cognitive action) in genetic problem-solving. Anderson's production rules are condition-action pairs. For example, one of the "Englishified" version (Anderson, 1987) of productions for solving genetic problems is:

If an individual is a pure breeding of a trait

Then the two allele for the trait are the same.

Productions are relatively well structured, simple and homogenous, and independent of one another. Production is interpreted as the unit of procedural knowledge in the ACT* system. Productions control over all cognitive processes and activities. They are the units in which knowledge is acquired and the steps that define and determine the problem solving procedure.

When the problem solver first confronts a problem, information or instruction for solving the problem is first encoded as a set of facts in the form of declarative knowledge. ACT* system assumes that declarative knowledge is available for processing when it is activated. Main concepts in the instruction are sources of activations. Activation spread runs rapidly through the declarative network, setting up various levels of activation. The activation level determines the probability of access to memory and the rate of access. Memory which is in a high level of activation can be accessed rapidly and reliably. Thus spreading activation can be conceived as a process that identifies knowledge relevant to a current focus of attention and that favours the processing of that knowledge.

After the encoding of the information needed, knowledge is converted from declarative mode to procedural mode. This is the knowledge compilation stage in which productions are matched to the active declarative knowledge. When a novice is attempting the problem, he/she uses domain-general problem-solving productions to interpret the declarative knowledge. The declarative knowledge is used as the source of information for identifying suitable problem solving procedures. Children are, therefore, believed to be able to bring in plenty of weak but general problem-solving methods to initiate the problem solving in new domains. Activation level will rapidly decay for the unattended items and items have to be maintained in high active state for matching to be completed. The problem solver sometimes needs to rehearse the information required verbally. Productions which are indexed by the factual part are matched and joined in a novel sequence. As matching poses a heavy workload on the working memory and there are limits on the amount of information to be maintained in a high activation level, slow and piece-meal application of problem solving method can be detected and errors can be observed in problem solving in this stage.

As all procedures are organized to reach the goal state in problem solving, there is a hierarchial goal structure. For example, the goal state in genetics problem-solving is to find out the genotype of all the individuals in a family. To solve a problem, the first subgoal is to find out the genotype of the parents. Then, what follow is getting the genotype of the progenies by making genetic cross. The stacks of goals for solving the problem are sequenced in a hierarchial goal structure. Further practice of the same problem will lead to the collapse of productions in the sequence into a single production. This chunking process which creates macroproductions is called composition. Declarative knowledge will also build into the productions to form steps for guiding how to do things and this process is called proceduralization. After compilation of the productions, the problem solver can simply retrieve the single production formed and the retrieval of declarative knowledge is no longer needed in the execution of the production. There will be a dramatic one-trial speedup in solving the problem and verbal mediation in performing the task also disappears. As the demand on working memory is reduced, the problem solver can also perform a second concurrent task that demand attention. Problem solving performance in this stage is said to be autonomous.

Still further practice will lead to improvement in behaviour by the mechanism called strengthening. Successful applications of the new production will increase its strength which makes it easier to be retrieved when the same condition is met again. Unsuccessful applications, on the other hand, will decrease its strength which makes the production less accessible when facing the problem afresh. The whole process which enables the problem solver to recognize situations suitable for reapplying the productions is called tuning of the production. The effect is more autonomous and precise response ensure on the part of the problem solver. Anderson formulates a general equation which he calls the power law (see Appendix A for details). This equation shows how ACT* predicts a power function about the effect of practice on speed of performance (Anderson, 1976; 1982; 1983; 1984; 1987; 1990a).

(ii) Schneider & Detweiler's Model

Architectural structure of the brain as proposed by Schneider and Detweiler

Schneider and Detweiler have proposed an architectural structure of the brain which they think is derived from the present understanding of attention literature, neurophysiology and communication theory (Schneider & Detweiler, 1987, 1988).

Information processing is assumed to occur in networks of neural-like units. Units are organized into modules that process a particular class of inputs so each module contains a vector of output units (the micro level). The message is represented by the state of the output units of the modules. The set of activities of the output units of a module is the "message vector" (MV) for that module. Information flow (output) from a module is regulated by an "attenuation unit" (an implementation of attention, see Schneider & Detweiler 1987 for details) within the module. Each module's activities is regulated by a control structure and module will report its activity to the control structure. There is also a control circuit which ensures messages from a set of modules to be delivered sequentially. When one module is transmitting message, neighboring modules' transmission is inhibited. This avoids interference and loss of information.

Though all modules in the brain are similar in structure, they are organized into levels and regions (the macro level) according to their functions (see Figure 2). Levels represent successive processing stages within a region. For example, in the visual module, there may be a "level one" for processing features, "level two" for characters and "level three" for words while in the motor module, there is a "level one" for processing movements, "level two' for sequences and "level three" for tasks. Regions represent sets of levels specializing in a particular type or mode of processing, for example, "visual region" for vision inputs, "semantic region" for associative processing and "motor region" for motor outputs. The innermost levels of each region communicate with other regions by passing vector messages. Regions are connected to and communicated with one another by associative connection in such a way that each region can communicate with other regions directly. This enables faster single-message transmission and allows multiple regions to jointly activate a region. However, parallel transmission on the inner loop does not imply parallel processing.

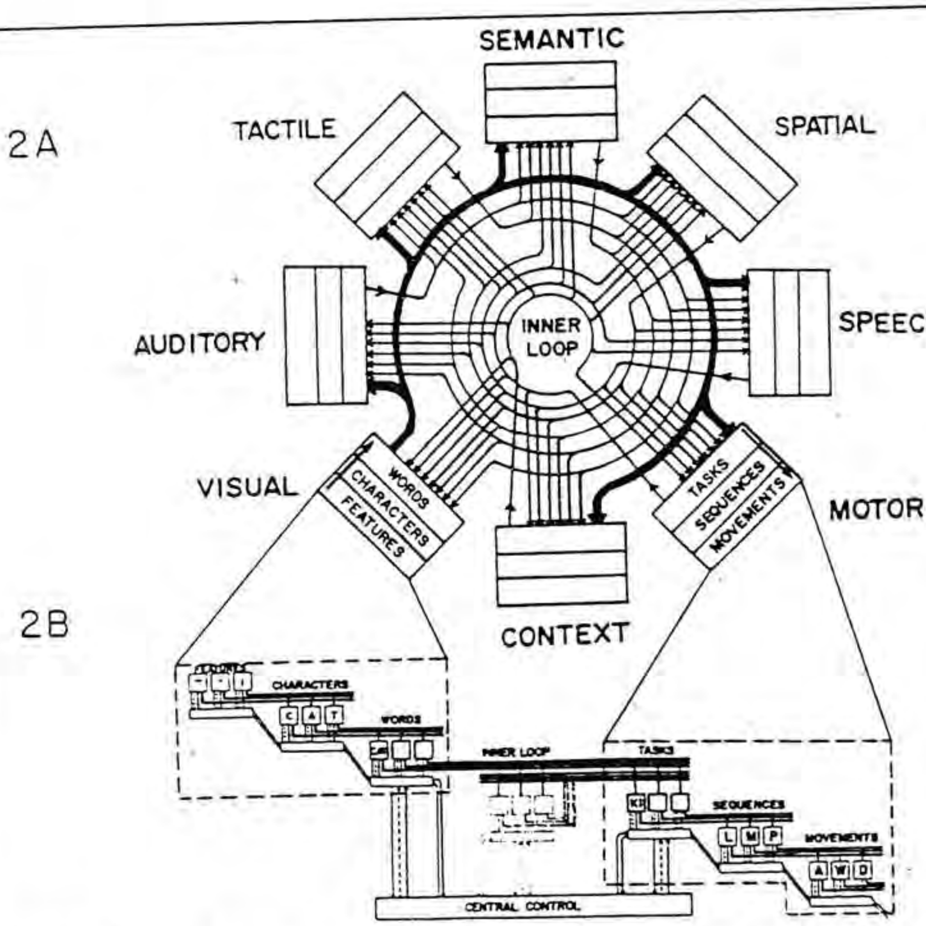


Figure 2. A system-level discription of the model with reference to Schneider & Detweiler's architecture for working memory. Figure 2A is a top-down view of the regions of processing within the system. Figure 2B illustrates interactions among sets of modules in the macrolevel structure (Schneider & Detweiler, 1987; 1988).

All the message vectors coming to a module are summed and this causes intermessage interferrence. So it is the number of competing messages received that determines limits on the number of concurrent message transmissions. Control processing is the mechanism that moderates message transmission on the inner loop. Two categories of information, message and control information, flow in the system. Message flow involves the transmission of a vector representing a code from one module to another. Control flow involves exchanges of control information between the modules and the control structure of the module. Control information denotes the importance of messages waiting to be transmitted and the transmission state of any modules. So information flow is modulated at the macro level. At the system level, there is a central control structure which receives activity reports from each region and modulates the output of regions transmitting the central innerloop.

The strength of the synaptic dendrite connections between neurons is called connection weight. Connection weights operate under the influence of a variety of learning-rate constants. These constants determine the rate of change and duration of retention of the change. Knowledge or memory is stored in the connection weights between neural-like units in the system and so learning involves changing these connection weights. As Schneider and Detweiler hold a temporal point of view for working memory in the system and adapt Baddeley's saying "a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning, and reasoning." (Baddeley, 1986). Working memory is, therefore, multifaceted in this architecture. They include areas with fast learning, fast decay connection weights such as code maintains in module after transmission and the regional controllers in modules which hold connection weights about priority of the messages waiting to be transmitted. Besides, much of the knowledge is stored as slow rate connection weights in the network and could be considered as the long term memory of the system (Schneider and Detweiler, 1987; 1988).

Skill acquisition as explained by Schneider and Detweler's model

When a novice first confronts a problem, controlled processing is used. Controlled processing is conceived as a central processing mechanism with limited capacity. It does not directly send messages between units but regulates the transmission of messages between units. He serially compares the input pattern to a rule and to perform the appropriate response based on the match.

To solve a task, it is necessary to keep the instruction and task-relevant information in working memory. This involves loading and maintaining memory vectors in modules. To solve a genetic problem, the system must store the genetic rule, e.g., "if a third character appears between cross of two pure breedings, then it is a codominance inheritance pattern.". The problem solver first rehearses the rules concerned to enable the context to load the buffers. The context would load into appropriate modules at the first hand. For example, load the target state (e.g., appearing of a third character) in the context modules, the response on a match (e.g., judgement of codominance inheritance pattern) in the motor module.

When a problem is presented, a controlled comparison would occur between the input and the target output. To perform a comparison, two vectors are added together. If the two vectors are similar, the added vector is nearly twice as long. If the two vectors are dissimilar, a vector shorter than the sum of the two vectors is produced. Processing is serial as paired comparsion is needed for accurate result. It is effortful as many shifts of attention are needed in monitoring the process. When the matching is identified, message will be transmitted for the appropriate response. As a result of these controlled processing operations, the input pattern will be transmitted followed by the output pattern being transmitted. Connection weights in the transmitting modules will change as a consequence. So learning can be said to occur after a vector of activation is transmitted and a second vector of activation is output.

If the problem solver practises in a way that there is a consistent relationship between the message transmissions, improvement in performance will be observed. Controlled processing will shift to context-maintained controlled comparison. Information will be maintained in fast learning weights that associate vectors stored in modules to the context. Activating the context module can refresh information in modules. Further practice will develop the goal-state-maintained controlled comparison in which the goal state can reload the modules in addition to the context-base reloading. More gaining of connection weight with practice will eventually lead to automatic processing. This occurs when automatic processing substitutes for attentional/controlled processing.

Automatic processing develops as a function of two types of learning mechanisms: Associative learning mechanism and priority learning mechanism. Associative learning mechanism modifies the unit to unit associative matrix. The association matrix encodes associations by storing the strengths of connections, i.e. the connection weights between the input and output units. In consistent practice, discriminative associations will develop in the connection weights such that a stimulus vector will evoke an appropriate response vector. Priority learning mechanism tunes the units transmission so that important messages are transmitted at high gain and unimportant messages are transmitted at low gain. When there is a consistent relationship, the priority learning mechanism will tune the network discriminately. The target stimuli become foreground and "pop out" of the display. The distractor stimuli become background and, in a sense, disappear from the display. Automatic processing occurs when the connection weights gained from associative learning mechanism and priority learning mechanism have sufficiently developed. At this time, one vector will evoke a following-on vector without controlled processing (Schneider, 1985; Schneider & Detweiler, 1987; 1988).

(iii) **Research in skill acquisition**

Criticism about composition of productions into a single production

Carlson, Sullivan and Schneider (1989b) have performed experiments to examine the acquisition of procedural skill. Digital logic gates were used as tasks. Subjects had to predict or judge the output from the inputs according to the rule about the gate. The main reason for choosing this task was that the variables describing gate type and judgement type had consistent effects on latency. This characteristic could be used to track changes in the structure of cognitive processes. More time was required for negated gate as one more step was required. Verification judgements required more time than prediction because of the same reason.

Subjects had more than 8,000 trials of practice, latency for all logic gates judgements declined with practice, following approximately the power-law function (see Appendix A). However, the effect of gate type and judgement type did not disappear. As the tasks differed in just one step and Anderson had stated that with extensive practice, composition collapsed the sequences of productions for the task into a single production. Carlson, Sullivan and Schneider expected that composition would eliminate the negation effect and judgement effect with practice. As predicted by Schneider's theory (1985), task complexity would be reflected in the autonomous stage as extended practice might simply increase the speed of a cascade of sequential processes during processing. The persisting effect of gate and judgement type reflects that complexity of the cognitive processes remain unchanged. The explaination regarding automatic processing proposed by Schneider was more logical in interpreting the result of their study (Carlson et al., 1989b, 1989c).

Anderson explained that task complexity will not be eliminated after composition. The conditions are larger for the composed productions that deal with more a complex task. Anderson also queried whether composition had happen in the experiment of Carlson et al. and said the best experiment he knew about composition was that of McKendree and Anderson (1987). They had subjects evaluating combinations of a programming language - LISP functions for 4 days. Subjects evaluated more rapidly for the combinations which were encountered more frequently. Subjects' performance did show evidence of composing the basic LISP functions into combinations and differential strengthening of these combinations as predicted by the power law (Anderson, 1989).

Criticism about working memory as the single work place

At two points in learning (after 336 and 1,232 trails of practice per rule about logiic gate, in Carlson et al 1989b). Subjects were tested on the retention of a "memory set" while making logic gate judgements. The "memory set" was presented in three conditions: "Irrelevant", "access" and "expected" (see Appendix

B or Carlson et al 1989b for details). In both the "irrelevant" condition and "expected" condition, the clues provided were not designed helpful to solve the logic gate problem. However, in the "access" condition, the clues were designed helpful to solve the logic gate problems.

The procedures for the task was that a "memory set" was presented first. The "memory set" was presented in one of the three conditions as discussed above. After that a logic gate problem appeared. As before, subject had to tackle the logic gate problem immediately. Then a memory probe was presented and subject had to indicate whether the probe was correct or incorrect immediately. The latency and correctness of the solutions for the two tasks were recorded. Result showed that at either level of practice (after 336 or 1,232 trails of practice), short term memory loads had little effect on logic gate problem solving latency except for the "access" condition.

Carlson et al. believed that this result indicated that there were different capacities for storage and processing in the working memory as in distributed models of working memory. The single working memory as implied in Anderson's ACT* theory in 1983 was disconfirmed (Carlson et al., 1989b, 1989c). Anderson argued that the relevant factor was not how much information was maintained in working memory, differences in the level of activation of the piece of information which was used to match a condition was the major factor. So there was little effect in the "irrelevant" condition and the "expected" condition. In the "access" condition, memory load had to be maintained in high activation for matching. The amount of activation diminished as a result of fan effect. Fan effect means the amount of activation reaching a proposition is inversely related to the number of links leading from it (Anderson, 1990a). This resulted in longer gate judgement time (Anderson, 1989).

Comments on the two divided views on acquisition of procedural knowledge

In explaining automatic processing, both Schneider & Dentweiler's explanation and Anderson's theories can explain the improvement in performance as predicted by the power law (see Appendix A). Schneider & Dentweiler explains the drastic speed up as input directly evokes output while Anderson attributes this fact to proceduralization and composition. In fact, Anderson's "composition" which takes productions in to a sequence is comparable to Schneider & Dentweiler's association learning in which appropriate modules were joined by connection weight. Schneider & Dentweiler's priority learning which "pop out" important stimuli is also in some way similar in function to Anderson's proceduralization.

The main difference between them is that Anderson's composition will finally "collapse" the sequence of productions into a single production while messages in Schneider & Dentweiler's model have to pass through all the modules to produce the response. In other words, processing is not seen as a single production. That may be the reason why Carlson, Sullivan & Schneider challenged Anderson through their experiment. The interpretation of Carlson, Sullivan & Schneider seems to be more favored in light of the evidence produced. If composition cannot eliminate the complexity difference between task to the extend it cannot reduce latency of just a single step, it is very questionable about the meaning of putting forth this idea. Besides, it is very difficult to accept that 8,000 trials of practice is not enough for composition to occur if productions can really collapse into a single production.

As Anderson has defended that ACT* predicts a complexity effect before and after composition (Anderson, 1989), we can, however, accept the final single production from an abstract point of view. The meaning of putting all the conditions in the 'if' clause and all the response in the 'then' clause to construct a single production is to emphasize the one step retrieval of the rule when executed.

It is very interesting to note that as the amount of information needs to be retrieved from the different modules (Schneider & Detweiler, 1987; 1988) increases, the latency for finishing the task will increase. It is true that memory that has to be matched with the "production" have to be kept in higher activation (Anderson, 1987). However, as the different kind of memory loads got similar result in the memory probe test that followed, difference in activation level of Anderson is adequate in explaining the result. On the other hand, behavioral data provides informations about what goes into the information processing system and what comes out ("what comes out" means behaviours like response latency or intensity, Anderson 1990b). There is an infinite number of mechanisms that can represent the same input-output functions. Mechanistic implementations (e.g. Schneider & Dentweiler's models) which try to find what is inside the head have identifiability problems (Anderson, 1990b; 1991; Anderson & Milson, 1989).

An overall critique

Schneider and Detweiler are connectionists who are concerned about matching of cognitive theories with our understanding of the physiology of neural processes. Anderson holds the conventional sequential processing view in cognitive processing. In discussing skill acquisition, however, both Anderson's ACT* theory and Schneider and Detweiler's explanation are about serial processing. This is not surprising as connectionists believe that only processing that happen very quickly - less than .25 to .5 seconds - occurs essentially in parallel. Processes that take longer will have a serial component and can more readily be described in terms of sequential information-processing models (McClelland & Rumelhart, 1986). As skill acquisition takes time, it is basically serial.

Though the two theories seem very different at first glance, they are very similar when examined in detail. While Anderson has stated the skill acquisition mechanism in abstract form, Schneider & Dentweiler try to concretize it in their architecture of the brain. In fact, Schneider has said that the mechanism for changing the controlled-processing gain that allocates to unit in his theory is represented as a sequence of steps of a program. This program is the series of productions in Anderson's theory (Schneider, 1985).

4. Cognitive theroy and transfer of problem solving performance

In most domains, learning which attains greater generality is more useful. As transfer has such great value in problem solving, it has received much attention and has been tackled in various domains in a number of ways (e.g. Bassok, 1990; Gick, 1990; Gick & McGarry, 1992; Kotovsky & Fallside, 1989; McDaniel & Schlager, 1990; Lehrer & Littlefield, 1993; Niedelman, 1991; Picerce, Duncan, Gholson, Ray & Kamhi, 1993; Riesenmy, Mitchell, & Hudgins, 1991). Transfer is the activation and application of knowledge in new situations (Gagne, 1985). Transfer is also a phenomenon involving change in the performance of a task as a result of the prior performance of a different tasks (Gick & Holyoak, 1987). Transfer can be classified into self transfer, near transfer, far transfer, vertical transfer and lateral transfer according to the degrees and types of similarity between the learning task and the transfer task. Transfer can be either positive, nonexistent or negative depending on its direction of effect on the transfer task.

Early educational psychologist believed that the mind was composed of a collection of general faculties, such as observation, attention, discrimination and reasoning. The Doctrine of formal discipline (Angell, 1908; Pillsbury, 1908;

Woodrow, 1927) claimed that studying such esoteric subjects as Latin and geometry was of significant value because it served to discipline the mind. Transfer was, therefore, thought to be broad and across diverse disciplines. Thorndike, on the other hand, thought that transfer was very specific. In his "theory of identical elements", transfer would only occur between activities which had common situation-response elements (Thorndike, 1906). Though experimental investigations could not demonstrate the existence of general transfer, more transfers were observed than could be explained by common stimulus-response elements alone.

(i) Transfer and Anderson's ACT* theory

Singley & Anderson apply ACT* theory to the study of transfer. The elements of transfer are subsets of elements of learning. Single productions, being the unit of cognitive skill, serve as the identical elements in Thorndike's theory. They believe that productions have four desirable features that make them suitable for this purpose: (i) productions are learnt independently, (ii) compilation process in productions is one-trial, (iii) production rules have strength accrual upon successful application and (iv) production rules have a desired level of abstraction (Singley & Anderson, 1989).

In the identical-productions model, transfer is a function of overlapping in productions between two tasks. Positive transfer of skill will occur when there is overlapping in productions between two tasks. Zero or no transfer occur when there is no overlapping in productions between two tasks. While interference is well documented in declarative knowledge, it is not suggested in procedural knowledge. Negative transfer is either the transfer of nonoptimal methods or the transfer of productions whose conditions match but whose actions are completely inappropriate. For example, Einstellung effect (set effect) of Luchins (1942) is one well documented kind of negative transfer (Anderson, 1990a; Singley & Anderson, 1989).

The condition for vertical transfer in Anderson's ACT* theory suggests the benefit of part-task practice for complex tasks. It is because compilation can only occur between the productions which are in the working memory at the same time. Complex tasks which have too many productions for them to reach high activation level at the same time will limit the chance for compilation. Part-task practice of component procedure helps to speed up the component procedure's execution, to reduce the demand of working memory capacity in running the task as well as to encapsulate the component procedures so that it is more context free. All these can facilitate composition of complex tasks. As transfer of skill will occur when there is overlapping in productions between two tasks, learning two tasks have no advantage over learning one task regarding lateral transfer. Besides, identical goal structure is not necessary for lateral transfer to occur (Anderson, 1987; Singley & Anderson, 1989).

(ii) **Other study and explanation about transfer**

Gick and Holyoak (1987) believed that transfer depended on the recognition of similarity between tasks and the successful retrieval of knowledge from memory. They were interested in the conditions in which transfer could occur. The condition at encoding during training was one of the factors which was said to determine transfer. Studies from different domains have indicated that positive transfer increases with the number of instances provided during training (Weisberg, 1991; Shea & Kohl, 1990).

In word recall, it is well known that spacing repetition (repetitive practice with another task interventing in between) is better than mass repetition (repetitive practice with no interventing task) (Jacob, 1978). Melton (1967) described the facilitating effect of spacing repetitions as phenomenon which seemed to suggest that forgetting helps memory. Cuddy and Jacoby (1982) also believed that the condition of repeating a problem in which the solution was not readily accessible would enhance mental processing. Retrieval would be easier as a result. They conducted a study using pairs of related words. When subjects had to restore the missing letters for a word twice, it was found that decreasing the similarity of the repetition enhanced learning. Similarity were reduced by having missing letters in one of the words in the pairs on its second presentation. This dissimilar repetition was said to have advantage because the subjects' had to solve problems on their first presentation as well as on their second. Cuddy and Jacoby (1982) concluded that both encoding variability and strengthening accounted for the learning effect.

Catrambone and Holyoak (1989) performed five experiments to probe ways of overcoming the limitation of context or delay on transfer. Subjects were presented with analog stories in the treatment section. The problem solving task was given immediately or in a delayed situation. Subjects were said to have transfer if they could produce convergent solutions to solve the task. It was found that giving more examples during training facilitated transfer even in the delayed test condition. Multiple analogies might help to form general rules or form internal representation which resulted in more retrieval paths.

Experiments found that practice schedule could also affect retention and transfer. In the learning of motor skills, many studies have revealed that practice in high contextual variety facilitates retention and transfer (Lee & Magill, 1983; Shea & Morgan, 1979; Shea & Zimmy, 1983; 1988). Wrisberg and Liu (1991) investigated the effect of block and varied practice on the retention and transfer in badminton tasks. The study was conducted in a physical education class and long service and short service in badminton task were examined. Students were divided into the experimental and control groups (block vs. alternating practice) according to pretest scores. After five class periods of practice, a retention test and transfer test were conducted. Alternating practice group performed better in the retention test for both the long and the short services. However, only the results in the short service were significant. In the transfer test, varied practice group was better than the block group significantly in both long and short services.

Elaboration and action plan reconstruction are enhanced in alternating or varied practice schedule. In block (same variation repeating) practice, subjects had to construct the process mentally only in the first trial. In varied practice, action plan of previous movement was more likely to be forgotten. Subjects had to reconstruct the action plan for each trial. Items of the action plan would be in the working memory and this facilitated elaboration of the items and strengthens flexibility of the memory representation concerned (Wrisberg and Liu, 1991).

(iii) Research in transfer

Transfer of part-task practice

The implication of the part-task training benefit, however, has received little experimental support. Carlson, Sullivan and Schneider (1989a) studied part-task effect in learning logic gate. Subjects had practised on the component process before solving complex problems which required the component knowledge. Even after large number of trials, there was no significant effect of component practice on the complex task. On the other hand, having learnt the complex task followed by a few trials on the complex task improved not only the performance of the complex task but the component skill as well. The difficulty level of the component process was exaggerated in performing the whole task showing that there was no encapsulating effect of the component task even after extended practice. Elio's (1986) study on mental arithmetic procedure got similar result. It seems that cognitive context like information and workload may influence some overall problem solving strategies. Preserving this context is very important for the success of segmentation learning approach.

Acquisition context and transfer

Carlson and Yaure (1990) examined the contextual effect of practice schedules in learning cognitive procedural skill. Equation-chaining task of Boolean logic functions was used as the learning task. Three experiments were conducted. In each experiment, subjects first practised individual logic functions and then solved equation-chain problems. Presentation of the tasks and collection of responses were controlled by computers, so reaction time and accuracy could be precisely measured. In all the experiments, subjects had practice for at least eight times and there were forty-eight trials each time.

Skill acquired under random practice schedules showed superior transfer to problem solving in experiment 1 and 2. In experiment 3, subjects practised component skills in a blocked schedule with an intervening task between each trial. Intervening tasks which required active processing, the same-different judgements and mental arithmetic tasks, produced transfer similar to random practice. Neither short-term memory nor long term memory intervening tasks which required storage demand produced transfer effect. Thus, random practice was said to produce contextual interference effect like the spacing effect.

Two cognitive processes could be concluded from explanations which were put forth to explain how random practice facilitates transfer. One of them focused on the schema structure in the long term memory. In random practice, consecutive productions could be in the working memory at the same time. Subject could be able to contrast the productions to be learned. These interitem processings encoded the similarities and differences between the to-be-learned items, resulting in better organization of the skills in the long term memory. Recognition and retrieval of appropriate skills thus would be better (Shea & Morgan, 1979; Shea & Zimny, 1983, 1988).

Some cognitive psychologists thought that increase in the fluency of accessing and using component skills was more important. In block practice, productions for the execution of the task or even the solution of the task was in the working memory. The level of processing was thus reduced in block practice. In random practice, active retrieval of appropriate production for solving the problem from the long term memory was needed in every trial. Random practice had the advantage of spacing effect. It provided more practice of intraitem processing such as reconstructing the movement plan in motor skills or loading the procedures in verbal task as well as cognitive skills. Processing efficiency was increased as a result (Lee & Magill, 1983; Cuddy & Jacoby, 1982).

Carlson and Yaure (1990) suggested that interitem processing and intraitem processing were both needed to account for the phenomena associated with skill acquisition in random practice. Interitem processing accounted for the slower acquisition. Acquisition of the task itself as well as tuning of the tasks occurred at the same time. Based on the fact that intervening tasks could produce learning effect as random practice, the researchers concluded that intraitem processing produced the transfer benefit.

Carlson and Schneider (1989) examined the development of procedure for using causal rules. University students learned to use causal rules describing digital logic gates. Subjects received instruction with either verbal rules or truth tables and practised either predicting or verifying logic-gate outputs. Subjects were transferred to the untrained judgement task after 200 trials of practice with each rule. It was found that judgement and prediction showed asymmetric transfer with verification judgements better transferred than prediction judgements. The acquisition context - representations used for initial instruction affected both the initial acquisition of and the procedure for using causal rules. Truth-table showed advantages especially for verification judgement. From the above result, Carlson and Schneider thought that the asymmetries observed in causal judgement might result in part from lasting effects of acquisition context, although some asymmetry might be inherent in the requirement of alternative judgement tasks.

5. Research in genetic problem solving

Genetics is a problem-solving science which is included in all high school Biology courses (Hong Kong Examination Authority, 1992a; 1992b; Okebukola, 1990; Slack & Stewart, 1990). However, many studies review that students perform poorly in genetics (Walker, Mertens & Hendrix, 1979; Longden, 1982; Radford & Bird-Stewart, 1982; Pearson & Hughes, 1986; Kindfield, 1991) or even avoid this field of biology (Johnstone & Mahmound, 1980; Thomas, 1983). When first-year university students were asked to list out topics of A-level Biology that they found most difficult, genetics appeared high in the list (Johnstone & Mahmound, 1980).

Genetics is a fruitful area in biology to study problem-solving performance (Simons & Lunetta, 1993; Smith, 1992; Smith & Sims, 1992). Steward and Dale (1981) have identified that meaningful genetic problem-solving required both procedural knowledge and conceptual knowledge. Procedural knowledge involves the strategies and specific steps concerned in attempting to solve the given problem. Conceptual knowledge is the declarative knowledge that is needed for the decision in the employment and rejection of steps. Research in genetic problem solving has identified component steps for successful solvers. It models the problem-solving procedures which help in developing effective instruction method (Smith, 1988). Analysis of the inappropriate steps in genetic problem solving can also review the misconceptions of the solvers (Borwn, 1990). With the understanding of the nature of genetic problem solving, diagnostic and tutorial genetic computer programs may be developed to assist in teaching genetics. Research-based recommendations for teaching genetic problem solving can also be tested in the classroom.

Smith and Good (1984) had a study on expert-novice performance in genetic problem-solving. In the study, novices were undergraduate students and experts were graduate students and instructors. Problems were difficult enough to require the experts to process other than just to recall and yet simple enough to allow novices to have a chance for solution. Detailed analysis of the protocols identified 32 problem-solving tendencies used by successful problem solvers. They included: seeking a solution rather than an answer, checking for consistent logic, working forward, checking for one trait (variable) at a time and looking for evidence that would invalidate previous assumptions.

In 1988, Smith did another study. He interviewed 16 undergraduates and 11 genetics graduate students and Biology faculty members. Think-aloud techniques were used to examine the difference in cognitive processes between the successful and unsuccessful problem solvers in solving genetic pedigrees. After analysis of the protocols, fifteen distinctions which were thought to cause failure in the problem solving were listed. As pedigree problem had not been used in previous studies, this study extended researchers' understanding of genetic problem-solving performance.

Slack and Stewart (1990) had studied the problem-solving performance of

30 high school students. Subjects were students from grades 9 to 12 who had completed a three to four week genetics course. One hundred and nineteen realistic genetics problems generated by a computer program "Genetics Construction Kit developed by Jungck and Calley (1985)" were used as tasks. The think aloud protocols and the printout records of the subjects were analyzed. Three trends in general problem-solving procedures were concluded from the experiment. They were: (1) an unplanned approach, (2) working backward and (3) emphasis on quantitative level of counting number and using ratios in individual cross.

6. Brief summary of literature review

The related literature review in this chapter covered two aspects of learning: Acquisition and transfer. Anderson's ACT* theory can explain and predict learning behaviour such as acquisition of procedure knowledge. However, "overlapping in productions between two tasks" does not seem to be adequate to account for positive transfer of skill. Acquistion context (Carlson , Sullivan & Schneider, 1989a; Carlson & Yaure, 1990) which affects interitem processing and intraitem processing during learning have great influence on transfer.

Among variables that determine learning, consistency is one of the most widely studied ones (e.g Carlson & Lundy, 1992; Duncan, 1986; Neves & Anderson, 1981). In motor and verbal learning, research found out that random practice schedules produced poorer acquisition performance but superior retention and transfer relative to block practice (e.g. Cuddy & Jacoby, 1982; Shea & Morgan, 1979). Recent studies have extended to the study of learning cognitive procedural skills (e.g. Carlson et al., 1989, Carlson & Yaure, 1990). Nevertheless, the most suitable level of consistent practice in knowledge specific domains such as genetic problem solving awaits to be explored.

Chapter III

Research Design

1. Definition

Problem:

Problems exist in relation to the problem solver's point of view. If a person has a goal and has some obstacles to attain the goal, he / she is said to have a problem (Newell & Simon, 1972).

Problem-solving:

Problem-solving is the process of assembling an appropriate sequence of component procedures (or operators) to accomplish a goal. It is said to be fluent when component skills can be accessed and used efficiently (Carlson & Yaure, 1990).

Practice schedule:

Practice schedule means that the practice is scheduled in terms of variations both in content and sequence. In this study, there are two types of practice schedule: block practice and random practice. Block practice is the practice with repeating practice of the same variation while varied / random practice is practising with trials of different variations (Wrisberg & Liu, 1991).

Transfer:

Transfer is the activation and application of knowledge in new situations (Gagne, 1985). Vertical transfer is the transfer between lower-level and higher-level skills that exist in a part-whole, prerequisite relationship to one another. Lateral transfer is the kind of transfer that spreads over a broad set of situations at roughly the same level of complexity (Gagne, 1966). Transfer can also be classified into near transfer and far transfer according to the degree of similarity between the learning task and the transfer task (Gick & Holyoak, 1987).

Protocol:

Protocol is a record to transcribe the verbalization of a subject's thinking processes during the course of problem-solving activities. In order to increase the density of observation and to externalize the invisible thinking processes, the subject is asked to tell everything he/she is thinking of while performing a task or interviewed retrospectively (Ericsson & Simon, 1980; Lester, 1980; Leinhardt, 1988; Miller & Cannell, 1988; Simon, 1978).

Protocol analysis:

Protocol analysis is the qualitative and quantitative analysis made on the think-aloud protocols transcribed from recordings of the thinking-aloud problem-solving interview (Ericsson & Simon, 1980; Leinhardt, 1988).

2. Hypotheses

(i). There is no significant difference between the two practice schedule groups and between the immediate posttest and delayed posttest when the result of acquisition scores and transfer scores are used as dependent variables with the pretest scores as a covariate.

(ii). There is no significant interaction between the groups and posttests when the result of acquisition scores and transfer scores are used as dependent variables with the pretest scores as a covariate.

3. Sampling

In this study, five schools were selected. Different types of Anglo-Chinese grammar schools were included: a boys' school, two girls' schools and two coeducational schools. The schools' performance in the Hong Kong Certificate of Education Examination ranged from good to poor. However, only two of the seven classes from the selected schools had students whose abilities were average and below average. The other five classes had students whose abilities were above average. Hong Kong students like to study science and competition into the science classes is very keen. Average and high ability students are more likely to be found in the science classes in Hong Kong.

There were altogether 264 subjects from 7 intact classes. Half of the subjects in each intact class were randomly assigned into block group and the remaining half were in random group.

4. Subjects

The subjects were secondary 5 science students. They had just learnt the knowledge and concepts about the "simple dominance inheritance pattern in monohybrid cross" and "codominance inheritance pattern in monohybrid cross" in genetics. However, they had not applied such knowledge in solving any genetic problems.

There were 264 subjects participating in the practice schedule experiments. Six of them were selected to participate in the task-based interview for obtaining the protocol data.

5. Materials

Problems given to the subjects were constructed to be parallel with the genetic topics that they had just learnt. The researcher had meetings with each participating teacher before genetics was taught. Simple dominance inheritance pattern in monohybrid cross is the topic included in the Hong Kong Certificate of Education Examination. Consensus was made to ensure that the topics were all taught with the same depth and width. Codominance inheritance pattern in monohybrid cross is actually not necessary for the Hong Kong Certificate of Education Examination so supplementary note (see Appendix C) was given to them.

Three types of problems were used in the pretest (see Appendix D), the exercises in the treatments (see Appendix E) and acquisition posttests (see Appendix F) of the study:

(i) Monohybrid cross with simple dominance inheritance pattern in which the type of dominance and parents' genotypes were given (MS1).

(ii) Monohybrid cross with simple dominance inheritance pattern in which parents and progenies' phenotypes were given (MS2).

(iii) Monohybrid cross with codominance inheritance pattern in which phenotypes of parents and progenies were given (MC).

Four types of problems were used in the transfer tests (see Appendix E) of the study:

(i) Monohybrid cross with codominance inheritance pattern in which only phenotypes of progenies were given (MCT).

(ii) Monohybrid cross of simple dominance inheritance pattern shown in the form of pedigree. In these questions, the type of dominance and parents' genotypes were given (MP1).

(iii) Monohybrid cross of simple dominance inheritance pattern shown in the form of pedigree. In these questions, parents and progenies' phenotypes were given (MP2).

(iv) Monohybrid cross with inheritance patterns codominance and multiple allele (MC&MI).

Questions from the same types of problems were constructed in a way that the same procedural knowledge was needed in solving them.

6. Procedure

This research involved two pilot studies and a main study.

(i) Pilot studies

Two pilot studies were conducted. They tried to assess: (1) the validity and appropriateness of the practice materials and the test materials. (2) the number of problems of the same type that were needed within a practice block. (3) the degree of variability of the practice schedule arrangement that should be conducted.

The pilot studies with totally 43 subjects were carried out. A-level classes from Anglo-Chinese secondary schools in Kowloon and the New territories were involved. Subjects in each intact class were randomly assigned to different practice groups. Subjects had two / three days' practice of about an hour each day. Suggested solutions were given immediately after each practice. One day after the practice, a posttest was administered. Through these two pilot studies, six types of practice schedules and two sets of practice materials had been tried.

Two subjects were invited to participate in task-based interviews. The posttest materials were used in the interviews. They were asked to solve the problems in the "think-out-loud" mode and protocol sessions were audio-taped. The records were transcribed and analyzed.

The researcher analyzed the result of the pilot studies. The results of the pilot tests together with data gathered from the think-aloud interviews provided useful and valuable information for the design of the present research. As a result, important experimental factors such as the grade of subjects chosen, degree of randomization and length of treatment were taken into consideration in the main study.

(ii) The main study

The main study began once subjects had learnt the knowledge and concepts concerned. The main study was divided into pretest, practice schedule experiment, posttests and delay posttest. All the 264 Form five students in the study had the same pretest and delay posttest. The exercises and immediate posttests for the two groups were also identical in content. The exercises and immediate posttests for the two groups were different in arrangement only.

The pretest

The pretest (see Appendix D) was given a day before the practice schedule experiment and contained problems as shown in the table below:

Table 1

Types and number of problems appeared in the pretest

type of problem	number
MS1	1
MS2	1
MC	1

[M=monohybrid cross; S=simple dominance; C=codominance; 1=question in which the type of dominance and parents' genotypes were given; 2=question in which parents and progenies' phenotypes were given].

The results of the pretest were used to adjust the posttest scores only.

The practice schedule experiment

Participating subjects in each class were randomly assigned into two groups: the block practice group and the random practice group. In the block practice group, similar problems appeared in sequence in each practice. In the random practice group, two types of problems appeared at a random sequence in each practice. These formed the two independent variables (see Appendix E). There were three days of practice. In each day, subjects solved five problems which required about 35 minutes. Suggested solutions for the problems were given immediately after each practice. After the first and second practice, a posttest which took about 7 minutes were given. The posttests had questions testing acquisition. After the final practice, a posttest which tapped acquisition as well as transfer was given (see Appendix F). The scores of the acquisition questions and transfer questions of the posttests formed the dependent variables. The tables below show the types and numbers of problems that appeared in the two practice groups:

Table 2

Types and number of problems appeared in the practice sections and posttest of the block group

	day 1 type	no.	day 2 type	no.	day 3 type	no.
practice	MS1	5	MS2	5	MC	5
posttest	(A)MS1	2	(A)MS2	2	(A)MC	2
					(T)MCT	1
					(T)MP1	1
					(T)MP2	1
					(T)MC&MI	1

[M=monohybrid cross; S=simple dominance; C=codominance; C&MI= codominance and multiple allele; 1=question in which the type of dominance and parents' genotypes were given; 2=question in which parents and progenies' phenotypes were given; T=question in which only progenies' phenotypes were given; P=pedigree question; (A)=question test for acquisition; (T)=question test for transfer].

Table 3

Types and number of problems appeared in the practice sections and posttest of the random group

	day 1 type	no.	day 2 type	no.	day 3 type	no.
practice	MS1 MS2	3 2	MC MS1	3 2	MS2 MC	3 2
posttest	(A)MS1 (A)MS2	1 1	(A)MC (A)MS1	1 1	(A)MS2 (A)MC (T)MCT (T)MP1 (T)MP2 (T)MC&MI	1 1 1 1 1 1

[M=monohybrid cross; S=simple dominance; C=codominance; C&MI= codominance and multiple allele; 1=question in which the type of dominance and parents' genotypes were given; 2=question in which parents and progenies' phenotypes were given; T=question in which only progenies' phenotypes were given; P=pedigree question; (A)=question test for acquisition; (T)=question test for transfer].

The delay posttest

A delay posttest (see Appendix F) was given a week after the third posttest. The delayed posttest contained problems as shown in the table below:

Table 4

Types and number of problems appeared in the delay posttest

type of problem	number
(A)MS1	2
(A)MS2	1
(A)MC	1
(T)MCT	1
(T)MP1	1
(T)MP2	1
(T)MC&MI	1

[M=monohybrid cross; S=simple dominance; C=codominance; C&MI= codominance and multiple allele; 1=question in which the type of dominance and parents' genotypes were given; 2=question in which parents and progenies' phenotypes were given; T=question in which only progenies' phenotypes were given; P=pedigree question; (A)=question test for acquisition; (T)=question test for transfer].

The experimental manipulations, therefore, resulted in a 2(practice conditions) X 2(test types) X 2(test time) factorial design with the pretest as a covariate.

Collection of protocol data

Interviews were performed with six of the subjects. Only subjects who had tried to answer all transfer questions in the immediate posttest were considered. Three of them were selected from the block group and the remaining three were from the random groups. Owing to the administration difficulty, all subjects were girls. They were selected according to their scores in the posttests. It was expected that subjects in the block group were comparable to subjects in the random group. In each group, there were two students with high scores and a student with an average score in the acquisition tests. Their scores were either fairly good or moderately poor in the transfer tests within their group.

Two task-based interviews were held for each subject. The first interview was administered within the week just following the three-day treatments. Problems in the delay posttest were used as task in the first protocol sessions. These six subjects were not required to sit for the delay posttest. Their delay posttest scores were regarding as missing in statistical analysis. The transcripts of the think-aloud record (see Appendix H) and the worksheets used by the students were analyzed. Problems for the second interviews (see Appendix G) were constructed to clarify the problem-solving patterns of the acquisition problems only. In the second protocol, subjects solved three lengthened questions which were similar to the acquisition problems. Their protocols were audio-taped, transcribed and analyzed as before.

The protocol analysis aimed at exploring problem-solving procedures only. Patterns of problem-solving procedures in the acquisition problems were analyzed. Effects of training on transfer performance were also examined. The problem-solving processes of subjects were analyzed in the following manner:

(i) initial data interpretation

(ii) factors in the initial data that influenced hypothesis generation

(iii) when and on what basis hypotheses were generated

(iv) the means (qualitative or quantitative) that subjects used to interpret data

(v) the inferences subjects made

(vi) the nature of the justifications and solution confirmation procedures (Slack and Steward, 1990).

7 Data analysis

(i) The practice schedule experiment

The following procedures for data analysis were taken:

1. The reliability of the pretest and the posttests were analyzed.

2. A one-way MANCOVA with treatment as between-group factor, type of tests (acquisition and transfer) and time conditions (immediate and delayed) as within-group factors was conducted using scores in the posttest as dependent variables and scores in the pretest as covariate. In view of the result, the following analyses were conducted:

(i) A one-way MANCOVA was conducted on the immediate posttests scores with treatment (block and random) as between-group factors and type of tests (acquisition and transfer) as within-group factors using the pretest scores as covariate.

(ii) A one-way MANCOVA was conducted on the delayed posttests scores with treatment (block and random) as between-group factors and type of tests (acquisition and transfer) as within-group factors using the pretest scores as covariate.

(iii) A one-way MANCOVA was conducted on the acquisition posttests scores with treatment (block and random) as between-group factors and time conditions (immediate and delayed) as within-group factors using the pretest scores as covariate.

(iv) A one-way MANCOVA was conducted on the transfer posttests scores with treatment (block and random) as between-group factors and time conditions (immediate and delayed) as within-group factors using the pretest scores as covariate.

(v) One-way ANCOVA was conducted on the acquisition scores of the immediate posttest between the two groups using the pretest scores as covariate.

(vi) One-way ANCOVA was conducted on the transfer scores of the immediate posttest between the two groups using the pretest scores as covariate.

(vii) One-way ANCOVA was conducted on the acquisition scores of the delayed posttest between the two groups using the pretest scores as covariate.

(viii) One-way ANCOVA was conducted on the transfer scores of the delayed posttest between the two groups using the pretest scores as covariate.

(ii) The protocol

The audiotaped protocols were transcribed and the written answers were matched with the transcripts. The actions and comments generated by the subjects were noted. Steps such as data redescription, hypothesis generation, performing cross and giving solution were identified (Collined 1986; Slack and Steward, 1990; Smith, 1988). Problem-solving procedures were examined carefully to determine whether goals or subgoals were formed in the process. Common patterns such as working forward and means-ends analysis were analyzed. Differences between subjects from the two groups were distinguished.

Chapter IV

Analysis and Result

1. Statistical analysis of tests scores

The 264 subjects from 7 intact classes were randomly assigned to the two experimental groups. The block group had 133 subjects with 61 boys and 72 girls. The random group had 131 subjects with 70 boys and 61 girls. The marks in all the tests were adjusted into percentage scores before analyzed.

(i) Reliability

The reliability of the tests was conducted to test the internal consistency of the questions. Results indicated that Cronbach alpha of pretest, acquisition posttest, transfer posttest, delayed acquisition posttest and delayed transfer posttest were consistently high (see Table 5).

Table 5

Cronbach alpha for the reliability of the pretest, immediate acquisition posttest, immediate transfer posttest, delayed acquisition posttest and delayed transfer posttest

Test	Number of items	ALPHA
pretest	3	.8068
immediate acquisition posttest	6	.8025
immediate transfer posttest	4	.7010
delayed acquisition posttest	4	.8129
delayed transfer posttest	4	.7379

(ii) Comparison of the problem solving test scores between the two groups

The first two posttests and the first two questions in the third posttests and the first four questions in the delayed posttest tested for acquisition. Subjects generally performed very well in the acquisition tests. Performance in the simple dominance monohybrid cross with parents and F1's phenotype given (MS2) were not so good as the other two types of problem (see Table 6).

Table 6

Means and standard deviations for the acquisition posttests

Question	M	SD	N
Immediate acquisition posttest:			
MS1 - Q1	8.36	2.76	256
MS1 - Q2	8.92	2.13	255
MS2 - Q1	7.51	2.57	258
MS2 - Q2	8.20	2.32	260
MC1 - Q1	8.43	3.11	262
MC1 - Q2	8.46	2.76	259
Total Average	8.33	1.85	247
Delayed acquisition posttest:			
MS1 - Q1	8.67	2.68	246
MS1 - Q2	8.80	2.45	246
MS2	6.65	2.79	246
MC1	8.68	2.82	246
Total Average	8.02	2.21	246

The last four questions in the third posttest and delayed posttest tested transfer. Question 3 and question 5 in posttest 3B and 3R, and question 8 and question 6 in delayed posttest were designed to test for vertical transfer. While questions 4 and 6 in posttest 3B and 3R, and questions 5 and 7 in delayed posttest were designed to test for lateral transfer.

Question 3 in posttest 3B and 3R, and question 8 in delayed posttest were designed to test for near transfer. They were "monohybrid cross with codominance inheritance pattern" in which only phenotypes of progenies were given (MCT). Question 5 in posttest 3B and 3R, and question 6 in delayed posttest were designed to test for far transfer. They were exactly the same question in both tests and the question was "monohybrid cross with inheritance patterns codominance and multiple allele" (MC&MI).

Questions 4 and 6 in posttest 3B and 3R, and questions 5 and 7 in delayed posttest were "monohybrid cross of simple dominance inheritance pattern shown in the form of pedigree". For question 4 in posttest 3B and 3R, and question 5 in delayed posttest, the type of dominant and parents' genotypes were given (MP1). Only parents and progenies' phenotypes were given for question 6 in posttest 3B and 3R, and question 7 in delayed posttest (MP2). It was expected that question 4 in posttest 3B and 3R, and question 5 in delayed posttest (MP1) were easier than question 6 in posttest 3B and 3R, and question 7 in delayed posttest (MP2).

The statistical analysis of the scores coincided with the researchers' expectation in terms of item difficulty (see Table 7).

Table 7

Means and standard deviations for the transfer posttests

Question	M	SD	N
Immediate transfer posttest:			
MCT	6.81	3.52	263
MP1	4.39	2.69	263
MP2	3.11	2.13	263
MC&MI	.94	.92	263
Total Average	3.18	1.92	263
Delayed transfer posttest:			
MCT	5.91	4.21	244
MP1	4.07	2.37	244
MP2	3.85	2.77	244
MC&MI	.70	.63	244
Total Average	3.63	2.17	244

To compare the general performance of the two groups, mean and standard deviation of the percentage scores of all the tests for the two groups were computed. The results are shown in Table 8.

Table 8

<u>Means and standard deviations for pretest, immediate acquisition posttest, immediate transfer posttest, delayed acquisition posttest and delayed transfer posttest performance in each group</u>

Test	Group	M	SD	N
pretest	block	5.48	2.99	132
	random	5.59	2.65	131
immediate posttests:				
acquisition	block	8.66	1.65	125
	random	7.98	1.99	122
transfer	block	3.35	1.91	133
	random	4.29	1.81	130
delayed posttests:				
acquisition	block	7.94	2.35	122
	random	8.10	2.06	124
transfer	block	3.19	2.07	122
	random	4.07	2.18	122

(iii) Effects of treatment groups, test types and time conditions on the performances

As mentioned earlier, the results of the pretest were used to control the initial differences statistically. A one way - Treatment groups (block and random) MANCOVA with repeated measure on the Type of tests (acquisition and transfer) and Time conditions (immediate and delayed posttests) was then conducted using scores in the posttests as dependent variables and scores in the pretest as a covariate. In the MANCOVA test, 229 cases were accepted and there were 116 cases in the block group and 113 cases in the random group.

For both groups, the immediate posttest performances were better than the delayed posttest performances and the difference was statistically significant [$F(1,227)=9.76$, $p<.005$]. Acquisition was better than transfer in the two tests for both groups and the difference was statistically significant as well [$F(1,227)=36.39$ $p<.001$]. There was significant three-way interaction [$F(1,227)=15.69$ $p<.001$] in treatment groups (block and random) by time conditions (immediate and delayed) by type of tests (acquisition and transfer). This result indicated that the practice schedule (block and random) had different effects on different types of tests (acquisition and transfer) at different points of time (immediate and delayed) (see Table 9).

Table 9

Means and standard deviations for immediate acquisition posttest, immediate transfer posttest, delayed acquisition posttest and delayed transfer posttest in each group

	immediate posttest				delayed posttest		
	M	SD	N		M	SD	N
block							
acquisition	8.774	1.493	116	acquisition	7.995	2.335	116
transfer	3.568	1.821	116	transfer	3.258	2.051	116
random							
acquisition	8.108	1.934	113	acquisition	8.157	2.063	113
transfer	4.369	1.789	113	transfer	4.051	2.235	113

One-way MANCOVA with repeated measure was conducted. There was no significant difference [$F(1,243)=.01, p>.05$] between the two treatment groups (block and random) when the two types of tests (immediate acquisition posttest and immediate transfer posttest) were analyzed together. There was significant difference [$F(1,244)=2618.84, p<.001$] between the two types of tests (immediate acquisition posttest and immediate transfer posttest) when the two treatment groups (block and random) were analyzed together. There was significant two-way interaction [$F(1,244)= 68.59$ $p<.001$] in treatment groups (block and random) by the type of tests (immediate acquisition posttest and immediate transfer posttest).

It was found that block group had higher score in the immediate acquisition posttests but got lower score in the immediate transfer posttest when compared with the random group (see Figure 3).

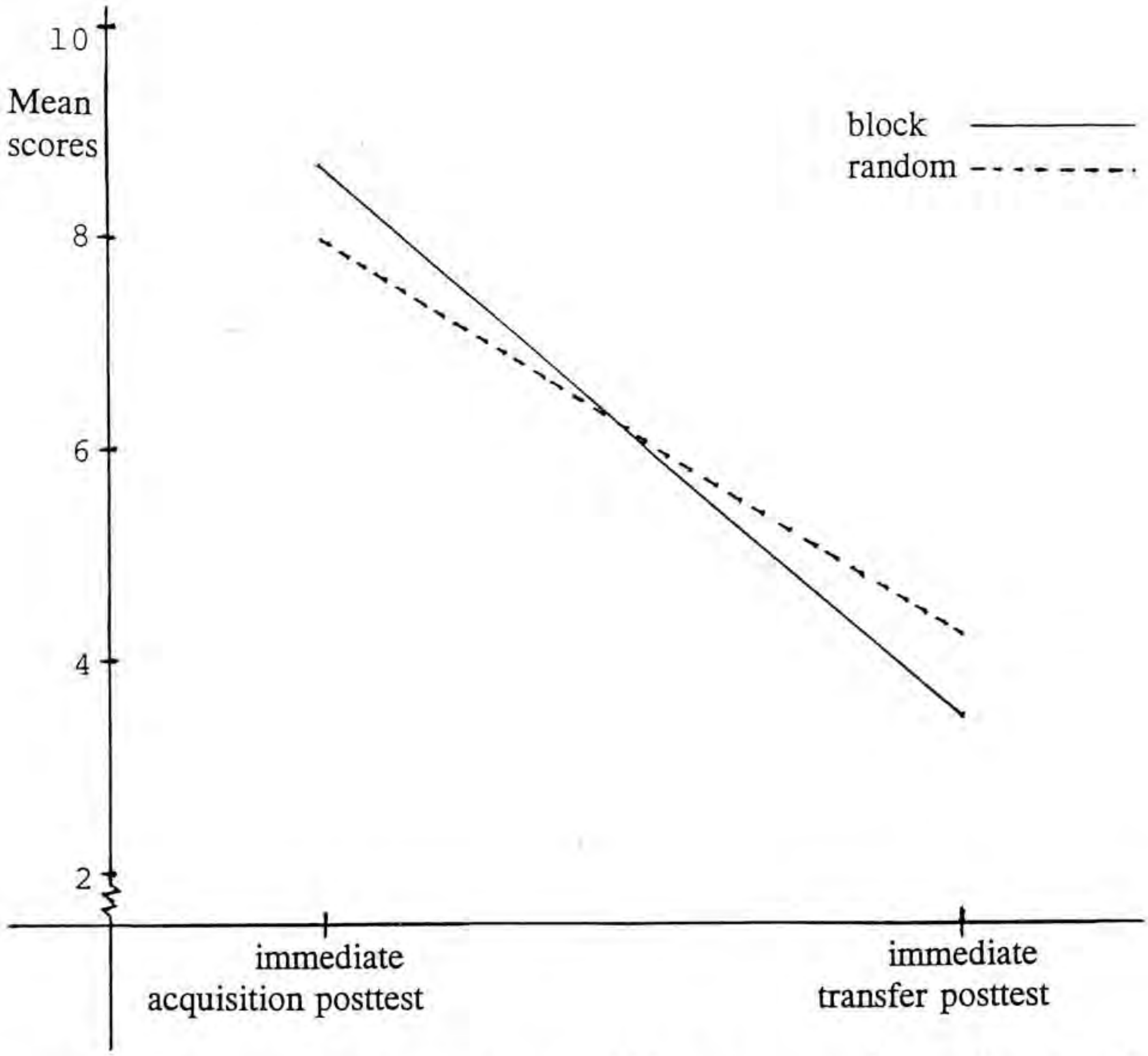


Figure 3. Mean scores for immediate acquisition posttest and immediate transfer posttest in each group.

There was no significant difference [$F(1,240)=3.78$, $p>.05$] between the two treatment groups (block and random) when the two types of tests (delayed acquisition posttest and delayed transfer posttest) were analyzed together. There was significant difference [$F(1,241)= 1686.40$, $p<.001$] between the two types of tests (delayed acquisition posttest and delayed transfer posttest) when the two treatment groups (block and random) were analyzed together. There was significant interaction [F(1,241)= 12.15 p<.005] in treatment groups (block and random) by the type of tests (delayed acquisition posttest and delayed transfer posttest). However, scores of the random group were higher than scores of the block group in both delayed tests (see Figure 4).

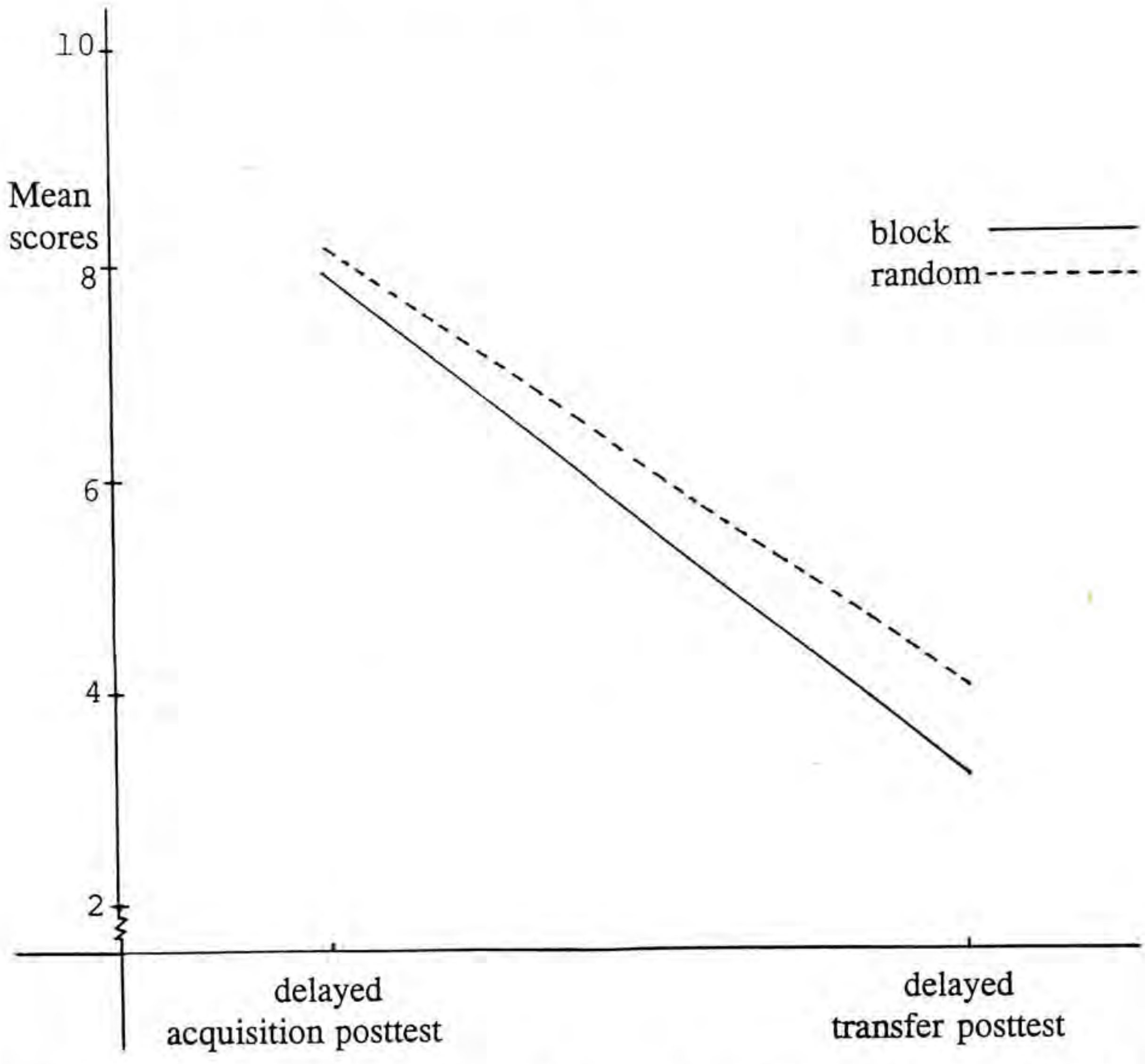


Figure 4. Mean scores for delayed acquisition posttest and delayed transfer posttest in each group.

There was no significant difference [F(1,228)=2.63, p>.05] between the two treatment groups (block and random) when acquisition tests of different time conditions (immediate acquisition posttest and delayed acquisition posttest) were analyzed together. There was significant difference [$F(1,229)=14.60$, $p<.001$] between the two time conditions (immediate acquisition posttest and delayed acquisition posttest) when the two treatment groups (block and random) were analyzed together. There was significant interaction [$F(1,229)=19.52$ $p<.001$] in treatment groups (block and random) by time conditions (immediate acquisition posttest and delayed acquisition posttest). The block group got higher scores than the random group in the immediate acquisition posttest. In the delayed acquisition, the random group outperformed the block group. For the random group, scores in delayed acquisition posttest were a little higher than scores in the immediate acquisition posttest (see Figure 5).

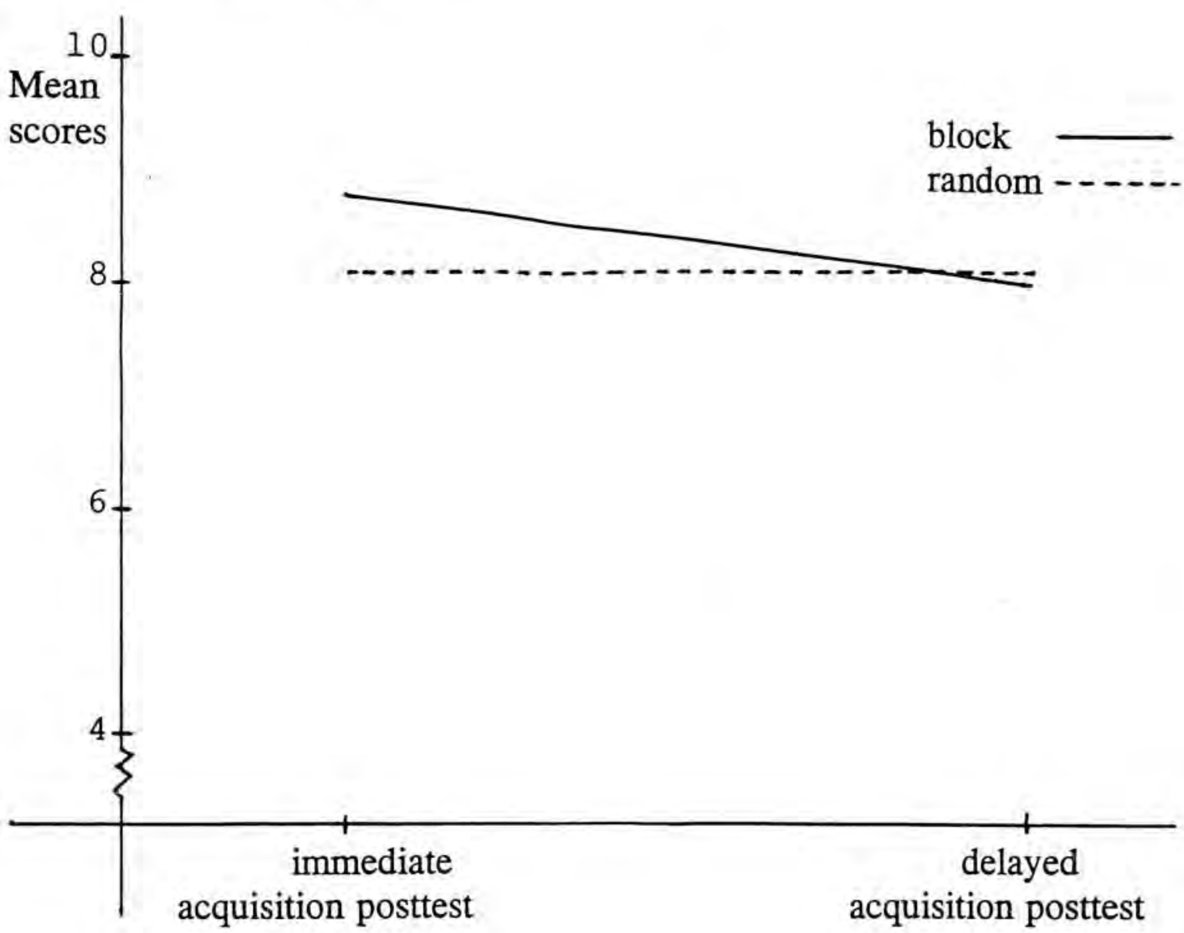


Figure 5. Mean scores for immediate acquisition posttest and delayed acquisition posttest in each group.

There was significant difference [F(1,239)=12.99, p<.001] between the two treatment groups (block and random) when transfer tests of different time conditions (immediate transfer posttest and delayed transfer posttest) were analyzed together. There was also significant difference [F(1,240)=20.00, p<.001] between the two time conditions (immediate transfer posttest and delayed transfer posttest) when the two treatment groups (block and random) were analyzed together. There was no significant interaction [F(1,240)=.08, p>.05] in treatment groups (block and random) by time conditions (immediate transfer posttest and delayed transfer posttest). Scores of the random group were higher than scores of the block group in both transfer tests (see Figure 6).

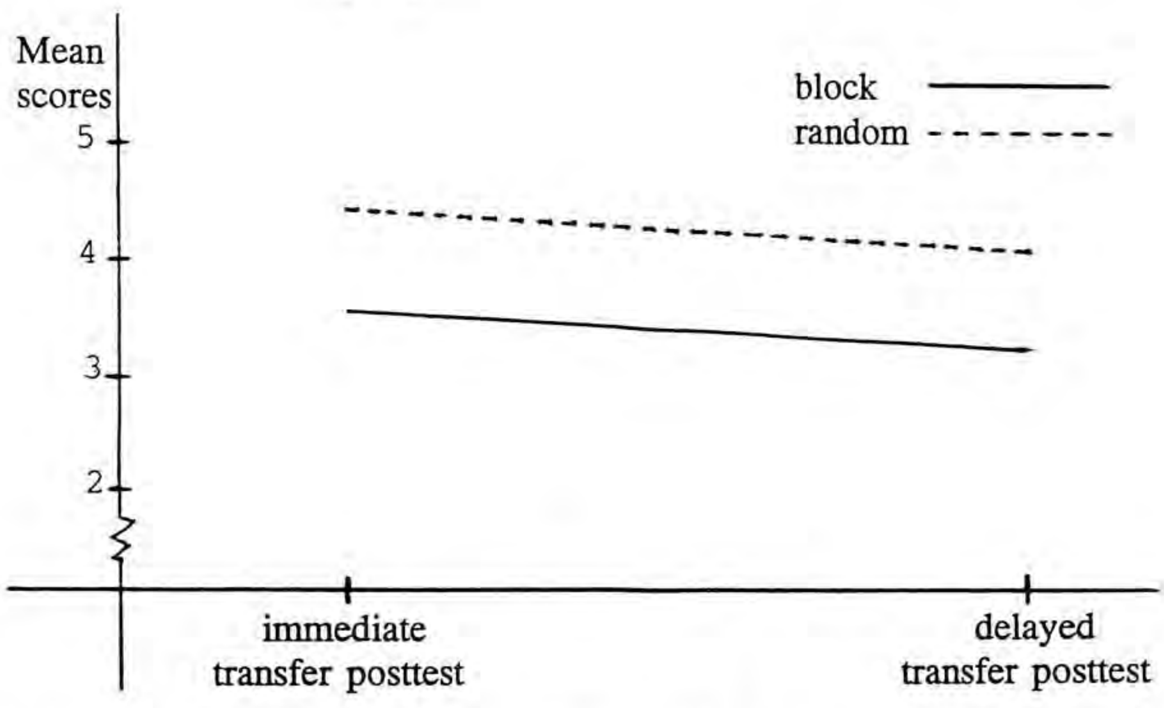


Figure 6. Mean scores for immediate transfer posttest and delayed transfer posttest in each group.

One way ANCOVA was conducted to verify the above findings. The block group performed better in the immediate acquisition posttest and the difference was statistically significant [F(1,244)=11.105 p<.001]. The random group performed better in the delayed acquisition posttest, immediate transfer posttest and delayed transfer posttest. The differences of the two transfer posttests reached the level of statistical significance [$F(1,261)=15.399$ $p<.001$ in immediate transfer posttest and $F(1,242)=9.351$ $p<.005$ in delayed transfer posttest]. Whereas in the delay acquisition posttest, difference between the two groups did not reach the .05 alpha level of significance criterion.

2. Analysis of the protocol

(i) Problem-solving procedures

(A) in acquisition problems

In the first interview, the first four questions assessed acquisition levels. Question 1 and Question 3 were simple dominance monohybrid cross with type of dominance and parents' genotypes given (MS1). Question 1 stated the dominant character but Question 3 gave the recessive character. Question 2 was codominance monohybrid cross with parents and F1's phenotype given (MC). Question 4 was simple dominance monohybrid cross with parents and F1's phenotype given (MS2). The problem-solving procedure for these three types of problem are stated below.

1. "Simple dominance monohybrid cross" with type of dominance and parents' genotypes given (MS1):

[1] assign symbols to represent genotypes of parents.

[2] make the cross.

[3] assign phenotypes for F1.

2. "Simple dominance monohybrid cross" with parents and F1's phenotypes given (MS2):

[1] determine the dominant character.

[2] determine parents' genotypes and assign symbols to represent them.

[3] make the cross.

[4] assign phenotypes for F1.

3. "Codominance monohybrid cross" with parents and F1's phenotypes given (MC):

[1] determine parents' genotypes and assign symbols to represent them.

[2] make the cross.

[3] assign phenotypes for F1.

(B) in transfer problems

In the first interview, the last four questions tested transfer. Question 8 was the "monohybrid cross with codominance inheritance pattern" in which only phenotype of progenies were given (MCT). Question 5 and 7 were both "monohybrid cross of simple dominance inheritance pattern shown in the form of pedigree". In Question 5, the type of dominance and parents' genotypes were given (MP1). Only parents and progenies' phenotypes were given in Question 7 (MP2). Question 6 was on "monohybrid cross with inheritance patterns codominance and multiple allele" (MC&MI). The problem-solving procedures for these four types of problems are stated below.

1. "Monohybrid cross with codominance inheritance pattern" in which

only phenotypes of progenies were given (MCT):

[1] determine genotypes of F1.

[2] determine genotypes of parents.

[3] determine phenotypes of parents and the kind of dominance.

2. "Monohybrid cross of simple dominance inheritance pattern in pedigree" with the type of dominance and parents' genotypes given (MP1):

[1] determine that genotype of 1 is Rr because 1 and 2 (rollers) produce a non-roller (recessive).

[2] determine that genotype of 3 can be RR and Rr because both can produce a roller with 4.

[3] determine that genotype of 4 (recessive phenotype) is rr.

[4] make the cross of 1 and 2.

[5] determine the probability of 5 being heterozygote.

3. "Monohybrid cross of simple dominance inheritance pattern in pedigree" with only parents and progenies' phenotypes given (MP2):

[1] determine that normal is the dominant character because normal parent can produce short-sighted progeny.

[2] determine genotypes of 1 and 2.

[3] make the cross of 1 and 2.

4. "Monohybrid cross with inheritance patterns codominance and multiple

allele" (MC&MI):

[1] determine the kind of dominance.

[2] determine genotypes of parents.

[3] make the cross.

[4] determine genotypes of F1.

(C) in lengthened acquisition problems

In the second interview, the problems were lengthened acquisition problems (see Appendix G). Question 1 was simple dominance monohybrid cross with type of dominance and parents' genotypes given (MS1). However, it involved two successive generations and stated the recessive character . Question 2 was simple dominance monohybrid cross with parents and F1's phenotypes given (MS2). Again, students had to solve two successive generations. Question 3 was about codominance monohybrid cross with parents and F1's phenotypes given (MC). It also involved two successive generations. The problem-solving procedure for these three problems are stated below.

1. "Simple dominance monohybrid cross" with type of dominance and parents' genotypes given-lengthen (L-MS1):

[1] assign symbols to represent the genotypes of parents.

[2] make the cross.

[3] assign phenotypes for F1.

[4] assign symbols to represent the genotypes of parents (which are F1) in the second cross.

[5] make the cross.

[6] assign phenotypes for F2.

2. "Simple dominance monohybrid cross" with parents and F1's phenotypes given-lengthen (L-MS2):

[1] determine the dominant character.

[2] determine parents' genotypes and assign symbols to represent them.

[3] make the cross.

[4] assign phenotypes for F1.

[5] assign symbols to represent the genotypes of parents (which are F1 and a recessive) in the second cross.

[6] make the cross.

[7] assign phenotypes for F2.

3. "Codominance monohybrid cross" with parents and F1's phenotypes given-lengthen (L-MC):

[1] determine parents' genotypes and assign symbols to represent them.

[2] make the cross.

[3] assign phenotypes for F1.

[4] assign symbols to represent the genotypes of parents (which are F1) in the second cross.

[5] make the cross.

[6] assign phenotypes for F2.

(ii) Problem-solving performance

(A1) Acquisition in the block group

Parents' genotype symbol chunked well with the cross and phenotypes of F1. All 3 subjects were observed to "work forward" in solving these parts for both Question 1 and 3 (MS1). In assigning symbols to represent the genotypes of parents, subjects <B1> and <B2> were observed to "work forward" in Question 1 but only subject <B3> worked forward in Question 3.

In Question 4 (MS2), subject <B3> worked forward for the whole problem. Subject <B2> worked by "means-ends analysis" in determining the kind of dominance and the parents' genotypes. Subject <B1> got the type of dominance once she read the question. However, she was considered to solve the whole problem by "means-ends analysis". She checked and copied answers from her previous work.

In Question 2 (MC), subjects <B1> and <B2> worked forward for the whole problem. Subject <B3> showed chunking only in making the cross from parents' genotypes symbol. "Means-ends analysis" was used in deciding parents' genotypes and assigning phenotypes of F1.

(A2) Acquisition in the random group

In Questions 1 (MS1), all 3 subjects were observed to "work forward" for the whole problem. In Question 3 (MS1), only <R1> and <R2> worked forward for the whole problem. Subject <R3> had to use "means-ends analysis" in finishing the cross.

In Question 4 (MS2), subjects <R1> was observed to "work forward" for the whole problem. Subject <R2> and <R3> used "means-ends analysis" to determine the dominant character but worked forward for the rest of the problem.

In Question 2 (MC), <R1> worked forward while <R2> and <R3> had to used "means-ends analysis" in deciding the parents' genotypes. Parents' genotypes symbols chunked well with the cross and all 3 subjects were observed to "work forward" in solving this part. In assigning phenotypes of F1, <R3> worked forward while <R1> and <R2> used "means-ends analysis".

(A3) Overall acquisition performance

For subjects in both groups, parents' genotypes symbols seemed to chunk well with the cross for all types of problems. Subjects in the random group seemed to have greater difficulty in solving codominance problem. They were weaker in determining phenotypes from genotypes symbols for codominance problems (See Table 10).

Table 10

A summary of the performance of interviewed subjects in acquisition problems

Q1 (MS1)	B1	B2	B3	R1	R2	R3
[1] assign symbols to represent the genotypes of parents.	F	F	M	F	F	F
[2] make the cross.	F	F	F	F	F	F
[3] assign phenotypes for F1.	F	F	F	F	F	F
Solution	R	R	W	R	R	R

Q3 (MS1)	B1	B2	B3	R1	R2	R3
[1] assign symbols to represent the genotypes of parents.	M	M	F	F	F	F
[2] make the cross.	F	F	F	F	F	M
[3] assign phenotypes for F1.	F	F	F	F	F	F
Solution	R	R	R	R	R	R

Q4 (MS2)	B1	B2	B3	R1	R2	R3
[1] determine the dominant character.	M	M	F	F	M	M
[2] determine parents' genotypes and assign symbols to represent them.	M	M	F	F	F	F
[3] make the cross.	M	F	F	F	F	F
[4] assign phenotypes for F1.	M	F	F	F	F	F
Solution	R	R	R	R	R	R

Q2 (MC)	B1	B2	B3	R1	R2	R3
[1] determine parents' genotypes and assign symbols to represent them.	F	F	M	F	M	M
[2] make the cross.	F	F	F	F	F	F
[3] assign phenotypes for F1.	F	F	M	M	M	F
Solution	R	R	P	R	R	R

Note. "F" represents "work forward". "M" represents "means-ends analysis". "R" indicates the solution is correct. "W" indicates the solution is wrong. "P" indicates part of the solution is wrong.

(B1) Transfer in the block group

In Question 8 (MCT), subjects <B1> and <B2> were observed to "work forward" for the whole question. Subject <B3> got genotypes of parents' and F1 immediately. But subject <B3> made mistakes in determining type of dominance and was wrong in parents' phenotypes.

In Question 5 (MP1), subjects used "means-ends analysis" in most of their problem-solving. All 3 subjects got correct genotype for 1, but explanation of subjects <B1> and <B3> were incomplete. In finding genotype of 3, they all got one of the 2 possible answers (RR) only. Although all three subjects' answers for 5(ii) were incorrect, subjects <B1> and <B2> had right concepts about the cross concerned. Generally speaking, they all seemed to be firmly restricted by the typical progeny ratio of the cross especially for subjects <B1> and <B3>. Subject <B1> was the weakest among the three. She was misled by the male and female symbols. She got the wrong concept that the mother had greater influence on the daughter and the father had greater influence on the son. Subject <B3> was also confused when the ratio differed from the theory. She resolved this problem by avoiding using cross in her explanation.

All three subjects used "means-end analysis" in solving question 7 (MP2). They were still affected by the typical progeny ratio of the cross especially for subject <B2>. They all got the right kind of dominance but their reason was not completely right. Subject <B1> referred to her previous works in the acquisition problems in her decision. In determining genotypes of 1 and 2, subject <B2> made one correct guess in the protocol. However, she could not make the final decision because she thought that information was insufficient. Subject <B3> was the best among the 3 in this problem. In addition to getting the right genotype for 1 and 2, her explanation was correct.

In Question 6 (MC&MI), subject <B1> recognized the problem and retrieved the solution while subjects <B2> and <B3> used "means-end analysis". In the posttest, subject <B1> only knew that parents should be heterozygote and could not solve the problem. However, subject <B1> had found the solution before the interview. Subject <B2> also knew that parents should be heterozygote in the posttest but could not make a decision in the interview. Subject <B3> was very sure that parents were heterozygote. Her answer was only partly correct as she used only 2 kinds of genes.

(B2) Transfer in the random group

In Question 8 (MCT), subjects <R1> and <R2> worked forward in part of their problem-solving. "Means-ends analysis" was observed when subject <R1> searched for parents' genotypes and subject <R2> got parents' phenotypes. Subject <R3> solved the whole problem by "means-ends analysis".

In Question 5 (MP1), subjects <R1> and <R2> worked forward in most of their solution. <R1> used "means-ends analysis" in finding the genotype of 3 only while <R2> used "means-ends analysis" in finding the genotype of 1. They were not restricted by the progenies' ratio. Besides getting correct genotype for individual 1, their explanation was complete. They got both two possible answers for 3 and subject <R1> even answered 5(ii) correctly. Subject <R3> was very weak in answering this problem. She had no idea about how to solve the problem at first. At the beginning, when finding genotype for 1, she just guessed. Her concept in answering 5(ii) was wrong too.

In Question 7 (MP2), subject <R1> worked forward to get all the answers except explaining the dominant character. Subject <R2> had to use "means-ends analysis" to find the genotype of 1. Subject <R3> found all the answers by "means-ends analysis". Besides, subjects <R2> and <R3>'s explanation for the dominant character were not completely correct.

Subjects <R1> and <R3> worked forward while <R2> used "means-ends analysis" in solving Question 6 (MC&MI). Subject <R2> solved the problem correctly in both the posttest and interview. Subjects <R1> and <R3> only knew that parents should be heterozygote and could not solve the problem in the immediate posttest. But they had found the solution before the interview.

(B3) Overall transfer performance

In Question 8 (MCT), training seemed to have positive effect on transfer in both groups. The block group, however, performed better. In Question 5 (MP1) and 7 (MP2), the effect of training on transfer was not so good for the three subjects in the block group. Set effect and confusion were observed. As for the random group, positive transfer occurred in Question 5 and 7 and they performed better. In Question 6 (MC&MI), though some subjects could not solve the problem, all six subjects knew that parents were heterozygote. Their performance could, therefore, be considered as positive transfer.

(C1) Performance of the block group in lengthened acquisition problems

Subjects <B1> and <B2> were observed to "work forward" in Question 1. Subject <B3> had to use "means-ends analysis" in determining parents' genotypes in symbols and to decide F1's phenotypes. Subject <B3> "worked forward" in both two crosses and in determining F2's phenotypes.

In Question 2, all 3 subjects showed chunking in only part of the problem. Subject <B1> had to use "means-ends analysis" in determining one of the parents' genotypes in the second cross. Subject <B2> worked by "means-ends analysis" in determining the kind of dominance and also the parents' genotypes in the first cross. Subject <B3> got parents' genotypes in the first cross by "means-ends analysis".

In Question 3, subjects <B1> and <B3> worked forward for the whole problem. Subjects <B2> worked forward except for assigning the phenotypes of F2.

(C2) Performance of the random group in lengthened acquisition problems

In Question 1, all 3 subjects were observed to "work forward" for the whole problem.

In Question 2, subject <R1> used "means-ends analysis" to determine the dominant character. Subject <R2> used "means-ends analysis" to determine the dominant character and parents' genotypes. Subject <R3> used "means-ends analysis" to determine parents' genotypes. They worked forward for the rest of the problem.

In Question 3, subject <R1> had to use "means-ends analysis" to decide the phenotypes of F2. Subject <R2> had to use "means-ends analysis" to decide the parents' genotypes. Only subject <R3> was observed to "work forward" in all her solutions.

(C3) Overall performance in lengthened acquisition problems

Question 2 was the most difficult for all the subjects. The original problem (MS2) involved the greatest number of steps among the three. Lengthening it might make it too complicated to be in the working memory at the same time. Again, parents' genotypes symbols seemed to chunk well with the cross for all subjects in all the problems. Subjects in the random group seemed to work better in Question 1 (L-MS1) but have greater difficulty in Question 3 (L-MC) (See Table 11).

Table 11

A summary of the performance of interviewed subjects in lengthen acquisition problems

Q1 (L-MS1)		B1	B2	B3	R1	R2	R3
[1]	assign symbols to represent the genotypes of parents.	F	F	M	F	F	F
[2]	make the cross.	F	F	F	F	F	F
[3]	assign phenotypes for F1.	F	F	M	F	F	F
[4]	assign symbols to represent parents' genotypes in the 2nd cross.	F	F	F	F	F	F
[5]	make the cross.	F	F	F	F	F	F
[6]	assign phenotypes for F2.	F	F	F	F	M	F
Solution		R	R	R	R	R	R

Q2 (L-MS2)		B1	B2	B3	R1	R2	R3
[1]	determine the dominant character.	F	M	M	M	M	M
[2]	determine parents' genotypes and assign symbols to represent them.	F	F	M	F	M	M
[3]	make the cross.	F	F	F	F	F	M
[4]	assign phenotypes for F1.	F	F	F	F	F	M
[5]	assign symbols to represent parents' genotypes in the 2nd cross.	M	M	M	M	M	F
[6]	make the cross.	F	F	M	F	M	F
[7]	assign phenotypes for F2.	F	F	M	F	M	F
Solution		R	R	R	R	R	R

Q3 (L-MC)		B1	B2	B3	R1	R2	R3
[1]	determine parents' genotypes and assign symbols to represent them.	F	F	M	F	M	M
[2]	make the cross.	F	F	F	F	F	F
[3]	assign phenotypes for F1.	F	F	F	F	F	F
[4]	assign symbols to represent parents' genotypes in the 2nd cross.	F	F	F	F	F	F
[5]	make the cross.	F	F	F	F	F	F
[6]	assign phenotypes for F2.	F	M	F	F	F	F
Solution		R	R	R	R	R	R

Note. "F" represents "work forward".
"M" represents "means-ends analysis".
"R" indicates the solution is correct.

3 Discussion

Findings of this study are consistent with the prior research on the learning of motor skill (Shea and Morgan, 1979; Wrisberg and Liu, 1991) and the learning of cognitive procedural skill (Carlson and Yaure, 1990). Block practice in genetic problems produced better acquisition in immediate posttests. However, retention and transfer were better for subjects who received random practice during training. These results generalize the findings of previous research to classroom teaching and learning environment. They demonstrate the effect of practice schedule on genetic problems which is a domain specific problem solving task.

(i) Acquisition

Acquisition performance was better in block than in random practice schedule. In the block practice, subjects had to learn just one type of problem. Problems were consistent in their structure but varies in data e.g. parents' genotypes. As they required the same problem solving procedure, this condition facilitated learning particularly in acquiring the problem solving procedures. In the random practice, subjects had to solve two types of problems. Learning how to solve the problems as well as differentiating the type of problems occurred at the same time. Acquisition was, therefore, weaker in random practice schedule (Carlson and Yaure, 1990).

Protocol analysis were used to obtain information about the problem-solving procedure of the subjects. In the protocol analysis, "working forward" was frequently observed among the good performers in both two groups. "Working forward" was the result of knowledge compilation in ACT* theory. In the ACT* theory, practice will lead to proceduralization. Data in the question statement will build into the domain specific productions. After that, repeated practice of the same type will lead to collapse of productions in the sequence. Productions for solving the problem is chunked into a macroproduction (Anderson, 1987).

If a subject read "In common pea, long stem is dominant to short stem", she immediately said "Big letter 'L' for long stem and small letter 'l' for short stem". After reading "A heterozygous long stem pea is crossed with short stem plant", she could decide parents' genotypes, made the cross and determined phenotypes in F1 immediately. She is said to be "working forward" for the whole problem. This showed that data in the problem had stimulated retrieval of the marcoproduction in subject's mind.

Lengthened acquisition problems were used to confirm subjects problem solving procedure in the acquisition problems. "Working forward" was observed in subjects from both groups. Evidence of "working forward" were also observed in the good performers in the random group. Higher order consistency such as consistency in hierarchical goal structure might be enough to produce learning effects that followed the ACT* theory (Anderson, 1987). The frequency of chunking also followed the amount of practice. As the same parents' genotypes always follows the same type of cross for all problems. Chunking was most frequently observed between parents' genotypes and cross.

(ii) Retention

Performance in the delayed posttests were better in random than in block practice schedule. When delayed acquisition posttest and delayed transfer posttest was analyzed separately by ANCOVA, only the delayed transfer posttest reach the .05 alpha level of significance.

In the block practice, problems in each practice varied only in data. After the first trial, productions for solving all the problems were in the working memory. The level of processing was reduced. There was less training in distinguishing between different types of problems. Whereas in each random practice, two types of problems appeared randomly. Procedures of productions in the working memory might not be similar or suitable for solving the problems. Subjects had to retrieve appropriate productions from the long term memory for each problem encountered. This deeper processing may account for the better retention in the random group (Carlson and Yaure, 1990; Lee, 1983; Cuddy and Jacoby, 1982). Random practice also allowed the differentiated and consecutive production step to stay in the working memory at the same time. Subject could compare and contrast the productions to be learned and so advance the production organization and consolidation in the long term memory. Recognition and retrieval of the productions would thus be facilitated (Shea & Morgan, 1979; Shea & Zimny, 1983, 1988).

(iii) Transfer

Transfer occurred in both groups. This result supported Anderson's ACT* theory. Anderson stated that transfer occurs when there is overlapping in productions between two tasks (Anderson, 1987). However, transfer performance of the random group was better than the block group in both the immediate transfer posttest and delayed transfer posttest. Transfer seems to be also greatly affected by the practice schedules in which component productions are acquired as discovered by Carlson and Yaure (1990).

Carlson and Yaure (1990) suggested that intraitem processing and interitem processing were both enhanced in random practice schedule. Subjects in the random group had to retrieve appropriate productions from the long term memory in every problem solving practice. Processing efficiency of component production was increased and this facilitated transfer. Subjects had to distinguish two types of problems and this resulted in the "tuning" of the productions. Besides, productions for solving two different problems might be differentiated in the working memory at the same time. Subjects were able to contrast the productions. Encoding of the similarities and differences would enhance organization and tuning of the productions during application. Recognition and retrieval of appropriate skills would be better and, as a result, transfer would be easier.

Protocol analysis were also used to reveal the differences in transfer performances. For the four transfer problems, the two pedigree problems (MP1 and MP2) were different in structure as compared with the acquisition problems while the other two differed in difficulty level (MCT) or required an additional concept while solving the problem (MC&MI).

The strategy of "means-ends analysis" was more frequently observed for all the subjects. "Means-ends analysis" is generally applied when a subject first confronts a problem. Facts or information in the problems will act as source of activation. Subjects will try to match the facts in the problem with productions previously learnt (Anderson, 1987). "Means-ends analysis" is usually observed as subject has to restudy the problem to reconfirm facts or even compare possible answers with facts in the problem.

If, for example, a subject read the whole Question 5 (MP1), then tried to find out the genotype of individual 1 in the question. She made a few crosses to represent the possible genotypes of individuals 1, 2 and their progenies. She finally chose an answer which best fit the pedigree. She is said to solve the problem by "means-ends analysis". If a subject could deduce that the genotype of individual 4 is 'rr' and genotype of individuals 1 and 2 are both 'Rr' when she reached the pedigree. She is said to solve the problem by "working forward".

All six subjects had positive transfer in (MCT) and (MC&MI). Subjects seemed to be less affected by the practice schedule they received. Subjects in the block group performed better in the near transfer problem (MCT). Problems (MCT) and (MC&MI) were designed to test for vertical transfer. When compared with the practice problems (MC), less information was given in problem (MCT) while an additional concept was required in solving problem (MC&MI). The "critical cues" and problem-solving procedure in these two problems were, however, very similar to the acquisition problems.

Problems (MP1) and (MP2) were design for lateral transfer. In the two pedigrees (MP1 and MP2), progeny ratios are of little value because of the small sample size of the population represented in the pedigree. The "critical cues" in solving these two problems differed greatly from the acquisition problems (MS1 and MS2). Subjects in the block group were less aware of this constraint and were the weakest in solving these problems. Practice seems to produce the set effect (Einstellung effect or mechanization of thought) in them. Memory of the problem solving procedures for the acquisition problems blinded them from looking at other possibilities. On the other hand, subjects in the random group were not restricted by the progeny ratio learnt in the acquisition practice. Though <R3> did not know how to solve (MP1) at first, she showed no sign of "set effect". Positive transfers could be said to observe in the three subjects from the random group.

The difference in transfer performance was a point of interest in this study. ANCOVA was ran for each transfer problem. Results showed that the block group was weaker than the random group in every transfer problem.

(iv) General discussion

Repeated practice of the same type of problem did facilitate learning. Block practice in genetic problems produced better acquisition in the immediate posttests. In the protocol analysis, some of the subjects "worked forward". This revealed that they simply retrieved the macroproduction in their solution. However, working forward was observed in subjects from both the block group and the random group. As Anderson's compilation of productions were also observed even in a block with two items each time, higher order consistency such as consistency in hierarchical goal structure might be enough to produce learning effects that matched the ACT* theory.

Anderson's (1987) statement that overlapping in productions between two tasks is enough for transfer to occur has been supported. Nevertheless, as Carlson and Yaure (1990) discover, processing context in which component productions are acquired is also important in affecting transfer. In genetic problems, retention and transfer were better for subjects who received random practice during acquisition. Random practice schedule increased intraitem processing and led to fluent access of component skills. Interitem processing also has the effect to prevent mechanization of processing from occurring. In the protocol analysis, subjects in the block group were more restricted by the typical conditions they learnt during training. They were unable to distinguish differences between learning tasks and transfer tasks and so applied productions which did not fit into solution. This may account for the poor transfer for the block group in the pedigree problems.

Chapter V

Conclusions and suggestion for further investigations

1. Conclusions

In the present study, the effects of practice schedules on the problem-solving performance in genetic knowledge were investigated. Null hypotheses were set on the bases of Anderson's theory and Carlson and Yaure's orientation. As significant differences were found in treatment effects and significant interaction discovered among treatment groups, type of tests and time conditions. Anderson's theory and Carlson and Yaure's hypothesis were supported.

Effect of practice schedules on problem-solving performance in genetic knowledge.

(i) There was significant difference in the immediate acquisition score between the block and the random groups, favouring the block group.

(ii) There was significant difference in the immediate transfer score between the block and the random groups, favouring the random group.

(iii) There was significant difference in the delayed transfer score between the block and the random groups, favouring the random group.

(iv) There were significant three-way interaction effects between the two treatment groups on the immediate acquisition scores, immediate transfer scores, delayed acquisition score and delayed transfer score. The block group got highest score in the immediate acquisition posttest and lowest score in the delayed transfer posttest.

(v) There were significant two-way interaction effects between the two treatment groups on the immediate acquisition scores and immediate transfer scores. The block group got highest score in the immediate acquisition posttest and lowest score in the immediate transfer posttest.

(iv) There were significant two-way interaction effects between the two treatment groups on the delayed acquisition score and delayed transfer score. The random group outperformed the block group in both two tests and the delayed acquisition score of the random group was the highest.

(vii) There were significant two-way interaction effects between the two treatment groups on the immediate acquisition scores and delayed acquisition scores. The block group got highest score in the immediate acquisition posttest and lowest score in the delayed acquisition posttest.

(viii) In the protocol analysis, "working forward" was observed for subjects from both the block group and the random group. Higher order consistency may be enough to produce learning effects that match the ACT* theory.

(ix) In the protocol analysis, subjects in the block group were observed to be more restricted by the typical conditions they learnt. Application of productions in unsuitable situation may account for poor performance in the pedigree problems.

2. <u>Suggestion for further investigations</u>

(i) If another study is performed, the sample should include equal number of subjects in all the ability groups. Analysis may take the three ability groups into consideration. The same experimental procedure can have statistical manipulations resulting in a 2(practice conditions) X 3(ability groups) X 2(test types) X 2(test time) factorial design with pretest as covariate.

(ii) If there is a large sample size, the experiment may be extended to four groups. The added two groups are identical with those in this experiment except that they also tackle the transfer problems in their pretest. This enable comparison to be made on how much the practice affect performance in transfer problems.

(iii) If there is sufficient manpower, protocol analysis may also be carried out in various stages of skill acquisition. Subjects' performance in their first trial, just after the practice schedule training as well as after seven days' delay were recorded. Comparison of problem solving performance among these three stages would be possible. Protocol interviews should have boys and girls as subjects.

(iv) One of the best performers in the protocol used the same letter, "R" and "r", to represent any genotype she met. Further research may explore whether this would help in learning. An intervention program may be performed. Instructions may be designed to examine if consistency in the use of symbol would facilitate learning.

Bibliography

Ahn, Woo-kjoung, Brewer, W. F., & Mooney, R. J. (1992). Schema acquisition from a single example. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18(2), 391-412.

Anderson, J. R. (1976). Language, memory, and thought. Hillsdale, NJ: Lawrence Erlbaum Associates.

Anderson, J. R. (1982). Acquisition of cognitive skill. Psychological Review, 89(4), 369-406.

Anderson, J. R. (1983). The architecture of cognition. Cambridge, MA: Harvard University Press.

Anderson, J. R. (1987). Skill acquisition: Compilation of weak method problem solutions. Psychological Review, 94(2), 192-210.

Anderson, J. R. (1989). Practice, working memory, and the ACT* theory of skill acquisition: A comment on Carlson, Sullivan, and Schneider (1989). Journal of Experimental Psychology: Learning, Memory, and Cognition, 15(3), 527-530.

Anderson, J. R. (1990a). Cognitive psychology and its implications (3rd ed.). NY: W. H. Freeman and Company.

Anderson, J. R. (1990b). The adaptive character of thought. Hillsdale, NJ: Erlbaum.

Anderson, J. R. (1991). The adaptive nature of human categorization. Psychological Review, 98(3), 409-429.

Anderson, J. R., & Milson, R. (1989). Human memory: An adaptive perspective. Psychological Review, 96(4), 703-719.

Anderson, J. R., & Pirolli, L. P. (1984). Spread of activation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 10(4), 791-798.

Anderson, J. R. & Reder, L. M. (1979). An elaborative processing explanation of depth of processing. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory. Hillsdale, NJ: Erlbaum.

Angell, J. R. (1908). The doctrine of formal discipline in the light of principles of general psychology. Educational Review, 36, 1-14.

Ayres, P. L. (1993). Why goal-free problems can facilitate learning. Contemporary Educational Psychology, 18, 376-381.

Baddeley, A. (1986). Working memory. NY: Oxford University Press.

Barba, Robertta H., & Merchant, L. J. (1990). The Effects of embedding generative cognitive strategeies in science software. Journal of Computers in Mathematics and Science Teaching, 10(1), 59-65.

Bassok, M. (1990). Transfer of domain-specific problem-solving procedures. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16(3), 522-533.

Bransford, J. D., & Vye, N. J. (1989). A perspective on cognitive research and its implications for instruction. In L.B. Resnick & L.E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (pp.173-205). Reston, VA:Association for Supervision and Curriculum Development.

Briscoe, C., & LaMaster, S. U. (1991). Meaningful learning in college biology through concept mapping. American Biology Teacher, 53(4), 214-219.

Brown, C. R. (1990). Some misconceptions in meiosis shown by students responding to an advanced level practical examination question in biology. Journal of Biological Education, 24(3), 182-185.

Browning, M. E., & Lehman, J. D. (1988) Identification of student misconceptions in genetics problem solving via computer program. Journal of Research in Science Teaching, 25(9), 747-761.

Browning, M. E., & Lehman, J. D. (1991) Response to Dr. Smith's comments and criticisms concerning "Identification of student misconceptions in genetics problem solving via computer program". Journal of Research in Science Teaching, 28(4), 385-386.

Carlson, R. A., & Schneider, W. (1989). Acquisition context and the use of causal rules. Memory & Cognition, 17, 240-248.

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989a). Component fluency in a problem solving context. Human Factor, 31, 1-14.

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989b). Practice and working memory effects in building procedural skill. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15(3), 517-526.

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989c). Practice effects and composition: A reply to Anderson. Journal of Experimental Psychology:

Learning, Memory, and Cognition, 15(3), 531-533.

Carlson, R. A., & Yaure, R. G. (1990). Practice schedules and the use of component skills in problem solving. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 484-496.

Carlson, R. A. & Lundy, D. H. (1992). Consistency and restructuring in learning cognitive procedural sequences. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18(1), 127-141.

Catrambone, R., & Holyoak, K. J. (1989). Overcoming contextual limitations to problem-solving transfer. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 1147-1156.

Clark, A. (1990). Microcognition. Cambridge: The MIT Press.

Collins, A. (1986). Problem-solving rules for genetics. Paper presented at the meeting of the American eduational research association, San Francisco, CA.

Cratsley, C. (1991). Campbell biology prize essay: How problems can help. American Biology Teacher, 53(7), 390-392.

Cuddy, L. J., & Jacoby, L. L. (1982). When forgetting helps memory: An analysis of repetition effects. Journal of Verbal Learning and Verbal Behavior, 21, 451-467.

de Groot, A. D. (1965). Thought and choice in chess. The Hague: Mounton.

Duncan, J. (1986). Consistent and varied training in the theory of automatic and controlled information processing. Cognition, 23, 279-284.

Duncker, K. (1945). On problem solving. Psychological Monographs, 58(whole no. 270).

Elio, R. (1986). Representation of similar well-learned cognitive procedures. Cognitive Science, 10, 41-73.

Ennals, R. (1988). Can skills be transferable. In B. Goranzon & I. Josefson (Eds.), Knowledge skill and artifical intelligence. London: Springer-Verlag.

Ernst, G., & Newell, A. (1969). GPS:A case study in generality and problem solving. NY: Academic Press.

Ericsson, K. A., & Simon, H. A. (1980). Verbal report as data. Psychology Review, 87(3), 215-251.

Fish, A. D., Oransky, N. A., & Skedsvold, P. R. (1988). Examination of the role of "Higher-order" consistency in skill development. Human Factor, 30(5), 567-581.

Fitts, P. M. (1964). Perceptual-motor skill learning. In A. W. Melton (Ed.), Categories of human learning. NY: Academic Press.

Fitts, P. M., & Ponser, M. I. (1967). Human performance. Belmont, CA: Brooks Cole.

Gagne, E. D. (1985). The cognitive psychology of school learning. Boston: Little, Brown and Company.

Gagne, R. M. (1966). The conditions of learning. NY: Holt, Rinehart, and Winston.

Gayford, C. (1989). A Contribution to a methodology for teaching and assessment of group problem-solving in biology among 15-year-old Pupils. Journal of Biological Education, 23(3), 193-198.

Germann, P. J. (1991). Developing science process skills through directed inquiry. American Biology Teacher, 53(4), 243-247.

Gick, M. L. (1986). Problem-solving strategies. Educational Psychologist, 21(1&2), 99-120.

Gick, M. L. (1990). Transfer insight problems: The effects of different types of similarity. In K. J. Gilhooly, M. T. G. Keane, R. H. Logie, & G. Erodes (Eds.), Lines of thinking (Vol. 1, pp. 251-265). Chichester, England: Wiley.

Gick, M. L., & Holyoak, K. J. (1987). The cognitive basis of knowledge transfer. In S. M. Cormier & J. D. Hagman (Eds.), Transfer of learning. NY: Academic Press.

Gick, M. L., & McGarry, S. J. (1992). Learning from mistakes: Inducing analogous solution failures to a source problem produces later successes ni analogical transfer. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18(3), 623-639.

Gilhooly, K. J. (1989). Human and machine problem solving: Toward a comparative cognitive science. In K. J. Gilhooly (Ed.), Human and machine problem solving. NY: Plenum Press.

Glaser, R. (1976). Components of a psychology of instruction: Toward a science of design. Review of Educational Research, 46(1), 1-24.

Greeno, J. G. (1978). Nature of problem-solving abilities. In W. K. Estes (Ed.), Handbook of learning and cognitive processes (Vol. 5, pp. 239-270). NY: John Wiley & Sons.

Heyworth, R. M. (1988). Mental representation of knowledge for a topic in high school chemistry. Doctoral dissertation, Stanford University.

Hong Kong Examination Authority (1992a). Hong Kong advanced level examination: question papers (AL biology 1987-90). Hong Kong: Government Printer.

Hong Kong Examination Authority (1992b). Hong Kong certificate of eduation examination: question papers (CE biology 1987-90). Hong Kong: Government Printer.

Hafner, B., & Stewart, J. (1989). Comments on predicting genetics achievement in nonmajors college biology. Journal of Research in Science Teaching, 26(6), 551-553.

Jacoby, L. L. (1978). On interpreting the effects of repetition: Solving a problem versus remembering a solution. Journal of Verbal Learning & Verbal Behaviour, 17, 649-667.

Johnstone, A. H., & Mahmound, N. A. (1980). Isolating topics of high perceived difficulty in secondary school biology syllabus. Journal of Biological Education, 14(2), 163-166.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. Psychological Review, 99(1), 122-149.

Kindfield, A. C. H. (1991). Confusing chromosome number and structure: a common student error. Journal of Biological Education, 25(3), 193-200.

Klapp, S. T., Marshburn, E. A., & Lester, P. T. (1983). Short-term memory does not involve the "working memory" of information processing: The demise of a common assumption. Journal of Experimental Psychology: General, 112(2), 240-264.

Knapp, T. J., & Roberson, L. C. (1986). Approaches to cognition: Contrasts and controversies. Hillsdale, NJ: Lawrence Erlbaum Associates.

Kohler, W. (1927). The mentality of apes. NY: Harcourt Brace.

Kotovsky, K., & Fallside, D. (1989). Representation and transfer in problem solving. In Klahr, D., & Kotovsky, K. (Eds.), Complex information processing: The impact of Herbert A. Simon. NJ: Lawrence Erlbaum Association.

Kramer, A. F., Strayer, D. L., & Buckley, J. (1990). Development and transfer of automatic processing. Journal of Experimental Psychology:Human Perception and Performance , 16(3), 505-522.

Lavoie, D. R. (1991). The construction and application of a cognitive-network model of prediction problem solving. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Lake Geneva, WI. (ERIC Document Reproduction Service No. ED332864)

Lawson, A. E. (1988). Predicting genetics achievement in nonmajors college biology". Journal of Research in Science Teaching, 25(1), 23-37.

Lawson, A. E. (1989). A reply to Hafner and Stewart's comments on "Predicting genetics achievement in nonmajors college biology". Journal of Research in Science Teaching, 26(6), 555-556.

Lawson, A. E., & Weser, J. (1990). The Rejection of Nonscientific Beliefs about life: Effects of Instruction and Reasoning Skills. Journal of Reasearch in Science Teaching, 27(6), 589-606.

Lee, T. D., & Magil, R. A. (1983). The locus of contextual inference in motor skill acquisition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 730-746.

Lester, F. K. (1980). A procedure for studying the cognitive processes used during problem solving. Journal of Experimental Education, 48(4), 323-327.

Lehrer R., & Littlefield, J. (1993). Relationships among cognitive components in logo learning and transfer. Journal of Educational Psychology, 85(2), 317-330.

Leinhardt, G. (1988). Videotape Recording in Educational Research. In: Keeves J. P., Educational research, methodology, and measurement: An international handbook. Pergamon Press.

Longden, N. (1982). Learning difficulty in genetics. Journal of Biological Education, 15(2), 135-140.

Lock, R. (1991). Open-ended, problem-solving investigations-getting started. School Science Review, 73(262), 67-74.

Logan, G. D. (1988). Toward an instance theory of automatization. Psychological Review, 95(4), 492-527.

Logan, G. D. (1990). Repetition priming and automaticity: Common underlying mechanisms?. Cognitive Psychology, 22, 1-35.

Luchins, A. S., & Luchins, E. H. (1959). Rigidity of behavior: A variational approach to the effects of Einstellung. Eugene, OR: University of Oregon Books.

Macnab, W., Hansell, M. H., & Johnstone, A. H. (1991) Cognitive style and analytical ability and their relationship to competence in the biological sciences. Journal of Biological Education, 25(2), 135-139.

Mayer, R. E. (1983). Thinking, problem solving, cognition. New York: W. H. Freeman.

Mayer, R. E. (1989). Human nonadversary problem solving. In K. J. Gilhooly (Ed.), Human and machine problem solving. NY & London: Plenum Press.

MacKay, D. G. (1982). The problem of flexibility, fluency, and speed-accuracy tradeoff in skilled behavior. Psychology Review, 89, 483-506.

McClelland, J. L. (1986). On the time relations of mental processes: An examination of systems of processes in cascade. Psychological Review, 86(4), 287-330.

McClelland, J. L., & Rumelhart, D. E. (1986). Parallel distributed processing, explorations in the microstructure of cognition (vol. 1 & 2). Cambridge: The MIT Press.

McDaniel, M. A. & Schlager, M.S. (1990). Discovery learning and transfer of problem-solving skill. Cognition and Instruction, 7, 129-159.

McKendree, J. E., & Anderson, J. R. (1978). Frequency and practice working memory effects in building procedural skill. In J. M. Carroll (Ed.), Cognitive aspects of human-computer interaction (pp.236-259). Cambridge, MA.:MIT Press.

Melton, A. W. (1967). Repetition and retrieval from memory. Science, 158, 532.

Metcalfe, J. (1986a). Feeling of knowing in memory and problem solving. Journal of Experimental Psychology: Learning, Memory, and Cognition, 12, 288-294.

Metcalfe, J., & Weibe, D. (1987). Intuition ininsight and noninsight problem solving. Memory & Cognition, 15, 238-246.

Miller, P. V., & Cannell, C. F. (1988). Interviews in Sample Surveys. In J. P. Keeves, Educational research, methodology, and measurement: An international handbook. Pergamon Press.

Monsell, S. (1984). Components of working memory underlying verbal skills: A "distributed capacities" view. In H. Bouma, & D. G. Bouwhuis (Eds.), Attention and performance x. London: Lawrence Relbaum Associates.

Neves, D. M., & Anderson, J. R. (1981). Knowledge compliation: Mechanisms for the automatization of cognitive skills. In J. R. Anderson (Ed.), Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum.

Newell, A., & Simon, H. A. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.

Nolan, W. F. (1990). A Problem-solving approach to teaching electrochemical driving force to undergraduates. Advances in Physiology Education, 4(1), s1-s3.

Niedelman, M. (1991). Problem solving and transfer. Journal of Learning Disability, 24(6), 322-329.

Okebukola, P. A. (1990). Attaining meaningful learning of concepts in genetics and ecology: An examination of the potency of the concept-mapping technique. Journal of Reasearch in Science Teaching, 27(5), 493-504.

Pearson, J. T., & Hughes, W. J. (1986). Designing an A-level genetics course: identifying the necessary concepts and considering their relationships. Journal of Biological Education, 20(1), 47-54.

Perkins, D. N., Salomon, G. (1989). Are cognitive skills context-bound? Educational Researcher, 47, 16-25.

Palmer, S. E., & Kimchi, R. (1986). The information processing approach to cognition. In T. J. Knapp & L. C. Robertson (Eds.), Approaches to cognition: Contrasts and controversies (p. 37-77). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pillsbury, W. B. (1908). The effect of training on menory. Educational Review, 36, 15-27.

Pierce, K. A., Duncan, M. K., Gholson, B., Ray, G. E., & Kamhi, A. G. (1993). Cognitive load, schema acquisition, and procedual adaptation in nonisomorphic analogical transfer. Journal of Educational Psychology, 85(1), 66-74.

Ploger, D. (1991). Reasoning and Learning about Mechanisms in Biology.

Journal of Biological Education, 25(1), 53-60.

Radford, A., & Bird-Stewart, J. A. (1982). Teaching genetics in schools. Journal of Biological Education, 16(3), 177-180.

Resnick, L. B., & Klopfer, L. (1989). Toward the thinking curriculum: An overview. In L.B. Resnick & L.E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (pp.1-3). Reston, VA:Association for Supervision and Curriculum Development.

Riesenmy, M. R., Mitchell, S., & Hudgins, B. B. (1991). Retention and transfer of children's self-directed critical thinking skills. Journal of Educational Research, 85(1), 14-25.

Rowe, H. A. H. (1985). Problem solving and intelligence. Hillsdale, NJ: Lawrence Erlbaum Association.

Shemesh, M., & Lazarowitz, R. (1989). Pupils' reasoning skills and their mastery of biological Concepts. Journal of Biological Education, 23(1), 59-63.

Shepardson, Daniel P. (1991). Relationships among problem solving, student interactions, and thinking skills. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Lake Geneva, WI. (EDRIC Document Reproduction Service No. ED338494)

Schneider, W. (1985). Toward a model of attention and the development of automatic processing. In M. I. Posner, & O. S. M. Marin (Eds.), Attention and performance xi. Hillsdale: Lawrence relbaum associates.

Schneider, W., Dumais, S. T., & Shiffrin, R. M. (1984). Automatic and control processing and attention. In R. Parasuraman & D. R. Davies (Eds.), Varieties of attention. Orlando: Academic press.

Schneider, W., & Detweiler, M. (1987). A connectionist /control architecture for working memory. In G. H. Bower (Ed.), The psychology of learning and motivation (Vol. 21, pp.53-119). Orlando, FL: Academic Press.

Schneider, W., & Detweiler, M. (1988). The role of practice in dual-task performance: Toward workload modeling in a connectionist/control architecture. Human Factor, 30(5), 539-566.

Semb, G. B., Ellis, J. A., & Araujo, J. (1993). Long-term memory for knowledge learned in school. Journal of Educational Psychology, 85(2), 305-316.

Shea, C. H., & Kohl R. M. (1990). Composition of practice: Influence on the retention of motor skills. Research Quarterly for Exercise and Sport, 62(2), 187-195.

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. Journal of Experimental Psychology: Human Learning and Memory, 5, 179-187.

Shea, J. B., & Zimny, S. T. (1983). Context effects in memory and learning movement information. In R. A. Magill (Ed.), Memory and control of action (pp.345-366). Amsterdam: North-Holland.

Shea, J. B., & Zimny, S. T. (1988). Knowledge incorporation in motor representation. In O. G. Meijer & K. Roth (Eds.), Complex movement behaviour (pp.289-314). Amsterdam: North-Holland.

Simmons, P. E., & Lunetta, V. N. (1993). Problem-solving behaviors during a genetics computer simulation: Beyond the expert/novice dichotomy. Journal of Research in Science Teaching, 30(2), 153-137.

Simon, H. A. (1978). Information-processing theory of human problem solving. In W. K. Estes (Ed.), Handbook of learning and cognitive processes (Vol. 5 pp. 271-295), NY: John Wiley & Sons.

Simon, H. A., & Gilmartin, K. (1973). A simulation of memory for chess positions. Cognitive Psychology, 5, 29-46.

Singley, K., & Anderson, J. R. (1989). The transfer of cognitive skill. Cambridge, MA: Havard University Press.

Skinner, B. F. (1966). An operant analysis of problem solving. In B. Kleinmuntz (Ed.), Problem solving: Research, method and theory (pp.225-257). NY: John Wiley & Sons.

Slack, S. J., & Stewart, J. (1990). High school students' problem-solving performance on realistic genetics problems. Journal of Research in Science Teaching, 27(1), 55-67.

Smith, M. U. (1988) Successful and unsuccessful problem solving in classical genetic pedigrees. Journal of Research in Science Teaching, 25(6), 411-433.

Smith, M. U. (1991). Comments on "Identification of student misconceptionsri genetics problem solving via computer program". Journal of Research ri Science Teaching, 28(4), 383-384.

Smith, M. U. (1992). Expertise and the organization of knowledge: Unexpected differences among genetic counselors, faculty, and students on problem categorization tasks. Journal of Research in Science Teaching, 29(2), 179-205.

Smith, M. U., & Good, R. (1984). Problem solving and classical genetics, successful versus unsuccessful performance. Journal of Research in Science Teaching, 2(9), 895-912.

Smith, M. U., & Sims, O. S. (1992). Cognitive development, genetics problem solving, and genetics instruction: A critical review. Journal of Research in Science Teaching, 29(7), 701-713.

Solso, R. L. (1988). Cognitive psychology (2nd ed.). Boston: Allyn and Bacon, Inc.

Stewart, J., & Dale, M. (1981). Solution to genetics problems: Are they the same as correct answers ? The Australian Sscience Teachers Journal, 27(13), 59-64.

Stewart, J., & Maclin, R. (1990). Representing genotype-to-phenotype mappings. Journal of Biological Education, 24(2), 113-116.

Stencel, J. E. (1991). Using an Algorithm When Solving Hardy-Weinberg Problems in Biology. American Biology Teacher, 53(7), 426-427.

Tallent-Runnels M. K. (1993). The Future problem solving program: An investigation of effects on problem-solving ability. Contemporary Educational Psychology, 18, 382-388.

Thomas, I. (1983). Problems in genetics teaching in school. Journal of Biological Education, 17(1), 18-25.

Thomson, N., & Stewart, J. (1985). Secondary school genetics instruction: Making problem solving explicit and meaningful. Journal of Biological Education, 19(1), 53-62.

Thorndike, E. L. (1906). Principle of teaching. NY: A. G. Seiler.

Walker, R., Mertens, T. R., & Hendrix, J. R. (1979). Formal operational reasoning strategeies and scholastic achievement in genetics. Journal of College Science Teaching, 8, 156-162.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), Handbook of research on teaching. NY: Macmillan Publishing Company.

White, R. T. (1988). Matcognition. In: Keeves J. P. (Ed.), Educational research, methodology, and measurement: An international handbook. Pergamon

Press.

Weisberg, C. A. (1991). A field test of the effect of contextual variety during skill acquisition. Journal of Teaching in Physical Education, 11, 21-30.

Weisberg, R. W. (1992). Metacognition and Insight During Problem Solving: Comment on Metcalfe. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18(2), 426-431.

Wenestam, C. G. (1993). A critique of research on cognition and cognitive processes. British Journal of Education Psychology, 63, 34-35.

Wertheimer, M. (1959). Productive thinking (enlarge ed.). NY: Harper & Row.

White, R. T., & Tisher, R. P. (1986). Research in natural science. In M. C. Wittrock (Ed.), Handbook of research on teaching. NY: Macmillan Publishing Company.

Woodrow, H. (1927). The effect of the type of training upon transference. Journal of Educational Psychology, 18, 159-172.

Wong Ka Ming (1989). The effects of structural diagrams on the acquisition of knowledge structure and problem-solving performance in mathematics. Master's thesis, The Chinese University of Hong Kong, Hong Kong.

Wrisberg, C. A., & Liu, Z. (1991). The effect of contextual variety on the practice, retention, and transfer of an applied motor skill. Research Quarterly for Exercise and Sport, 62(4), 406-412.

Appendix A   The power law

Anderson (1983) had a study on how speed of retrival varies with practice. He had subjects practice sentences and looked at the effects of the practice on the time to recognize a sentence. The result of the experiment was as Figure 7 below:

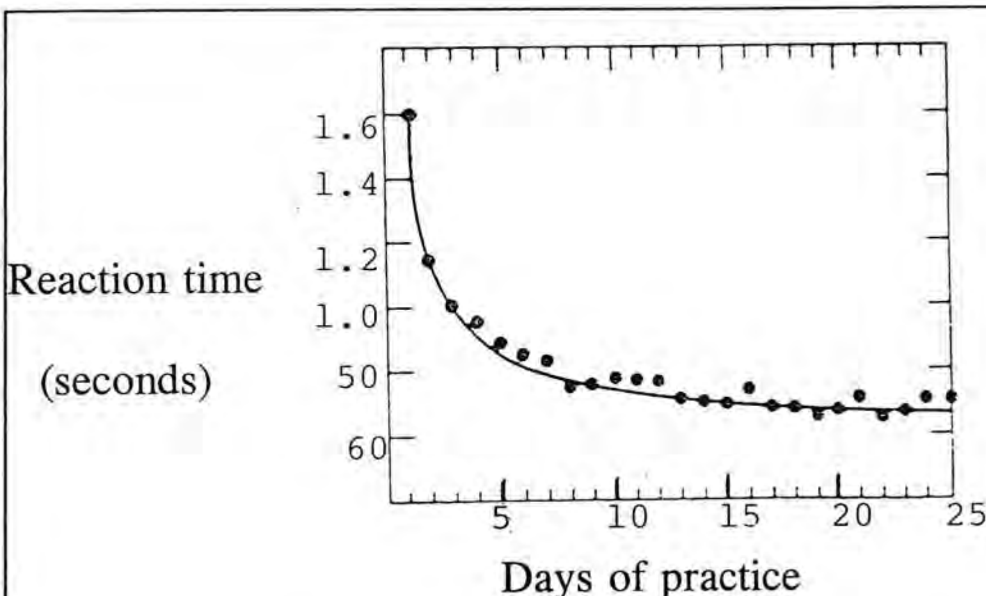


Figure 7. Time to recognize a sentence as a function of the number of trials of practice (Anderson, 1990a).

The data are nicely fit by a power function of the form

$$RT = .36 + .96 (D - 1/2)^{-.36}$$

where RT is the reaction time and D is the number of days of practice.

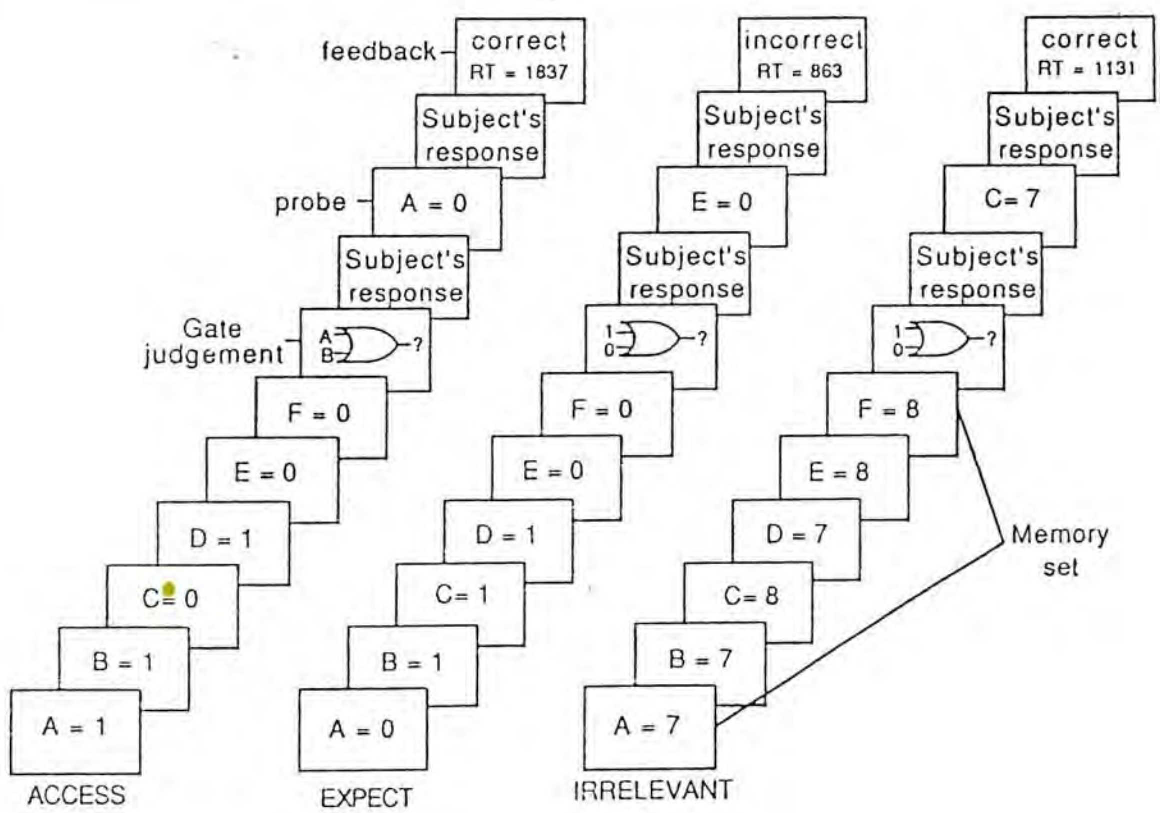


Figure 8. Sequence of evens on each trial in memory load task in the experiment of Carlson, Sullivan and Schneider (1989b).

Appendix C Supplimentary note

Codominance inheritance pattern

Codominance means: A pair of genes which control the expression of a certain character are equal in their effect on expression. When a pure-breeding red flower plant (RR) cross with a pure-breeding white flower plant (rr), in this kind of dominance, all F_1 (Rr) will have pink flower.

Pretest

1.In man the ability to roll the tongue is dominant to non-roller.

A pure breeding tongue roller married a non-roller. Make a diagram to show the cross and the possible phenotypic and genotypic result in the F_1 generation.

2.A grey body fruit fly is crossed to a fruit fly with ebony colour. It was found that all the F1 generation are grey body.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **G** and **g**, state and explain briefly the genotype of (i) the parent flys, and(ii) the flys in F1.

3.The flower color of a plant is controlled by a pair of alleles which is codominance in inheritance pattern. When a pure breeding red flowers plant is crossed with a pure breeding white flowers plant, all the F_1 plants have pink flowers.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

Appendix E Practice schedule exercise

There were two sets of exercise. Exercises 1B, 2B and 3B were for students in the block group and exercises 1R, 2R and 3R were for students in the random group. These exercises were given to the students in 3 sucessive day. Students in both groups solved the problems in the class. These two sets of exercise contained identical problems in different arrangements. Only suggested solutions of exercise 1B, 2B and 3B were appended here.

Exercise.1B

1.In rabbit long hair is dominant to short hair.

A heterozygous long hair rabbit is mated with a short hair rabbit. Make a diagram to show the cross and the possible phenotypic and genotypic result in the F_1 generation.

2.An extra finger in man is due to a dominant gene.

A man who is homozygous with an extra finger married a normal woman. Make a diagram to show the cross and the possible phenotype and genotype of their children.

3.In Dorsophila vestigial wing is recessive to long wing.

A homozygous long winged fly crosses with a heterozygous long winged fly. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

4.In tomato white flower is recessive to yellow flower.

A heterozygous yellow flower plant is self-pollinated. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

5.In domestic fowl short leg is dominant to long leg.

A heterozygous short leg fowl is mated with a long leg fowl. Make a diagram to show the cross and the possible phenotypic and genotypic result in the F_1 generation.

Exercise.2B

1.A green maize plant was pollinated with another green maize plant of the same strain. A total of 136 grains were taken and allowed to germinate in light. It was found that 100 seedlings were green 32 seedlings were white.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **G** and **g**, state and explain briefly the genotype of (i) the parent plants, and(ii) the seedlings.

2.A black guinea pig is mated to a brown guinea pig. It was found that all the pig produced are black.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **B** and **b**, state and explain briefly the genotype of (i) the parent pigs, and(ii) the pigs in F1.

3.A pea plant with axil flower was pollinated with a pea plant with axil flower. The grains collected were planted and it was found that 25% of the new plants have terminate flower.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **A** and **a**, state and explain briefly the genotype of (i) the parent plants, and(ii) the plants in F1.

4.A hornless bull is mated to a horned cow. It was found that all the cattle produced are hornless.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **H** and **h**, state and explain briefly the genotype of (i) the parent cattle, and(ii) the cattle in F1.

5.One of the five offsprings of a pàir of short leg fowl has long leg.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **L** and **l**, state and explain briefly the genotype of (i) the parent fowl and (ii) the short leg and long leg offsprings.

Exercise.3B

1.The coat colour of guinea pigs is controlled by a pair of alleles which are codominance in inheritance pattern. When a pure breeding yellow coloured guinea pig is crossed with a pure breeding white coloured guines pig, all the F_1 are cream coloured guiena pigs.

Shows the phenotype and genotype of the parents and F_1 by means of a diagram.

2.The hair length of Angora rabbits are controlled by a pair of alleles which are codominance in inheritance pattern. When two intermediate silky fur rabbits mated, one long hair, one short hair and two intermediate silky fur rabbits were produced.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

3.In a certain species of bird, colour intensity of feather are controlled by a pair of genes which are codominance in inheritance pattern. When a pure breeding pale blue bird is mated with a pure breeding purple bird, all the F_1 have deep blue feather.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

4.In light-skinned people, hair straightness is controlled by a pair of genes which are codominance in inheritance pattern. When a man with curly hair married a woman with straight hair, all their children will have wavy hair.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

5.The flower color of a plant is controlled by a pair of alleles which is codominance in inheritance pattern. When a pink flowers plant is crossed with a pure breeding white flowers plant, there are 10 pink flower plants and 9 white flower plants in the F_1 generation.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

Exercise.1R

1.In rabbit long hair is dominant to short hair.

A heterozygous long hair rabbit is mated with a short hair rabbit. Make a diagram to show the cross and the possible phenotypic and genotypic result in the F_1 generation.

2.A green maize plant was pollinated with another green maize plant of the same strain. A total of 136 grains were taken and allowed to germinate in light. It was found that 100 seedlings were green 32 seedlings were white.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **G** and **g**, state and explain briefly the genotype of (i) the parent plants, and(ii) the seedlings.

3.In Dorsophila vestigial wing is recessive to long wing.

A homozygous long winged fly crosses with a heterozygous long winged fly. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

4.In tomato white flower is recessive to yellow flower.

A heterozygous yellow flower plant is self-pollinated. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

5.A black guinea pig is mated to a brown guinea pig. It was found that all the pig produced are black.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **B** and **b**, state and explain briefly the genotype of (i) the parent pigs, and(ii) the pigs in F1.

Exercise.2R

1.The coat colour of guinea pigs is controlled by a pair of alleles which are codominance in inheritance pattern. When a pure breeding yellow coloured guinea pig is crossed with a pure breeding white coloured guines pig, all the F_1 are cream coloured guiena pigs.

Shows the phenotype and genotype of the parents and F_1 by means of a diagram.

2.In domestic fowl short leg is dominant to long leg.

A heterozygous short leg fowl is mated with a long leg fowl. Make a diagram to show the cross and the possible phenotypic and genotypic result in the F_1 generation.

3.The hair length of Angora rabbits are controlled by a pair of alleles which are codominance in inheritance pattern. When two intermediate silky fur rabbits mated, one long hair, one short hair and two intermediate silky fur rabbits were produced.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

4.An extra finger in man is due to a dominant gene.

A man who is homozygous with an extra finger married a normal woman. Make a diagram to show the cross and the possible phenotype and genotype of their children.

5.In a certain species of bird, colour intensity of feather are controlled by a pair of genes which are codominance in inheritance pattern. When a pure breeding pale blue bird is mated with a pure breeding purple bird, all the F_1 have deep blue feather.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

Exercise.3R

1.The flower color of a plant is controlled by a pair of alleles which is codominance in inheritance pattern. When a pink flowers plant is crossed with a pure breeding white flowers plant, there are 10 pink flower plants and 9 white flower plants in the F_1 generation.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

2.A pea plant with axil flower was pollinated with a pea plant with axil flower. The grains collected were planted and it was found that 25% of the new plants have terminate flower.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **A** and **a**, state and explain briefly the genotype of (i) the parent plants, and(ii) the plants in F1.

3.A hornless bull is mated to a horned cow. It was found that all the cattle produced are hornless.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **H** and **h**, state and explain briefly the genotype of (i) the parent cattle, and(ii) the cattle in F1.

4.In light-skinned people, hair straightness is controlled by a pair of genes which are codominance in inheritance pattern. When a man with curly hair married a woman with straight hair, all their children will have wavy hair.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

5.One of the five offsprings of a pair of short leg fowl has long leg.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **L** and **l**, state and explain briefly the genotype of (i) the parent fowl and (ii) the short leg and long leg offsprings.

Answer.1B

1. Let L represent the dominance gene for long hair
   and l represent the recessive gene

The cross should be

parents   Ll (long hair) X   ll (short hair)

gametes   L   l   l

F1   Ll (long hair)   ll (short hair)

1 : 1

Therefore, they will have long hair and short hair rabbit in the ratio 1:1.

2. P   EE   X   ee

G   E   e

F1   Ee (extra finger)

All children with extra finger.

3. P   LL   X   Ll

G   L   L   l

F1   LL   Ll

All F1 are long winged fly.

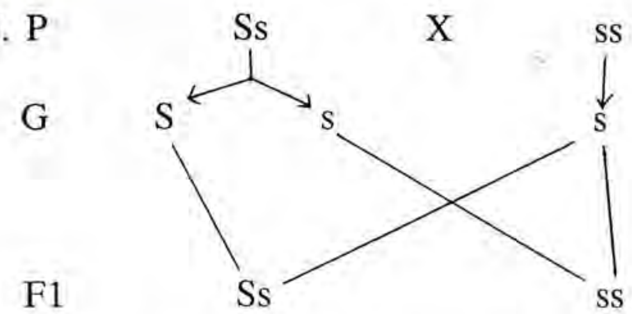
4. P   Yy   X   Yy

G   Y   y   Y   y

F1   YY   Yy   Yy   yy

Yellow and white will be in the ratio 3:1 in F1.

5.

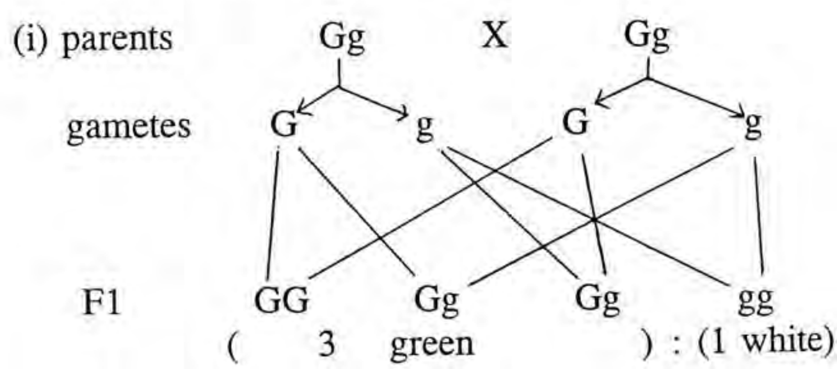


1/2 of F1 will be short leg fowl and 1/2 be long leg.

Answer.2B

1.(a) Green is the dominant character as Green and white are in the ratio 3:1 in the F1 generation.

(b) Let G be the dominant gene for green
and g be the recessive gene.



2.(a) black, as all F1 are black.

(b) (i) homozygous black (BB) and homozygous brown (bb).
(ii) All F1 are heterozygous black (Bb).

3.(a) axil flower, as axil and terminate flower plants in F1 are in the ratio 3:1.

(b) (i) both are heterozygous axil (Aa).
(ii) homozygous axil flower (AA), heterozygous axil flower (Aa) and terminate flower (aa) are in the ratio 1:2:1.

4.(a) hornless, as all F1 are hornless.

(b) (i) homozygous hornless (HH) and homozygous horned (hh).
(ii) All F1 are heterzygous hornless (Hh)

5.(a) short, as short leg and long leg in F1 are 3:1 in ratio.

(b) (i) both are heterozygous short leg (Ss).

(ii) homozygous short leg (SS), heterozygous short leg and long leg (ss) are in the ratio 1:2:1.

Answer.3B

1. Let Y represent gene for yellow coat
and y represent gene for white coat.

The cross should be:

Parent YY (yellow) X yy (white)

Gamete Y y

F1 Yy (creamy)

2.

P Ll (intermediate silky) X Ll (intermediate silky)

G L l L l

F1 LL Ll Ll ll

(1 long) : (2 intermediate) : (1 short)

3.

P PP (pale blue) X pp (purple)

G P p

F1 Pp (deep blue)

4.

P CC (curly hair) X cc (straight hair)

G C c

F1 Cc (wavy hair)

5.

P Rr (pink) X rr (white)

G R r r

F1 Rr (pink) rr (white)

Appendix F Posttests

Posttest 1B, 2B and 3B were for students in the block group and posttest 1R, 2R and 3R were for students in the random group. They were given after the practice schedule sessions. One week after the practice schedule exercises, the delayed posttest were given to students in both groups.

Posttest.1B

1.In common pea, long stem is dominant to short stem.

A heterozygous long stem pea is crossed with a short stem plant. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

2.Blue eyes in man are recessive to brown eyes.

A heterozygous brown eyes man married a heterozygous brown eyes woman. Make a diagram to show the possible phenotype and genotype of their children.

Posttest.2B

1.A white rabbit mates with a black rabbit are found to produce five offsprings which are all white.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **W** and **w**, state and explain briefly the genotype of (i) the parent rabbits, and (ii) the white and black offsprings.

2.Two red-eye Dorsophila were found to produce 35 red-eye and 12 white eye flies.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **R** and **r**, state and explain briefly the genotype of (i) the parent flies, and(ii) the flies in F1.

Posttest.3B

1.In Angora rabbit, hair length is controlled by a pair of genes which are codominance in inheritance pattern. When a long fur rabbit mates with a short fur rabbit, all their progenies have intermediate silky fur.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

2.The coat colour of guinea pigs is controlled by a pair of alleles which are codominance in inheritance pattern. When two cream coloured guiena pigs mate, 2 yellow coloured guinea pig, 2 white coloured guines pig and 4 cream coloured guiena pigs are produced.

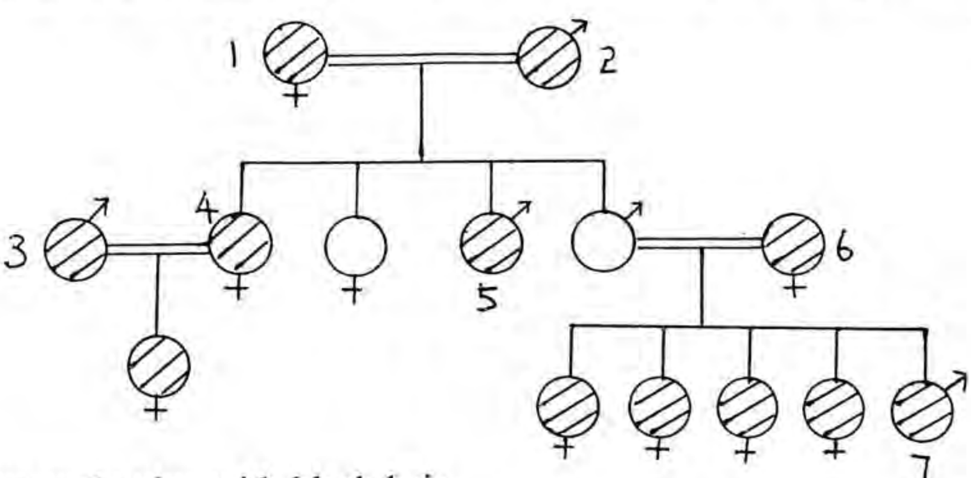
Shows the phenotype and genotype of the parents and F_1 by means of a diagram.

3.A pair of rabbits produces 6 rabbits with intermediate silky fur, 2 with long fur and 3 with short fur.

(a) Explain the genotype and pheontype of the parent and the progenies with the help of diagram.

(b) What is the name of the kind of dominance in the above cross ?

4.The black hair of guinea pigs is produced by a dominant gene B and white by its recessive allele b. The following diagram shows a family tree of guinea pigs.



 represent male pigs with black hair.

 represent male pigs with white hair.

 represent female pigs with black hair.

 represent female pigs with white hair.

A horizontal line is used to link up members of the same generation.

A double horizontal line indicates a mating.
The offspring of a mating are connected by a vertical line to the mating line.
Assume that individuals 3 and 6 do not carry the recessive allele.

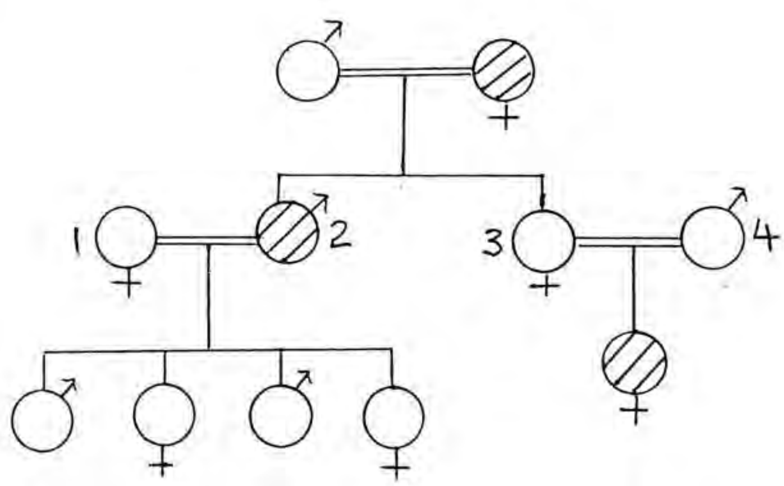
(i) State and explain the genotypes of individuals
 (a) 1 and 2.
 (b) 7.

(ii) What is the probability that individual 5 is a heterozygote? Why?

5.A man with blood group A married a woman with blood group B. They have four children of blood group A, B, AB and O.

Show the phenotype and genotype of the parents and children by means of a diagram.

6.In human, the presence of a six finger (polydactyly) is a hereditary character. A polydactylous woman marries a normal man. The following diagram represents the resultant family tree.



 represent normal male.  represent polydactylous male.

 represent normal female.  represent polydactylous female.

A horizontal line is used to link up members of the same generation.
A double horizontal line indicates a marriage.
The offspring of a couple are connected to them by a vertical line.

(i) Which character is dominant? Explain your answer.

(ii) State and explain the genotype of 1 and 2 by diagram.

Posttest.1R

1.Blue eyes in man are recessive to brown eyes.

A heterozygous brown eyes man married a heterozygous brown eyes woman. Make a diagram to show the possible phenotype and genotype of their children.

2.A white rabbit mates with a black rabbit are found to produce five offsprings which are all white.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **W** and **w**, state and explain briefly the genotype of (i) the parent rabbits, and (ii) the white offsprings.

Posttest.2R

1.In common pea, long stem is dominant to short stem.

A heterozygous long stem pea is crossed with a short stem pea. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

2.The coat colour of guinea pigs is controlled by a pair of alleles which are codominance in inheritance pattern. When two cream coloured guiena pigs mate, 2 yellow coloured guinea pig, 2 white coloured guines pig and 4 cream coloured guiena pigs are produced.

Shows the phenotype and genotype of the parents and F_1 by means of a diagram.

Posttest.3R

1.In Angora rabbit, hair length is controlled by a pair of genes which are codominance in inheritance pattern. When a long fur rabbit mates with a short fur rabbit, all their progenies have intermediate silky fur.

Show the phenotype and genotype of the parents and F_1 by means of a diagram.

2.Two red-eye Dorsophila were found to produce 35 red-eye and 12 white eye flies.

(a) Which is the dominant character? Explain your answer.

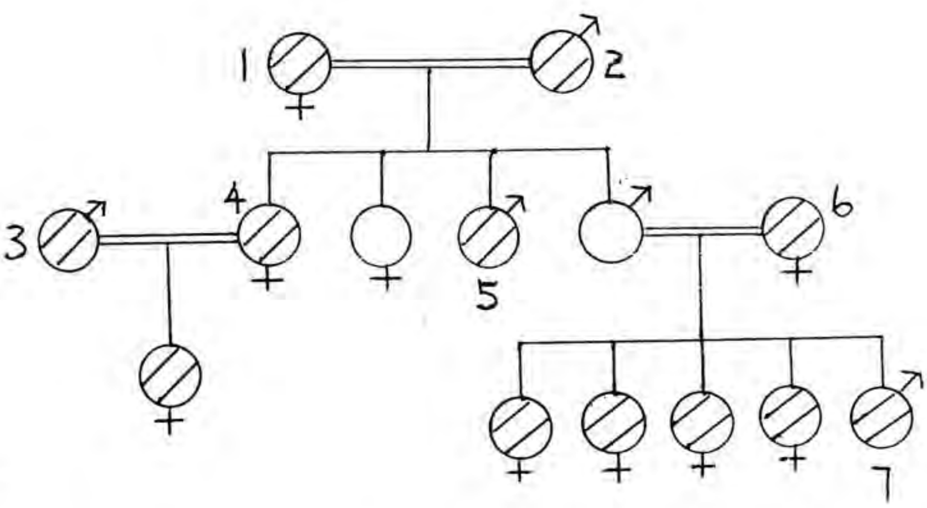
(b) Using symbols **R** and **r**, state and explain briefly the genotype of (i) the parent flies, and(ii) the flies in F1.

3. A pair of rabbits produces 6 rabbits with intermediate silky fur, 2 with long fur and 3 with short fur.

(a) Explain the genotype and pheontype of the parent and the progenies with the help of diagram.

(b) What is the name of the kind of dominance in the above cross ?

4. The black hair of guinea pigs is produced by a dominant gene B and white by its recessive allele b. The following diagram shows a family tree of guinea pigs.



 represent male pigs with black hair.

 represent male pigs with white hair.

 represent female pigs with black hair.

 represent female pigs with white hair.

A horizontal line is used to link up members of the same generation.
A double horizontal line indicates a mating.
The offspring of a mating are connected by a vertical line to the mating line.
Assume that individuals 3 and 6 do not carry the recessive allele.

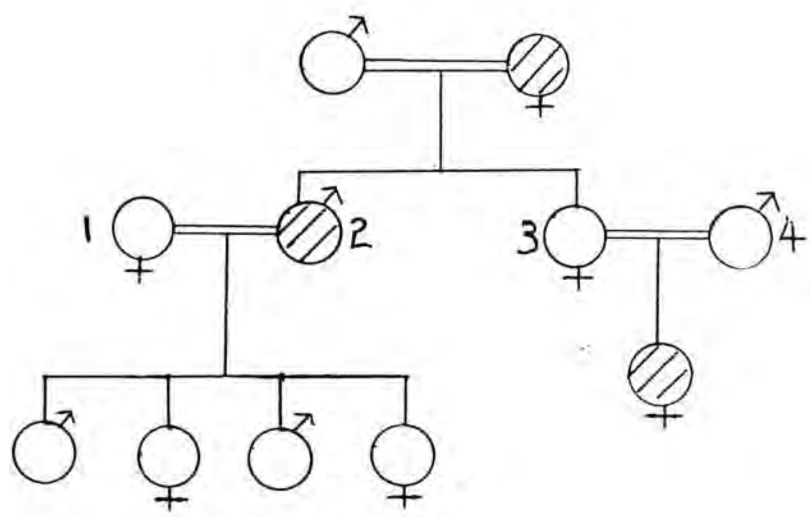
(i) State and explain the genotypes of individuals
  (a) 1 and 2.
  (b) 7.

(ii) What is the probability that individual 5 is a heterozygote? Why?

5.A man with blood group A married a woman with blood group B. They have four children of blood group A, B, AB and O.

Show the phenotype and genotype of the parents and children by means of a diagram.

6.In human, the presence of a six finger (polydactyly) is a hereditary character. A polydactylous woman marries a normal man. The following diagram represents the resultant family tree.



 represent normal male.

 represent polydactylous male.

 represent normal female.

 represent polydactylous female.

A horizontal line is used to link up members of the same generation.
A double horizontal line indicates a marriage.
The offspring of a couple are connected to them by a vertical line.

(i) Which character is dominant? Explain your answer.

(ii) State and explain the genotype of 1 and 2 by diagram.

Delayed Posttest

1. In fruitflies, grey body colour is dominant to ebony body colour.

A generation of heterozygous grey body flies is crossed among themselves. Make a diagram to show the cross and the result (phenotypic and genotypic) in the F_1 generation.

2. The flower color of a plant is controlled by a pair of alleles which is codominance in inheritance pattern. When a plant with pink flowers is self-pollinated, 5 red flower plant, 5 white flower plant and 10 pink flower plant are found in the F_1 generation.

Show the phenotype and genotype of the parents and F_1 progenies by means of a diagram.

3. Brown hair in man are recessive to black hair.

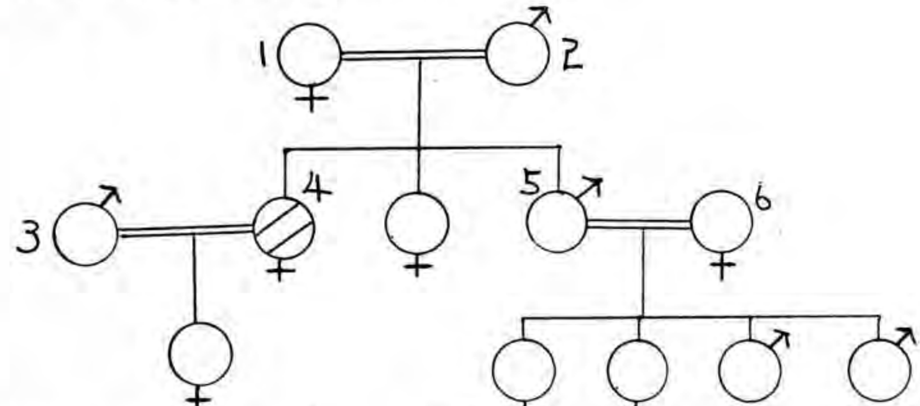
A brown hair man married a woman who is heterozygous black hair. Make a diagram to show the possible pheontype and genotype of their children.

4. One of the five offsprings of a pair of white rabbits is black.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **W** and **w**, state and explain briefly the genotype of (i) the parent rabbits, and (ii) the white and black offsprings.

5. In human, tongue rolling is determined by the presence of a dominant gene (R), whose recessive allele is represented by (r). The following diagram represents a family tree for a number of individuals.



♂ represent male roller. ⊘♂ represent male non-roller.

♀ represent female roller. ⊘♀ represent female non-roller.

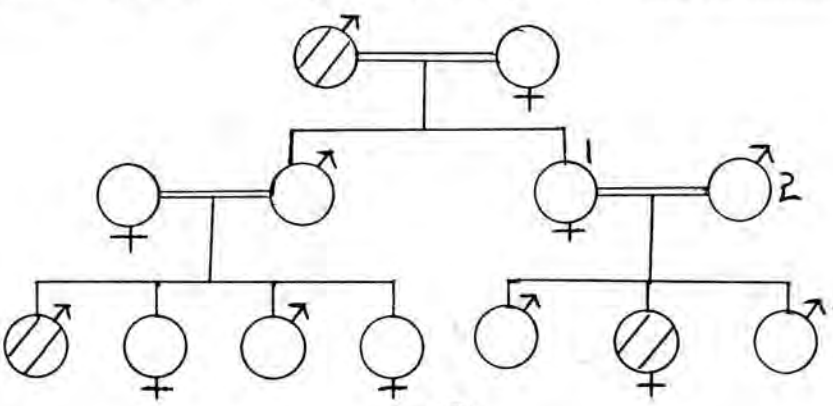
A horizontal line is used to link up members of the same generation. A double horizontal line indicates a marriage.
The offspring of a couple are connected to them by a vertical line.

(i) State and explain the genotypes of individuals
  (a) 1.
  (b) 3 and 4.
(ii) What is the probability that individual 5 is a heterozygote? Why?

6. A man with blood group A married a woman with blood group B. They have four children of blood group A, B, AB and O.

Show the phenotype and genotype of the parents and children by means of a diagram.

7. In human, the short sight is a hereditary character. A normal woman marries a short sight man. The following diagram represents the resultant family tree.



 represent normal male.  represent short sight male.

 represent normal female.  represent short sight female.

A horizontal line is used to link up members of the same generation. A double horizontal line indicates a marriage.
The offspring of a couple are connected to them by a vertical line.

(i) Which character is dominant? Explain your answer.
(ii) State and explain the genotype of 1 and 2 by diagram.

8. 21 seeds were collected from a plant and germinated. It was found that 6 of them have tall stem, 11 have stem with intermediate height and 4 with short stem.

(a) Explain the genotype and pheontype of the parent and the progenies with the help of diagram.
(b) What is the name of the kind of dominance ?

Appendix G Problems in the second protocol interviews

1.In garden pea terminal flower is recessive to axial flower.

A pure breeding pea plant with terminal flower is pollinated with a pure breeding pea plant with axial flower. The seeds resulting from this cross are collected and sown. When these plants (F_1) have flowers, they are self-pollinated. The seeds are collected and shown again and these are the (F_2).

Make diagrams to show the crosses and the possible phenotypic and genotypic results in the parents, the **F1** generation and the **F2** generation.

2.An red-eyed fruit fly is crossed to a fruit fly with white eyes. It was found that all the 60 fruit flies in the **F1** generation were red-eyed. The red-eyed fruit flies in the **F1** generation were then crossed to white-eyed fruit flies again. In the **F2** generation, 178 red-eyed fruit flies and 180 white-eyed fruit flies were produced.

(a) Which is the dominant character? Explain your answer.

(b) Using symbols **R** and **r**, state and explain briefly the genotype of (i) the parent flies, (ii) the flies in **F1** and(iii) the flies in **F2**.

3.The flower color of a plant is controlled by a pair of alleles which is codominance in inheritance pattern. When a pure breeding red flower plant is crossed with a pure breeding white flower plant, all the F_1 plants have pink flowers. The pink flower plants in F_1 is then crossed between themselves. Red flower plants, white flower plants and pink flower plants are produced in the ratio 1:1:2.

Show the phenotype and genotype of the parents, F_1, and F_2 by means of diagrams.

In the task-based interviews, the verbalizations made by subjects were in Cantonese together with English genetic terms. Protocols were orginally transcribed from cassette recordings in Chinese with English terms. Below are transcripts of the protocols of the six subjects. Records of two subjects (B3 and R2) were translated into English with Chinese transcribed for references.

I and S stand for the interviewer and the subjects respectively. Dots are added to indicate periods of silence. Other comments are inserted by square brackets to make these sentences more intelligible. The delayed posttest was used as tasks for the first interviews and can be found in Appendix F. The problems for the second interviews can be found in Appendix G.

Protocols of subject B1

(i) In the first interview:

Q1 MS1

S: fruit flies 之中灰色就 dominant to 呢個象牙色嘅。而呢個純種嘅灰色嘅呢，就佢地一齊 cross 左... 咁 Let 灰色嗰個個烏蠅啦，就呢個 B 啦，大 B 啦 parent 就咁... [一路寫... 到所有 Let 完] [再寫個 cross] [寫 parent BB × bb 和個 cross]

I: 點解你會覺得係 Bb呢, parents.

S: 佢講明左雜種.

I: 哦,兩個都係Bb嘅.

S: 佢話一對雜種嘛,佢話咗明係雜種㗎嘛,咁我咪兩個都係。[寫埋D phenotype]

I: 點解你會話三個都係grey 呢?

S: 因為呢個,唔,題目講明左啦,grey body 係會 dominant to 呢個 ebony body 嘅.

Q2 MC1

S: [看題目]. 呢個係 codominance 嘅 ... 嘗植物,粉紅色, self pollinated 個時候呢, 五朵紅色, 五朵白色, 同埋十朵粉紅色就會產生啦. [睇完整題, 做, 寫] [Let... Bb ...至cross完].

I: 點解你話個父母係 Bb 呢?

S: 唔,咁因為佢開頭講左係 codominance 啦, 啊, 而呢個 plant 呢, 有呢個粉紅色啦, 啊, 而佢之後產生個種呢有紅色同白色嘅, 而呢兩樣都好少量啦, 而反而粉紅色佢自己本身就多啦嘛, 咁睇返, 啊,咁個個圖啦, 咁通常佢自己都係多啦嘛 [指手中的 Bb].

I: 咁樣喀. [因爲D phenotype 立全題答完]

Q3 MS1

S: [看題目] 呢個 brown hair 係 recessive 嘅, 即 black hair dominance 啦。[睇] 個女人係雜種嘅.

I: 個女人係雜種, 個男人呢!?

S: 男人佢冇講明, 咁應該係純種 [跟住 Let ... 到 brown hair]

I: 通常你跟手 Let 左佢好似而家咁囉嗬?

S: 係吖, 好似, 做數目 [再做]

I: 邊個係 father?

S: 呢個, 要爲埋.

I: 嗬, 唔係, 唔係, ...而家邊個係 dominance.

S: 而家係 black hair.

I: Hum. Hum.

哎吔, 攪左 [改爲] 既睇唔清楚 ...... 哎吔, 爲咗 white 嘛.

I: 呢個係咩吖?

S: 啊，呢個係 father (bb) 呢個係 mother (Bb).

I: 點解你會估 father 係細b細b呢?

S: Hum，咁佢，講開話 recessive 呢個 brown hair，father 係 brown hair.

I: 所以 recessive 一定係咁嘅嗱?

S: 我通常 Let recessive 做細 [再完成個 cross，當中"bx"改至完成]. 其中一個係黑色嘅，即個個係，嗰個唔係 dominance [為 brown]

Q4 MS2

S: [看完全題] 其中一個係黑色嘅，即嗰個個係，吖，嗰個唔係 dominant [為 Let 而後插]

I: 你呢度係，邊個你話?

S: 我話 white 嗰個係 dominant… 我未 Let 住吖，佢而家 Let 左 [指題目 Ww] 但係，我重未唸到大嘅應該係，應該係邊個，其中一個純種，其中一個雜種嘅，定係兩個都係雜種，咁呢，因為，得一個係黑色吖，所製造出黎，其中四個全部都係白色拿喎，咁這，證明到呢，比較 recessive 嗰個呢，通常佢都會係比較少啲少D嘛，出來

咁所以我認為係黑色recessive囉. [寫a答案]

I: Hum.

S: [做b, Let] 2b係W係white, 細w係black, 佢有一隻出, 睇返前面, 睇返前面嗰個個圖 [轉前頁看自己Q.1.的diagram] 咁咗係兩個都係雜種. [開始做cross至完]... 大D既會有三隻係白色, 只有可能有時有誤差嘅, 唔佢有誤差嘅, 得一隻黑色, 同佢本身嗰隻係唔同啦.

Q5 MP1

S: Tongue roll係因為有dominance既gene R大R, recessive係細r, family tree, 有一個double既. 阿爸阿媽都可以捲利, explain嗰個一條... 唔, 1, 呢個係阿爸阿媽黎既, 究竟需唔需要用呢個diagram呢?

I: 你講解釋需唔需要用diagram? 可以用可以唔用嘅, 隨你啦.

S: 我估一係, 唔, ... 如果一係, 我估一係大R同埋細r.

I: 點解你估一係雜種呢!?

S: 既, Hum, 因為, 因為呢個頭 [指自己頭部].

I: 哈... 咁你硬係有D hint 喺嘛, 你睇到邊個所以估佢

係大R細r.

S: 我睇到兩個，兩隻生出聚有一隻係雞種啦，咪，有一個係roll到嚨，有一個係roll唔到嚟 [指嗰兩個女]

I: 你睇到就因為有一個roll唔到，有一個roll到.

S: 係吖.

I: 點解你諗係睇女仔唔睇男仔呢？

S: 男仔呀.

I: 佢生三個嚟嗰.

S: 但係我覺得好似男仔，好似決定嗰係爸爸嗰度.....我通常都會飛左佢嚟，呢題，呢題都係咁，我預啱呢D題目我都係飛左佢先嘅.

I: 係呀，咁但你依家嚟做吖，咁你就要諗吓拿，絕係話你估1係大R細r，Ha!

S: [點頭]

I: 你通常媽媽你就會睇個女仔？

S: 媽媽，係吖.

I: 咁如果我要你估二呢？

S: 我上次係冇咁諗到攞，(10)二係會睇個男仔囉，係呢次因為條題目唔同呢，所以就...

I: 條題目點唔同吖？

S: 同呢嘅咩？

I: 哈。

S: 我要試吓，我睇返前面先。

I: 這係你會睇返嗰個D cross吖嗬？

S: 係呀，睇鬼手做出嚟吖... [看着前面自己的cross來對個diagram] 如果將這兩個對比 [Q3] 咁只可以做到兩個，一個捲到脷，一個捲唔到脷，咁如果睇這呢個呢 [指Q2] 咁就可以有左分別嘑，咁當佢error嘑，咁佢做到兩個係，都係可以捲到脷，一個捲唔到脷...咁我當佢都係雜種嘑。

I: 其實前面嗰度，你係只睇下一代？有冇睇返佢個parent既phenotype，有冇同呢個一樣？你會唔會睇埋？

S: 點樣吖？

I: 這，係，你通常你睇返個cross嘑，你係成個cross睇，

抑或係你注意個 cross 嘅邊一部份呢？

S： 我注意係呢個，D，度生出黎嗰D嘅細路個度，譬如，睇吓佢比例囉，比例大概似邊個咁就揀嗰個嘞。[開始做] 我用圖解釋，可唔可以一個圖咁解釋晒全部。

I： 可唔可以一個圖解釋晒全部？

S： 因為佢，我覺得係有關連嘅。

I： 哦，但每次你都要自己解釋㗎囉……

S： [做 cross，做 5(i)(a)]

I： 如果前面冇你會唔會劃 cross 黎睇呢？

S： 我睇吓想像想像唔到囉，如果想像唔到就會劃。

I： 由個腦嗰個度呢想像？

S： 係吖。

I： 所以你揸住嗰個就係佢數（？）出黎嗰個？

S： 係吖，下面嗰個就係佢本身嘅，……做三、四、噢，explain 二同埋四，四就係呢個 non-roller，咁就係 rr 啦，咪牽又做番上面。

I: 唔需要，你用文字解釋都得㗎，但點解你肯定係rr呢？

S: rr, because [寫答案]… 女黎嘅，佢[翻前面，女則指三，但生個女]……，旦Rr，第二嘅[指仔受二影响]… 三就應該係呢個roller黎嘅啦。[寫三is R]

I: …佢係roller。

S: 我要睇下佢係咪雜種嘅，於是要劃圖[在答題紙側面劃小圖]，如果係兩個RR同rr，只可以出例一個，如果係 Rr出例兩個，啲兩個都唔同，咁應該係大R啦，兩個都係，佢只係出例一個。

I: 而家佢係生一個，佢生完唔生𠵱嘛。

S: 佢生完唔生，但係……啊……咁睇下先吓[用做兩個cross][test paper組嗰兩個]再劃多次，咁以前好似講過，話咩身体會 排斥嗰個咩。唔同嗰個咩身吓，個gene唔同，唔呢好似男女，排斥嗰個咩，比較recessive，這……Hum，呢個[指三]，唔係好清楚，我斷估咩。

I: 這，你決定唔到，但係你都估佢係大R大R。

S: 係的。[做正式answer嗰個cross]…[再看題目] probability of individual 五… 噫，呢個又要劃圖？

I: 你想唔劃呢你咪係改邊個圖你咪指。

S: P等於呢個2 over 3先，睇返呢度先，都係劃返雞種係1/2，因為唔係睇呢度 [指剛完成既不合用]

I: 點解你會覺得係1/2呢？

S: 因為我睇返呢個圖啦，我初時諗住2 over 3嘅，咁就睇呢個圖啦，咁有三個啦嗎，即係一個唔係，Am, non-roller，咁我初頭係睇呢個但係我而家覺得，既因為呢個係佢生出黎嘅積，或者佢裏面個種配合係唔同啦，所以揀呢個。

I: 咁跟據呢個圖點解你會覺得係1/2呢？

S: 咁呢度有四個機會，咁而，如果要佢雞種就係大R配細r吖嘛，咁咪2 over 4囉。

I: Hum.

S: [寫餘下既，即個cross].

Q6 MC&MI

S: 又係呢題!? [隨即開始做]...[Le] AO係個blood group A，BO係blood B... 直做完]

I: 你今次係認得個題目？

S: 係呀，上次我諗得好辛苦，上次唔係諗得好辛苦，係諗，

吓Let 邊個邊個咁.上次我係,我知道佢係應該、應該個gene呢有A啦有a啦,但係我唔知嗰D Let 嚹.

I: 點解你會覺得有a呢?

S: 既,因為有a產生,而a...

I: 即因為細路仔有個a.

S: 因為後尾聽過、且我聽人講過話明a係recessive嘅,所以覺得係咁嚹,而且佢兩家個種都有齊晒喇嘛.

Q7 MP2

S: Short sight, normal woman marries 一個short sight嘅man...which character係呢個dominant

I: Hum.

S: Normal,唔係normal,應該係normal嘅.

I: 你點睇啦,今次係.

S: 今次呀!今次我睇晒呢D嚹[指兩行]咁全部offspring所出都係normal嘅,咁兩個都係冇short sight嘅,都正常嘅,咁應該係有short sight嗰個recessive黎嘅.

I: 如果係咁你會點睇,淨係睇一、二,淨係睇呢個[遮住

一、二和單]

S: 我都係會睇short sight，唔係dominant，因為……因為如果佢係dominant嘅話呢，一個二都係有近視啦，即係有啦。因為如果佢係dominant嘅話呢，佢係雜種啦，咁就一定會表現在出黎。

I: 咁呢個同呢個比較，邊個sure D呀？

S: 當然係呢個。[指父母生一和有label嗰個family]

I: 點解呢？

S: 既，因為一睇落去呢，呢個dominant D，因為佢所有出個個都係呢個[指normal]……唔我要睇返前面D[翻看自己的作答]

I: 你多數睇前面而你覺得ratio好重要。

S: 係呀[看前面][然後做answer]

I: 你會揀呢個family來講。

S: 我會揀呢個[指最初的]

I: 點解呀？

S: 因為我一開頭睇呢，咁順完次序我會跟開頭先。[做個cross]

[做ii]

I: 一你會估佢點呢?

S: 一我已經估左佢係大B同細b嚟,經過呢個(cross)囉,[指(a)part嗰個(cross)]=我未估.[然後再看題目和前面的(cross)對]出兩個normal,一個short(ight).咁肯定呢係呢個,如果兩個係Bb……咁應該兩個都係Bb啦.[做個(cross)]

I: 然之後你就劃啦,即話你會計返佢既下一代,然之後對返你之前題目所做嘅cross,對下佢似邊個,然之後有phenotype,咁根住你先劃.

S: 係呀![全做完]

Q8 MCT

S: [看題目]六係長,十一係雜嘅,四係短嘅.

I: Hum. Hum.

S: parent咁229係有[不清楚]progeny點解.

I: 即下一代,相當於下一咁解囉.

S: [即刻Let……short][寫gamete]

I: 你咁快去到gamete嘅?

S: 咬吔, 做完嚟 [揸gamete, 改parent, 接着寫Bb. Bb. 至完成].

S: 找返前面抄codominance......咗, 大功告成.

I: 但係你都冇講個parent同個F_1係咩物嘢.

S: [加F_1在個cross及補parent Bb等].

(ii) In the second interview:

Q1 MS1-LONG

S: 咁recessive，跟住pure……嗰D seeds，咁就，都唔係好明。

I: 係呀。

S: 係第二次跟住又攞左D seed 然後再播種，又再生到D嘢出嚟嘅個D F_2. result in the… F_1 and F_2. [做] F_1呢，應該大A dominant嘅 [寫 A = axial flower ……做個cross完] 呢個係F_1, parents [補寫 parents gamete 等有人借釘書機] 但未必識用嘅。[繼續做] 再播種，呢度出 A a Aa 呢個 parents，gamete [寫至cross之完] [呢度呢就係呢a字頭嗰個flower嚟嘅 [補寫 all axial flower在F1] [即補phenotype] 即是呢三個都係嗰個 [寫axial flower在F_2的 AA 和 Aa Aa 寫 = terminal flower] 比例係咁，3比1，唔使解釋呀。

I: 你呢個係第幾代嘅？

S: [補寫F_1在cross之的parents]

I: 你做完嗱？

S: 係呀。

I: 既然，呢度點解你會話呢個係大A大A呢？

S: 唔，因為，佢話左呢個recessive to. 咁這係呢個dominant.

I: 哦，所以你就Let個axial係A，因為佢係dominant，點解你會話佢係大A大A呢？

S: 佢話pure吖嘛.

I: 呢個又係因為佢話pure啦，咁所以跟住你就覺覺得F1就係咁啦，咁所以就係axial嘅，咁跟住，呢度點解呢個你都會大A細a呢.

S: 睇下先，佢話F1啲D自己吖嘛，self-pollinated吖嘛，咁F1所得嚟啲個allele係Aa，大A細a吖嘛，咁應該係呢兩個囉.

Q2 MS2-LONG

S: red flies係cross 和呢個佢，跟F1係咁嘅，全咁都係，咁這係紅色係dominant啦，因為全部都係，Let左佢先[寫]... 等於white，跟住呢，就cross去個white eye，咁有given呢，係佢地一半一半嘅，所 出嚟啲D，咁即話呢，啲隻紅色啲隻應該係雜種呀，然後至一半一半.

I: 哦.

S: 試下先.

I: 你由parent啲隻做起啦.

S: [做].

I: 你依家做緊邊個呀?

S: 第二題, 白色呢係應該係recessive嘅嘛.

I: Hum. Hum.

S: 我依家, 唔, 答左個一先 [爲a. Red] dominant係咽個red囉, because係呢個 F_1, 咽個generation 嗰度呢, 全部都係, 呢個紅色嘅, 全部都係紅色嘅, 如果係recessive應該冇得可以show到出黎啦, 咁, Hum, 跟住咽個應該, 跟住所產生咽D咁既, 既, 咽D......, 這係要用cross 咽D parent [睇題目] genotype of parent flies in F_1 and F_2.

I: Hum, Hum.

S: 咁 parent 呢, 呢個要佢應該就係..., 應該全部都係大R, 咁出黎先至有可能, 咁至可能全部都係, 出左呢個樣嘢, 咁樣 [爲 1st cross 之完] 呢個係 F_1 generation.

I: 咁呢D係點樣呀!? 紅定白呀?

S: 呢個係紅, 我都唔識 explain.

I: Hum. Hum. 跟住你要做咩呢?

S: 好似要做下呀, 我而係度諗緊, 既, ...

I: F_2佢依度話點呀?

S: 佢依度話,佢話差唔多相等,呢個數目,白色同紅色.

I: 咁佢話F_1同啲物嘢cross嫁?

S: F_1,咪呀!同白色做到一半半啦.

I: 吓.

S: 做到一半半啦,呀,做完啦!

I: 咁你寫埋佢個phenotype!

S: 哦.

I: 個比例呢?

S: 1比1,佢都唔駛你做!

Q3 MC-LONG

S: 顏色,係呢個,而呢個codominance即係兩個一齊嚟啦.

I: Hum. Hum.

S: 白色同呢個紅色變成雜色,跟住全部一半一半,粉色囉,後面cross,咁白色,Let red flower係呢個.

I: 哦.

S: 咁我叫左佢呢個係右邊個係dominant嘅啦.

I: 吓吓.

S: 咁，是但啦. 呢個white flower，呢個 [指 a] 嘅代表佢係既，既代表紅r係recessive. Hum. F_1,F_2咁parent.

I: Parent都要整埋吖.

S: 呢個parento [做個cross] 已完. Ah. 呢個要左粉紅色啦.

I: Hum, Hum.

S: [寫pink] 咁呢個就F_1啦, 咁下佢自己cross個陣 [寫2nd cross] 係出左呢D嘢.

I: 哦.

S: [完成個cross] 因為codominance. 咁所以啦genetic ratio同個個ratio [指phenotype] 應該一樣 [寫F_1 gamete F_2] 咁呢個F_2, 呢個紅色, 呢個白色. Hum, 得啦.

I: 哦. 好快喎.

Protocols of subject B2

(i) In the first interview:

S: [看完整題，才開始做和講] 灰係dominant，既，呢個呢個點解，呢個黑身係recessive，咁，咁就Let左佢dominant gene，咦吔，佢會寫左呢個，dominant gene be大L啦，咁，recessive呢，recessive就係細e啦。

I: 細e，哦，咁dominant係邊隻呀？

S: 既，dominant就係grey，grey body囉，既呢個就係，既，recessive就係黑身囉。既咁我劃個圖，開始劃個圖嘅，…既，嗰個雜種，既雜種嘅灰色，就係大L同埋細e啦。咁既，咁既，cross with，兩隻兩隻，咁就係兩隻同樣係大L同埋細e啦，咁這，第一隻就有大L同細e，咁跟住cross左之後，就出左大L同埋……，大L細e，大L細e，跟住就係兩個細e，咁，Hum，所以所以，嗰個……其實我呢度有D問題呢，既，咁個，既，係咪parent係呢點講㗎？

I: 呢度話：Make a diagram to show the cross and the resultant phenotypic and genotype in the F1.

S: 點唔點寫D字㗎？個parent 我成日懷疑點呢點寫D字落去？

I: 你喺個圖有冇寫呀？

S: 噎，大L同細e囉，既，大L大L，細e細e，既，heterozygote，呢個

就係兩個大L細l. 既, 咁個ratio就係1比1比2. 所以就係呢, 既, 因為呢個灰色係dominant啦, 所以grey body比呢個象牙色係三比一. 我做完啦.

Q2 MC

S: [整題看一次, 然後做及講] 因為呢兩隻花係codominant啦, 咁所以Let左紅色嘅gene呢做大L細l. 白色嘅gene係細l細l. 既, 粉紅色嘅gene做大L細l咁, 劃左個graph之佰呢, 就, 呃, parent 既, parent 既, phenotype. 呃, 係兩個都係粉紅色啦, 係咪就咁寫兩個都係粉紅色就得啦?

I: 唔, 如果兩個都係, 依家係咪呀?

S: 係呀, 應該係 [read the sentences concern to the interview]. Both are pink flowers. 即係兩個都係粉紅色啦. 而呢個genotype呢就, 既, 因為佢地係粉紅色, 所以係hetero, heterozygous啦, 既, 分別係有大L同細l. 跟住嗰個F1呢, 就, 唔, 咁題目係左呢D顏色係呢, 點呢點再寫多次㗎? 因為佢又問, 安㗎呀?

I: 呢, 你可以寫係F1 D genotype下面.

S: 咁, Hum, [writing conclusion] 五朵紅色花呢就係有大L同細l, 五朵白色呢係細l細l. 而十朵粉紅色呢係大L細l.

Q3 MS1

S: [整題看一次, 然後做及講] 呃. 棕色既頭髮係recessive, 咁

定黑色係大L同埋大L gene，呢個啡色呢，係細l細l，咁，題目就係話一個啡色嘅男人，啡色頭髮男人，咁呢度話係啡色頭髮嘅男人，咁就係啡色頭髮嘅男人，咁就應該係一個大L同一個細l，就咁，就咁，定係唔一定係，可以咁，可以咁架喎，因為佢冇講清楚，可以一個大L一個細l，recessive...... brown hair man，既咁應該係細l細l啦，同埋一個woman，係黑色頭髮，就係......因為佢係heterozygous，就係大L同細l啦，咁劃 個圖，劃左圖之后呢，就咁啦。

I: Hum.

S: 咁呢，佢地個組合仔呢，就，既，個 phenotype 呢，就係應該，既，既有一半係，有一半係既黑色頭髮啦，就有個gene係大L細l啦，咁有一半呢就係啡色頭髮啦，就係細l細l咁囉。

Q4 MS2

S: 第四題呢就係話，唔，其中五個offspring有一個係白色，呢係，有五個offspring有一隻係白色嘅......吖，係，即係兩对白兔仔，咁，就，生左五個offspring，咁其中有一隻係白色。

I: 唔，唔。

S: 咁......呢個係dominant，咁，.....睇下先，既，應該，既，因為佢五份一之中只有一对係黑色啦，咁所以白色係dominant，既，咁答案既解釋就係話，因為白色嘅offspring就，既，係五隻——

I: 你係決定dominant 時，你有冇考慮佢parents 嘅？

S: 咁，個parent都係白色吖嘛，咁佢其中邊個係只有一個係黑色，咁唔係白色係dominant？

I: 哦，我只係問你考慮時有冇諗過parents啫。

S: 有，咁，唔，因為，因為，我淨係諗offspring個度，呢個多D應該係嗰個dominant

I: 唔，唔。

S: [看]meaning symbol……咁Let左嗰個[邊講邊寫]大W be dominant啦，就係白色啦，Let左個細w就係recessive，係黑色啦……咁，奇怪啦[指住個white]

I: 點解你指住個白色？

S: 唔，咁又唔知佢係純种定雜种，咁，跟住寫劃圖，唔知佢點？

I: 嗰度你自己諗啦，你覺得佢係純种定雜种呢？

S: 唔……唔……應該係，既，雜种，既，因為如果唔係唔出得個黑色，兩隻都係分別有大W細w，應該兩隻都係一樣……唔……因為既，佢，如果佢兩個都係純种，就出唔到黑色囉，咁，但係，如果兩個都係，出黎個結果應該唔會咁少黑色囉，即，如果兩個都係雜种，咁應該……四份之一，睇先，唉錯，好似唔係，呀，照做啦，咁呢既，出黎個diagram就應該係

I: 點解你照做既？

S：因为我諗返起應該係結果，頭先我做過呢，應該係，一隻係兩隻[gene]都係大W細w啦，一隻係，兩個，大W細w，大W細w跟住就兩隻都係細w，就会係黑色啦，咁，三份之一係黑色啦。如果係咁。

I：唔唔。

S：既，咁，cross出黎呢，就係咁個parents既，唔，所以兩個都係大W細w咗啦，係heterozygous咗啦，兩隻都係白色，咁，既white咁個offspring，就應該有，有D就有兩個都係大W，有D就係，既，一個大W一個細w咁囉，咁而，黑色呢，就会係，就应該兩個都係細w。

Q5 MP1

S：[看題目] Human, tongue rolling, dominant [已看完]……問genotype了一，唔，rollers，咁一就係個male roller，咁，就係female roller，咁……唔咁睇佢同出黎既細路仔就有，有，三份之一係non-roller咗啦咁，咁咁係roller多过non-roller，所以就应該係roller dominant roller dominance，所以一啲個就应該即係這個佢有dominant嘅，應該係dominant既gene咗啦。嗯，一……嗯……應該係dominant咗啦，嗯，我又唔知佢係雜种定純种啦，咁先。

I：唔，一係雜種定純種呢？

S：嗯，唔……估佢雜種嘅，因为佢出到non-roller出黎啦。

I：就係non-roller，佢佢係雜種。

S：其實二都有機會係雜種，但係……係啦，所以我諗到啦，不過佢又冇問。咁，我諗得，呢，所以佢應該有機會係純種同雜種。

I：點樣解呢！？

S：因為如果佢係，呢，就算佢係……就算呢個係純種啦，如果呢個唔係純種，咁，佢都可以produce呢個結果出黎。

I：都可以。

S：呢就一個純種一個雜種，都有一個係……咁，唔係應該全部都係dominant……係喎，應該全部都係dominant，冇，應該係冇，兩個都係recessive咁……應該兩個都係雜種，咁就應該係大R同細r啦，兩個都係大R同細r。［啦［看題目，想了很久］呢，呢個係roller啦……咁，呢就應該係，應該係純種嘅，因為呢你佢出黎嘅細路仔又係roller嘛，呢就……咁，如果佢個［三］係純種，咁呢個應該係雜種嘅［四］。呢，我估四，咪先，出黎出黎應該係純種。呢，好似唔啱咁……咁，因為呢個四係non-roller啦咁佢係應該係唔係recessive，呢就應該係recessive gene，咁佢既，佢既父母呢又係純種嚟嘛，咁佢應該係雜種，咁三，應該係純種啦，所以應該兩個都係R［寫下三一RR］咁四應該係……係雜種，以唔係喎，因為佢係non-roller，咁應該係兩個都係細r，唔應該係純種呀！因為佢係non-roller啦，咁即佢係應該係recessive gene，所係純種。

兩個組別 [寫下啲一 Lr] [困寫個D explain]

S: [做一、二個 cross] 呢……唔呢。

I: 點解你係咁做返一、二?

S: 因為、呢兩個揾豆咋嘛…… [寫完佢] 咁佢係 heterozygote,呢兩應該係、係咪½ 嘅機會呢、咁個 cross 呢,就應該有½個機會,唔知係咪,因為我唔識呢個,所以就出嚟。

I: 你正話嘗試用一、二來揾豆。

S: 唔、但係好似唔啱,出嚟的結果…因為呢個…係……全部都係有大R啦即全部都係 roller,咁、但係佢有啲係 non-roller,咁,即係唔啱啦,但係我又唔知點做,又唔知佢錯係邊個。唔……

I: 唔,做第二D。

Q6MC&MI

S:[看完題目] 第六題有一個 group A 即男人同一個 group B 就女人,咁就,佢就有 group A 啦 B 啦。AB 啦同埋 O。咁就個 group A 呢就係… [寫 LL] 就個 group B 呢就係 [寫 ee] 咁 cross 出嚟之後呢 [做個 cross] [做完,然後揀 L 和 e]

I 點解你又揀返個 L 嘅?

S: 唔、咁唔啱，諗錯左，唔睇先。[繼續做，至做完] 應該係，應該兩個都係雜種，係呢個，應該兩個都係雜種，因為睇佢個結果有四個唔同。唔……唔……因為出來有四個唔同。咪先……唉！[查剛做好的cross，做Ll，ll] 如果嘗即係dominant係group A，recessive係group B，咁A就係雜種，B就係純種啦。

I: 你會覺得A係雜，B係純種。

S: 唔。[繼續完成個cross之后] 唔……唔係好似咗係呀，唔……唔……呢個……唔……但係又諗唔到啲法。[表示不想做]。

I: 我再睇睇你正話點樣諗先，即係話初初你當一個係純種啦，另一個都係純種啦，咁你發覺出唔到四款嘢，咁佢條你當佢兩個都係雜種啦，咁結果你出到四款嘢啦，係咪呀。

S: 唔。

I: 但係結果佢兩個都有啲可能會唔同啦。

S: 唔。

I: 咁跟住你當佢一個純種啦，一個雜種啦，咁但係你發覺只係得兩款嘢，咁所以唔知點諗啦。

S: 唔。

I: 咁你一路的諗法都係當佢係simple dominance既？

S: 係.

I: 嗯.

S: 係,如果係codominance,咁呢,我唔知點做啦.

I: codominance,都係唸唔到.

S: 唔,因為codominance都係用這些Dgene出來嚟嘛,咁佢個result都係同解釋唔到嘅.

Q7 MP2

S: [看題目 ,然後看圖]short sight,short sight.

I: 你係點樣睇D嘢呢?

S: 呢個short sight嚟嘛 [指第一個] 呢個short sight [指最兩個].

I: 係,斜線係short sight.

S: 咁呢應該係normal呢,係dominant.

I: 點解呢?

S: 因為佢所有細路仔,都係normal嘅.[指那四個]

I: 佢兩個呢係佢細路仔. [指♀和♂, marriage入來個]

S: 咁dominance應該係, dominance應該係normal嘅.

I: 咁如果佢系係生一個, 咁你點算呀?

S: 嘅嘅... 咁, 生一個, 如果個個都係normal嘅, 應該係normal都係dominance嘅呢.

I: 你係度

S: 諗緊你頭先問我啲嘢, 呢...... 呢...... 咁, 如果得一個細路仔, 咁話, 如果佢都係normal嘅, 咁就應該係有一個純種, normal啦, 既有一個係雜種, short sight, 咁都應該係normal個個dominant, 呢即係我係咁諗.

I: 你認為short sight係雜種.

S: 呢... 應該normal係dominant, 因為佢哋都係[指二和三行] normal.

S: 唔, short sight.

I: 你依家睇緊邊度short sight?

S: [指一和二的下一代個個short sight].

I: 哦, 佢既下一代. Hmm. Hmm.

S: 咁呢個係normal個[指一]咁呢個[指二]。容自己Let gene啦。[寫Let……e]咁佢個仔3個引中有兩個係dominant啦，咁……唔…咁……唔知呀，唔知點諗好。

I: 唔知點諗好？

S: 因為我又，既唔知佢上面唔知點，推番出黎呀，因為我呢D又唔知[指一的父母]

I: 因為一呢既父母你又唔知，所以你就唔知點推一啦。

S: 嗯，但。

I: 但係你又注意返佢既下一代，係咪。

S: 唔，呢。

I: 咁你覺得有啲可能性呢？

S: 咁一係有兩個可能性，一係就雜種，一可以係大L細e，咁二就LL。

I: 即第另一個可能呢？

S: 兩個都係Le，因為出黎的仔都係normal的那D。

I: 你好似在腦裏做緊D cross。

S: 係,但係冇做練習.

Q8 MCT

S: 呢個應該係 codominant,因為佢有 intermediate 出現.

I: 哦,因為有 intermediate,所以你覺得係 codominance.

S: 呢......Let 左佢,呢個 gene [寫 Let...... e] 咁呢個係 codominance,就有兩個都係大L細l 啦,咁 [做個 cross]

I: 咁邊個係邊個? [指 b progeny 的 phenotype].

S: 咁呢個兩個都有 long stem 既 gene,咁呢個應該係 tall. 呢個應該係 short,呢個應該係 intermediate [寫出各 phenotype].

I: 咁個 parent 呢,個 parent 你話佢係大L細l,咁個高度點呀?

S: 應該兩個都係 intermediate.

I: 咁你會寫埋佢.

S: [寫到比例時,再看題目] 唔......好似同呢個數目唔係好同差少少,但係應該係冇影响,應該得嘅.

I: 係呀!吓!你覺得有冇影响?

S: 唔. 乎小小, 所以係選佢咪, 個D嘢, 應該係冇影响, 既[為埋 tall : inter : short = 1:2:1] [看完(b)題] 應該係 codominant 啦.

S: Terminal 呢，就 recessive 啦嘅，係咪，axial.

I: Ha.

S: Axial 就係，dominant 啦. Hum, pure breeding, terminal flower is, 咁就，Let.

I: 唔緊要慢慢諗吖，一定估到得嘅.

S: Pure breeding terminal flower is pollinated with, Hum, 呢個 terminal 嘅，pure breeding 嘅 plant 呢，就嘅，咁 Let 左 lo 個個嘅 genotype 嘅，叫佢住吖，嘅 genotype 係 呢個 terminal flower 嘅，terminal flower 係細階 g 嘅. 咁 Axial 嘅 flower 就係大階 G 啦，咁因為呢個純種嘅，又唔係 terminal 嘅，咁就一定係兩個細 g，兩個細階啦. 咁，pollinate with 呢個純種嘅 axial，咁出嚟就叫咁啦 [做 1st cross，做好] Ham, when these plants have flower, self-pollinated, what is F_2. Am, 寫出咪劃埋 F_2 個個，F_2 個個 graph 嚟.

I: Hum. Hum.

S: Make diagram to show the ..... 咁因為個個 F_2 係自己 self-pollinated 啦，咁所以就係咁啦 [做 cross 2] 好啦，做好.

I: Hum. Hum.

S: 跟住 possible... 咁F₁ 個個 genotype 呢就係 [寫] Han. F₁ 個 phenotype 就係全部都係, Axial 既.

I: 咁 genotype 呢? F₁?

S: 就係全部都大階G.細階g.

I: 哦.

S: F₂ 呢就係, Hum. [寫] Han. 呢個 axial 比呢個 terminal, 就係三比一, 咁 genotype 呢就係, Han. [寫 GG : Gg : gg = 1 : 2 : 1]

I: 做完啦, 係咪呀?

S: Hum.

I: 唔記得提你下次做完講比我聽, 点解 terminal 你會用細g 呢?

S: 因為佢 recessive 吖嘛.

I: 哦, 咁样, 点解呢度你以为兩個都係細g, 或者兩個都係大G 呢.

S: 因为佢兩個都係純种.

I: 哦. O.K. 咁呢兩個呢. 呢兩個點解都係aa既?

S: 因為佢地係self-pollinated, 咁佢地D geneo都應該係一樣啦!

I: 哦, 好吖.

Q2 MS2-LONG

S: 既... all the 60 fruit fly... 咁呢就. 既. 睇下先, 個個, 純种純种. Hum, 呢個.

I: 你劃花佢都唔緊要, 呀!

S: [試D genotype在題目紙]

I: 你係度諗緊D咩野呢?

S: 既, 因為佢呢度呢佢話既出黎個D全部係Am, 紅色啦. 咁就應該係. 既, 兩個純种或者一個純种, 一個雜种既. 咁吖. 咁我諗 呢個因為拿睇埋F₂個D既. Am. 比果. F₁. Am. 60.

I: 所以我見你係all the 60 個度睇左好多次.

S: Hum, Hum. Hum.

I: 起碼睇左三次.

S: ......[很向打] Hum. 咬呀, 睇漏左, 睇漏左呢個, 唔怪之得啦, 呢啲.

I: 哈哈, 哦, 原來你正話睇漏左個 white eye, 這話你係面諗極都諗唔倒, 你就冇睇反前面啦喎.

S: Hum, 唔怪之掛, 唔應該係咁, 因為既, 咁, 應該兩個都係純種, 因為佢出嚟全部都係既一個一個顏色嘛, 所以呢下個D就應該係有既 recessive 既嘢, 但係, 係下度就唔 show 出嚟, 咁這話, 係 parent 個度有啦, 咁A呢就係呢, red 啦 [做] because [做] Ham 睇返下 [看題目] explain the phenotype, the parent, 咁個 parent 呢就係.

I: 你用個 cross 嚟解釋佢啦.

S: [做] 哦, 哎, 唔記得左.

I: 嗯呀.

S: 呢個要分開佢出嚟.

I: 如果係咁話, 呢個都要走兩個得嚟啦.

S: 既[做], 係咁就得嚟嘅呀, 點先唔點先 explain 呀!

I: 几多x几多呀?

S: 一x一.

I: 你個explain呢，通常呢你就話，跟我跟反個圖，這話refer反幅圖，所以通常都係用圖explain好D…做完喋啦。

S: Hum.

I: 做完我問反你D嘢啦，咁第一就話，點解你覺得紅色係純种呢？

S: 既，因為如果佢雜种既時侯呢，F₁出世到全部都係紅色嘅。

I: 点解你会覺得紅色係dominant呢？

S: 哦，既，咁，因為我睇，因為一個唔同phenotype，唔同啦，這紅白，咁produce左同既顏色出黎，這一样顏色，既，咁又睇到，咁我初初以為佢应該係初初以為佢雜种，咁F₁冇show到，F₂就show左出黎，咁white应該係recessive嘅。

Q3 MC–LONG

S: 咁就，Codominance，co-do，…咁兩個都係純种啦，…咁就[做] Let 呢個，呢，Let 呢個red flower to be 大R，White flower to be 細r，因為佢codominant。

I: Co-dominance，咁係点呢？

S: 既，粉紅色，係啦，咁係F₁ 就係粉紅色嘅啦…

S: 咁F1就自己cross themselves．咁這話，同番自己cross啦．

I: Hum.

S: 咁就[做完個cross]咁個F1 phenotype就係，全部粉紅色啦．咁個[寫genotype]就係全部都[寫All Rr]組咁樣啦．F2就係 Hum. phenotype就[寫]一比二比一．genotype[寫]．

I: 呢度，我發覺你呢一見倒佢codominance同埋pure breeding就好有信心咁做，寫大R大R同埋細r細r，咁佢你就憑記憶做左呢個啦，係咪．

S: Hum.

I: 咁跟住你到左呢度，你寫佢係粉紅色，你係憑記憶，抑或要睇返題目呢？

S: 唔，都有睇，因為以前都做過，有少少記憶嘅．

I: 吓，你都有睇吓，但去到F2個度呢，我就好清楚睇到呢，當然，你好快做左大R大R同埋細r細r，呢個cross出黎，但你睇到佢個phenotype既時候你都refer去個題目．

S: 係．

I: 係咪．

S: 嗯.

I: 然後先寫red, pink, white、嗱係話你一睇大R大R你就red啦, 大R細r你就pink啦, 細r細r就white啦.

S: 嗯.

Protocols of subject B3

(i) In the first interview:

Q1 MS1

Grey body，咁大聲得㗎啦可？
S: Grey body. Is my voice loud enough ?

得，得，得，
I: O.K.

Grey body，唔．[閱題一次] 開始寫 Let B...
S: Grey body, hum……[read the whole question for one time] let B be….. [write

[然後再看題目]
the beginning let statements, then read the question again]

你依家係留意睇D咩嘢字呢？
I: Which words are you reading?

呢度．
S: [point to heterozygous grey body] Here.

Heterozygous grey body，即係點解呀？
I: Heterozygous grey body, what does that mean ?

即係， grey body 唔係純種．
S: That means, the grey body is not pure. [write down grey body's genotype ,

make the cross and finish the cross of Bb X bb]

想知道你係邊度睇倒係個 ebony body flies？ 點
I: Where do you see it's ebony ? [point to "ebony bb" in subject's answer] How

樣決定佢係大階B細階呢？點解呢？
do you know whether this one [grey body] is big B small b ?

因為佢係呢度一開始講左個grey body唔係純種囉.
S: Because here it said that, at the beginning that grey body was not pure
咁,就應該,唔, produce一個大階B同埋一個細階b.
breeding, that should be, hum, a big letter B and a small letter b.

咁於是你決定其中一個係大B細b啦. 咁另外一個呢？
I: So you think that one is big B small b. Then, how about the other one?

啊,另外一個呢,我就估啦.唔.估嫁咋,哈.
S: Ai, the other are, I, guess. Hum… then, just guess, Ha.

咁呀！點解你估呢？
I: Why do you make such a guess ?

啊,咁佢話, grey既顏色呢係主要D呀嘛.即係屬於主要,
S: Ai, it said this grey color, is the main color. That is belonged to the main.
係咪主要,即係,顯示呀！係啦, dominant啦,咁,我就会估佢
Is it main ? That is, dominant! Yes, it's dominant. Then I guess it's so. [I]
咁,估一估佢, 當佢係一個細階b囉. 但係,我就睇唔倒
make a guess [and] suppose it is a small letter b(s). But by no mean do I read
係邊度話佢係一個純種囉.
such statement from the question.

唔,唔. 呢個你估佢係一個純種.但你係跟據邊度話佢係
I: Hum, hum. You guess its a pure breeding. But base on what do you make this
一個純種呢？
guess ?

我就係跟據佢係第一行話grey body係dominant.
S: I base on the 1st line, it said grey body is dominance.

Q2 MC

[閱題一次] 咁就啊, Let佢大階F係個dominant
S:[read the whole question once] Then, Ai, let big letter F be the dominant
咁就 細階f 係白色
[write]……then,.. small letter f….. be white. [after finish the beginning let
[再看題目一次]
statements, read the question again]

你睇緊D咩嘢呀?
I: What are you looking for ?

睇個D好似result個D嘢啦，咁，我就会留心D睇.
S: I am looking at something like the result, then, I will read [it] more carefully.
諗吓佢應該係,佢会點出嚟.
Think about how it should be, how it is produced.

即係話,你見到係result你会比心機睇.
I: You mean you would study attentively when reading something like result.

係呀係呀,即係,再諗吓,再由底推翻上去上面,睇吓應該係點樣嚟.
S: Yes, yes, that is, I think again, then deduce the top from the bottom, see how it should be.

你係話由F1推翻上去?
I: You mean [you] think from F1 upwards ?

係呀,咁跟住再睇返前面呢D,就会諗吓佢邊兩個進行reproduction.
S: Yes, then, read these from the very beginning, then, think about which 2 [parents] carry out reproduction.

然之後你睇返前面,你即係話,通常你「立」一次,然之後再做.
I: Then you read the former part, you mean, you usually glance once then do it after that ?

係呀,係呀.
S: Yes, yes.

哦,原來咁.
I: I see.

[做, 寫完 genotype, 做 cross] 咁...咁就係兩個
S: [write the parents genotype and perform the cross] then…then it's 2 pink
pink flower... 呢個係大階F大階F, 咁就係個 F1
flower…this is big letter F big letter F…..then this is the F1 [finish the cross].
然之後, 睇吓佢地嘅 ratio, 咁就係, 就係有一個 red, 有一個 white,
Then, decide their ratio [write] then it is, it is, it is a red, a white, 2 pink. [read
有兩個 pink [睇返題目, 寫 phenotype]
the question again, then write down the phenotype of F1.]

red 比 white 係 3 比 1 ?
I: Red to white is 3 to 1 ?

係呀, 因為, 啊, 佢呢個, 我將 pink 入埋去 red 啦, 因為佢有一個
S: Yes, because, Ai, this one, I take the pink into the red, becaues it has one big
大階F, 呢就係 dominant.
letter F, which is dominant.

點解你將 pink 入埋去 red 呢?
I: Why do you take pink as red ?

啊, 因為, 啊, 我呢, 當佢係一個 dominant 黎睇呀嘛.
S: Ai, because, Ai, I, take [red] as a dominant.

點解你以為佢係 dominant 呢?
I: Why do you think it's dominant ?

因為呢, 睇返佢啦, 五個白色, 五個紅色同十個粉紅色呀嘛, 咁紅
S: Because, look at this, 5 white, 5 red and 10 pink, then, red plus white and you
色加埋白色話呢, 咁就唸佢會係粉紅色啦. 咁即係一比二比一囉, 咁
will think it's pink. Then its' [ratio is] 1 to 2 to 1. Then, thinking back, then,
跟住再推翻上去既話, 咁就因為佢紅色所以就 pink 囉. 所以紅色
it's pink because it [has] red. So red is dominant… I don't know, Ha.
係 dominant... 唔知點拒, 嘻.

好啦, 繼續得啦.
I: O.K., let's continue.

Q3 MS1

Brown hair係recessive，咁即係black hair係dominant. brown
S: Brown hair is recessive, then it means black hair is dominant .....brown hair
hair man married a woman black hair係雜種 咁佢
man married a woman, black hair is heterozygous [write the let statements] then,
冇指明佢係純種定雜種，所以當佢係純種.
it hasn't stated whether it's pure or hybrid, so take it as pure.

唔，唔.
I: Hum, hum.

咁再show埋佢哋個ratio 咁就應該
S: ......[finish the cross] then, show their ratio..[write conclusion] then it should
係一個black hair，比，一個brown hair.
be 1 black hair to 1 brown hair [finish the question].

即係話，當你睇題目嗰時，你覺得佢冇指明佢係純種定雜
I: That means, when you study the question. When you think it has not indicate
種嗰時，你通常當佢係純種啦喎.
whether it's pure or not, you usually take it as pure.

係呀.
S: Yes.

即係有時你会自己估嘅，去determine個parent嗰時.
I: That means, sometimes you make a guess, to determine the parents.

如果佢有result嘅話呢，咁就再係result推返上去囉、但係
S: If it has a result, then, [I will] deduce from the result. But, if it hasn't state,
如果佢冇講明嘅話，好似話，比如佢話係一個normal嘅，normal
like, for example, it said a normal, normal man or normal woman, then, I take
man或者normal woman嘅話，我就當佢係純種囉.
it as pure.

哦，咁樣樣好啦，繼續啦。
I: O, I see, let's continue.

Q4 MS2

One of the five offspring of a pair of white rabbit is black，咁這話五隻有四隻係白色，一隻黑色，咁即係話白色係佢嘅dominant character.
S: One of the five offspring of a pair of white rabbit is black, then, that is 5 with 4 white and 1 black, then, that is white is it's dominant character.

即係話你見到佢四隻白色，一隻黑色你就覺得白色係佢dominant character.
I: That means, you find that it has 4 white and 1 black, then you think white is the dominant character.

係呀！
S: Yes.

哦。
I: I see.

因為佢個比例上係大D.
S: Because it has a larger ratio.

哦。 你依家做緊D咩嘢？
I: I see. …. What are you doing now ?

既，解釋緊。
S: Ai, explaining.

注話 解釋你正話同我講個D嘢。
I: You are writing what you have just told me.

係呀.[寫4(a)答案] 咁,跟住就[Parent寫...]咁parent就兩
S: Yes, [write answer 4(a)]…then, it is [write parents' phenotype and the cross]
隻白同白色既.
then, parent is 2, white with white

Hum. Hum.
I: Hum, hum.

咁就應該係兩隻都係,都唔係純種,因為佢有一隻,佢生左出黎
S: Then, it should be, both 2, are not pure, because there is 1, they produce one
既BB有一隻係黑色嘅.
baby which is black.

個parent係白色你係邊度睇到架?
I: From what resources do you know that parents are white ?

因為佢話, a pair of white rabbits 咁就有三隻
S: Because it said, a pair of white rabbits….. [write conclusion] then, it has 3
白色,一隻係黑色.
white, 1, hum, is black.

Q5 MP1

Tongue rolling, 出一個R. 兩個都可以,兩個都係可以捲到
S: Tongue rolling, produce a big R. Both two can, both two can roll [their]
脷嘅. produce 左有兩個可以... 咁... state and explain... parent,
tongue. They produced with 2 [progenies] , both 2 can roll their tongue. The
咁就... 個個... 個個..., 一, 個 ratio 係... 個兩個 genes....
2 [progeny] can …. then … state and explain … parent, then … the ….the
都係, 一個大R同埋一個細r, 即係佢唔係純種. 吓.
[individual] 1 … the ratio is …. the 2 [parents] have genes … both are, a big R

and a small r, that means they are not pure. Yes.

Hum, Hum.
I: Hum, Hum.

[做]
S: [write her answer] .....

一呢個genotype你估係一個大R同埋一個細r?
I: You think that genotype of [individual] 1 is a big R and a small r ?

吓.
S: Yes.

點解你咁估呢?
I: Why do you make such a guess ?

因為,佢生左出黎有一個係唔識得捲利脷,有兩個識得捲,咁即係,比例上捲利係大過冇捲利嘅.咁如果兩個都係純既話呢!咁就係人都識得捲㗎囉,咁即話係應該有一個唔識得係唔係純種,係兩個都唔係純種,這兩個都唔係純種,咁先會生都一個唔識得捲利脷.
S: Because, [progenies] she produced with 1 cannot roll tongue, 2 can roll tongue. That means, roller has larger ratio than non-roller. If both 2 [parents] are pure, every person [they produced] will be roller. That means there should be a non-roller, not pure, that is both 2 [parents] are not pure. Both 2 [parents] are not pure, so [they] will be able to produce a non-roller.

不如咁睇啦,如果一同二生四個個係捲唔到利脷,咁你會點睇佢地呢?一、二剩係生一個,生左四個之後就唔再生啦?
I: If 1 and 2 produce 4, the non-roller, only. What will you conclude ? 1 and 2 only produce one [progeny], they stop to have baby after having 4 ?

咁.............. Hum......... 唔知到.
S: Then .... Hum............. I don't know.

這話你都睇,你係睇佢個比例黎決定啦?
I: You need the [typical progenies'] ratio ?

係的.
S: Yes.

如果唔係得一個比例你，你就估唔到㗎？
I: You can't get the answer when there is no [typical progenies'] ratio.

係吖.
S: Yes.

好吖，繼續做吖.
I: I see. You may continue with your work.

咁，解釋吓，因為佢個 [為 it is because……] ratio，呢個 roller [完成 a 的答案] 咁，三同四，咁佢……嘅，三同四都估佢，個個，佢地兩個都應該係純種.
S: Then, explain .. because …. ratio … is the roller [finish part a]. Then [individuals] 3 and 4, they are … [I] guess 3 and 4 are, their, they both are pure.

點解你估四係純種呢？
I: Why do you think that 4 is pure ?

嘅，因為佢嘅生左個個係捲利脷嘅，咁即話佢，嘅……唔. 吖，咁再睇返一、二嘅時候呢，咁睇落嚟呢，咁四呢，嘅係，啲個個底冲，非捲脷利嘅個個唔，咁即話一係呢，應該係兩個細 r 囉.
S: Ai, because he, produces a, roller. That means, his …. Ai … Hum. Ya, Looking back at [individuals] 1 and 2, follow [the pedigree] downward, [individuals] 4 is at the bottom [of the pedigree], a non-roller, that means, it's, should be 2 small r.

Hum. Hum.
I: Hum, Hum.

咁就估佢會係純種，而三呢，一就同佢，嘅……應該都會係純種囉. 如果唔係，生左出嚟啲個個會，即生左出嚟之後，應該會有一個識捲，一個唔識捲囉.
S: So [I] think she is pure. And [individuals] 3 is, 1 with him, Ai, …. should also be pure. If he is not [pure], their progeny will. That is after reproduction, should have a roller and a non-roller.

但係佢哋生一個咋喎！
I: But they have one [baby] only !

嘻！………咁，………既………

S: Ha ! .... then, ... Ai ....

如果………唔………三呢，三…佢可能會係，亦都可能唔係

S: If............Hum .... 3 is, 3 ... He may be, and may not be [pure].

嚟，但，唔，但响呢度睇就，當佢係嚟。

Hum, but, from here, take it as [pure].

咁你覺得佢可能係，可能唔係，抑或佢一定係呢？

I: Well, [what is your decision ?] you think he may be, may not be [pure] or you

you think he must be [pure] ?

既，可能係可能唔係嘅。 因為，Hum，唔可以知道佢究竟

S: Ai, [3] may be and may not be [pure]. Because, Hum, I am not sure what he

係咩嘢，因為佢得一個仔嚟…… [寫下解釋]

is, as he only has one son .... [write down the explanation]

點解你唔考慮用cross黎解釋？這呢D，你会點去諗嘅？

I: Why don't you use cross in explaining the answer in question 5 ? How is your

method of thinking in this [kind of question] ?

我，這，既，上面呢D問題呢，我會比較容易D諗到嚟，但一到

S: I, that is, Ai, The questions here [Q1 to Q4], I will be easier to get the

呢D呢，我就，唔係好識得諗嘅。

answer. But once meeting this [Q5], I will be, at a lost and do not know how to

solve it.

Hum，Hum，通常你諗嗰時有冇用cross咁嘅？

I: Hum, hum. Will you use the cross in thinking [about the answer] ?

既，望住，係吖，這個腦裏面自己會畫左個cross出黎，但係

S: Ai, looking at, yes, yes. I will draw the cross in my brain. But, it's, [I] think

就，覺得好似同呢D有D出入嚟。

there is differences between these [pedigree and the practiced problems].

所以你就唔劃cross嗱. 所以你就用文字嚟去講嗱.
I: So you don't use cross. You explain in words.

吓. 但是就, 既, 覺得好難囉. 但係劃cross就唔知點樣表達佢出嚟, 這覺得好似唔完滿囉.
S: Yes, but then, Ai, [I] find it difficult to solve. However, [when thinking about] drawing cross, [I] don't know how to express. [I] have a sense that it's very incomplete.

這, 唔係一個好完滿嘅cross, 所以你就劃唔到出嚟?
I: [You] mean it's an incomplete cross, so you can't draw ?

這, 唔係一個好完滿嘅answer.
S: [I] mean, it's an incomplete answer

好喇.
I: O.K.

諗返個個cross係點樣, 這, 諗吓佢, 這, 一個純種同埋一個雜種, 既, produce出嚟會係, 既個兩個係, 一個大R同埋一個細r, 同埋兩個細r. 咁同埋兩個係純種produce出嚟兩個有冇分別囉. 咁如果佢係, 既, roller嘅說話呢可以捲到, 咁就這話既, 佢應該會係一個大R同埋一個細r囉.
S: [I] think what the cross is, that is, think about them, a pure and a hybride, ai, what's produce will be, two, one is a big R and a small r, and one is 2 small r. Then, [compare] with those produced when both 2 are pure. Are there differences between them ? If she is a roller, that means, she will have a big R and a small r.

咁呢度你唔寫嗱?
I: Why don't you write anything ?

我唔識再表達嗱!
S: I don't know how to express !

唔, 唔. 好吖. 下一題嗱咁樣.
I: Hum, Hum. O.K. [Let's do] the next part.

既,又係呢個....
S: Ai, this [question] again. ....

你又諗緊D乜嘢呢?
I: What are you thinking about ?

估佢佢應該係,佢可以係一個純種或者雜種嘅囉. 因為,既,我
S: [I] guess, he, he should be... He can be a pure or a hybride. Because, Ai,
睇一個時估佢應該係,係,Hum,估佢應該係一個,唔係純種嘅
When I look at [individual] 1, I guess it should be, he should be one, hybride.
囉.這話佢出黎應該,兩個都唔係純種既話,佢出黎會有一個
That means, she[1] produces 2 hybride, she produces 1 pure, 2 has 3, that is, Ai,
係純種,兩個有三個. 這既,有一個係純種而佢又能夠可以捲脷
one is pure and can roll tongue, the other 2 are hybride and can roll tongue. And
既,有另外兩個唔係純種能夠可以捲脷嘅囉.咁依家,我就,這啲,
now, I, that is, Ai, these 2 are rollers, that is the one in the middle and 5 are
既,佢兩個都可以捲脷嘅.即是中間嗰個同埋五都可以捲脷,咁,
rollers. Then, I am not sure whether he's pure or not.
我就唔知佢係咪純種嘅囉.

Hum, Hum. 呢度係問你乜嘢呀?
I: Hum, Hum. What does the question ask you ?

Probability.
S: Probability.

係嘞,佢係問你個probability嘅嘛,吓?
I: Yes. It asks about probability, right ?

咁,佢個可能性,這,既,我諗,都應該,高既,因為佢,跟住
S: Well, it's probability, Ai, I believe, should be high. Because he, looking at
睇佢再結婚生出黎嗰D都係可以捲脷嘅囉.
the progenies he produced after marriage are all rollers.

吓,咁佢可能性係咪高啲?
I: He's probability is high for what ?

既佢,係,佢係純種嘅既可能性會係高,而雜種嘅既可能性會
S: Ai, he is, the probabiltiy for being pure is high. Probability for hybride is
係低D.

low.

Hum, Hum. 但係佢依家問你咩嘢既可能性呀?
I: Hum, hum. But now it asks about what kind of probability?

既, 雜種. [寫答案]
S: Hybride.

你認為下一代都有影响 ?
I: You think his progenies is also significant, do you ?

唔, 都有.
S: Hum, yes.

Q6 MC&MI

唔, 有一個… 咁, 咁樣睇法, 這話有一個 blood group A 既男人同
S: Hum… has one… that way, that way. That means, the man with blood group
埋呢個 blood group B 嘅女人應該都唔係純種嘅. 因為佢地個
A and the woman with blood group B, should be, both are not, pure. Because
D, 個四個細路哥, 都係唔同血型嘅.
their, the 4 children, are of different blood groups.

吓, 因為四個都係唔同血型吓.
I: Because the 4 [progenies] are of different blood groups.

應該會唔係純種嘅, 因為佢有兩個細路哥係AB型加嘛,
S: [They] should be hybride. Because they have 2 children with AB [blood
咁唔係, 這有兩個, 一個細路哥係A型, 一個細路哥係B型嘅.
group], O! No! [I] mean, two of them, one child is [blood] group A, one child

is [blood] group B.

唔, 唔.
I: Hum, Hum.

咁,既,咁,這話應該佢,既,如果我係let佢個dominant
S: Then, Ai, then, that means they should, if I let the dominant be B, big letter
係B吖,大階B而細階b係recessive嘅話,這話A型血應該係
B, and small letter b is recessive. Then blood group A should be 2 big letter B,
兩個細階b,而AB型就應該係一個大階B同埋一個細階b
and blood group B should be 2 small letter b, and AB should be a big letter B

and a small letter b.

Hum. Hum.
I: Hum, Hum.

咁就試吓劃個diagram先.
S: [I] try to draw the diagram now....... [finish the cross]

點解blood group A同blood group B個gamete會一樣呢?
I: Why do blood group A and blood group B have the same kind of genotype ?

Hum, ... 咁 ..... 冇諗過, 冇諗到, 嘻, 冇諗過吖.
S: Hum, ... Then ..... I haven't thought about that, I can't think about that ...

試吓吖!
I: Just try !

嘻.....La.... 諗唔到.
S: Ha .... La.... I can't solve.

Q7 MP2

[閱題] 咁就應該係, Hum, 應該呢, 就啲個個
S: [after reading the question] Then, it should be , Hum, should be, that normal
normal係dominant character, 因為佢4個細路仔, 既, 全部正常.
is the dominant character. Because, their 4 children, Ai, all normal.

你係指邊四個？
I: Which 4 are you talking about ?

1、2、3、4. 唉，係係. 嗰個兩個細路仔呢，就係正常㗎嘛. 咁
S: 1, 2, 3, 4, Ai, yes, yes. That means, the 2 children are normal. So it should
就應該，而且呢個係，既，short sight 嗰個，係雜種啦咁.
[be dominant] and this one is, that is, short sighted is hybride.

Normal 係 dominant?
I: Normal is dominant ?

吓. 因為佢哋兩個細路都 normal 嘅.
S: Yes, because their 2 children are normal.

點解你會覺得個 short sighted 係雜種嘅？
I: Why do you think that short sighted is hybride ?

因為佢，既，呢度，講嘅.
S: Because he, Ai, here, it said [point to the word "heredity" in the question].

呢個係 heredity, 遺傳嘅特徵.
I: This is heredity. It means character that can be pass to progeny. So ?

我估 normal 係 dominant.
S: I think normal is dominant.

點解你估 normal 係 dominant 呢？
I: Why do you think normal is dominant ?

既，睇返佢哋，兩個細路都係正常啦，咁，既，我估嗰個，
S: Ai, [answering part a] .. look at their, the 2 children are normal, so, then,
這，嗰個，normal 呢會係當佢係一個純種吖嘛，咁，既，既如果
...Ai I guess, this normal, take it as a pure, then, Ai, Ai if I take it as a pure,
我當佢係純種既話呢，咁，而家佢又係一條 dominant 既話呢，咁個
then, if it's also a dominant, then the baby she produced with this short sight
呢個 short sight 所產生既 BB，應該都係一個，既，正常嘅. [答完
[man], should be a normal one too.....[finish answering part (i), then read part

part(i) 然後睇part(ii)] 咁就，既，咁估佢，既，一同埋，一
(ii)] then, Ai, [I] guess [that] she, Ai, 1 and. For 1, I guess she is, that is, not
呢我估佢係一個，第唔係純種嘅啦，因為從佢，第既，Daddy
pure. Because [I] can see from her daddy and mommy. Then, look at, Ai, what
mommy睇到，跟住睇返，既佢同二生，係，出個D經路易呢，咁就
she produce with [individual] 2, the children are, well, with one is short sighted.
有一個有short sight，我估埋兩個都係一個純種嘅啦，咁先
I guess [individual] 2 is also hybride. Then it is possible to produce, Ai, one
有可能產生一個，既，有short sight嘅囉。
short sighted.

Hum, Hum.
I: Hum, Hum.

[寫個answer出嚟]
S: ....[write down the answer]

Q8 MCT

[閱題一次]咁第話，估佢，估佢，既，兩個都唔係純種既，兩個
S: [read the question once] That means, [I] guess it, guess it, Ai, both 2 [flower]
都係雜種，咁P......[做個cross] 咁就，既，估佢個dominant
are not pure, that is both of them are hybride, then, P ...... [writing the answer]
個character就應該係高嘅，而個個recessive就應該係short，就
then, Ai, [I] guess their dominant character is high. and the recessive [character]
係從佢個個，俾出嚟個個result睇囉，咁而十一個intermediate
should be short. That is [observed] from the, the result given, and also, 11
既height呢估佢係個，第，佢因為兩個都唔係純種啦，第應
intermediate in height, [so I] guess they are, that is, they, as both 2 are not pure.
該有，二，估佢有兩個係，唔係純種嘅。
That is, there should produce, Ai, a pure tall, a pure short and with 2 [of them]

are, not pure.

咁呢話呢一種係邊種既dominance?
I: That means what kind of dominance is this ?

Am, …. 我估應該係…
S: Am,….. I guess it should be …

Hum, Hum.
I: Hum, Hum.

我，我估，既，因為一高一矮，綜合左，我估係咪應該，既，佢地，
這，綜和左，綜和個種.
S: I, I guess, Ai, because one tall [gene] one short [gene], they [have] mix [phenotype]. I guess that is, they are, that is, mixing, the mixing type.

綜和個種，咁個種，既，記唔記得我講過叫咩 dominance?
I: The mixing type, then, that type, Ai, Can't [you] remember what is the kind of dominant I called ?

唔記得啦. 嘻, 嘻.
S: I can't remember. Ha, Ha.

咁你估佢個 parents 會係點樣呀?
I: What do you think about the parents ? [As she has written "seed" to represent the parents in the cross]

既，我估…兩個…兩個都係高.
S: Ai, I guess … Both 2 [parents] are tall.

咁係純定雜架?
I: Then, pure or hybride ?

雜既. 應該係，咁如果唔係雜呢，這冇可能有一個矮個
嚟，咁就話佢兩個都係高既.
S: Hybride. Well, if [they] are not hybride, it is impossible to have short, that means, I guess both of them are tall. [she then rub off "seed" and replaces with the word "tall"]

Hum, Hum.
I: Hum, Hum.

(ii) In the second interview:

Q1 MS1-LONG

開始.
I: Start.

唉!
S: Ai!

唔駛驚!
I: Don't be afraid!

唔 terminal flower係 recessive to 呢個,唔知叫咩嘢嘅 flower 咁,
S: Hum, terminal flower is recessive to , this, "something" flower, then..........[a very long pause]

你睇到邊度呀?
I: Where are you reading ?

睇到呢度囉.
S: Here.

哦,吓.
I: I see.

... result from this cross are collected and sown. When these
plants F1, have flowers, they are self pollinated, seed are collected
S:...result from this cross are collected and sown. When these plants, F1, have flowers, they are self-pollinated. Seeds are collected and shown again and these

& shown again and these are the F2 … make diagram to show the
are the F2] … make diagram to show the crosses the possible phenotype and
crosses & the possible phenotype & genotype, 咁係個parents嗰度, F1
genotype, then, in the parent, F1 generation and F2 generation, A Ya,
嘅generation同埋F2嘅generation, 係吧.

Hum.
I: Hum.

咁, 一開始, 咁就知道, 既……既, 兩個flowers都係pure
S: Then, it is known at the beginning, Ai …. Ai, both 2 flowers are pure
breeding, 咁, 單係純種, 咁這話佢地, 而terminal flower係先, 係呢
breeding, then, that is pure breeding, that means they are, and terminal flower
個 [再看題目] recessive to 呢個既flower, 其中一個會係大, 兩個都
is, let me see [read the question again] Is this, recessive to this, flower ? One
會係大R, 另外一個就兩個都係細r.
of them will be big, 2 big R. The other will be 2 small r.

Hum, 邊個係大吖?
I: Hum, which is the big one ?

既……recessive to …… 應該係……terminal flower 係兩個都係細
S: Ai….recessive to …. should be… terminal flower is 2 small r. Then, the
r, 佢係recessive, 咁另外嗰個就應該係兩個都係大R. 咁…寫
other is, should be 2 big R. Then, Can I write it down ?
得唔.

得唔, 你寫囉, 如果你覺得寫得.
I: You may write it down if you can.

哦, 咁就一個係, 呢個既flower喇, 而佢係兩個都係大R, 咁呢
S: I see, then, one is, this flower, it is 2 big R, this with 2 small r. Then it gets
兩個都係細r, 咁就會一個大R一個細r, 咁出左個大R細r, 咁嗰個係F1.
one big R one small r, the big R small r produced is F1. This is parent. This
呢個就係parent. 呢個係G, 咁跟住佢地再去自己同自己, 咁這話, 都
is G. Then, they do it by themselves, then, it is both ….
係……

你覺得另一個係咩吖?
I: What do you think the other one is ?

係一個大R同一個細r囉.
S: It's a big R and a small r.

咁你寫落去得嘅喇, 唔駛理佢...
I: It's [writing this way] O.K., you don't need to ..

咁就再.... [寫cross 2]... 咁樣呢, 出左個大R一個細r, 而另外一
S: Then, it, again .... this way, it gives a big R a small r, the other side is the
邊都係大R..細r, [寫cross] 咁就再, 互相...... [cross] 咁樣,
same... big R..small r, then, again, one another, this way....then it's F2
[cross] 咁就係F2出左, 咁, 就, 睇返佢地嘅phenotype同genotype
produced. Then, look at their phenotype and genotype got. F1 is.. Ai, the
嘅result, 咁就. F1呢就, 係, 應嗰個 phenotype [寫] 就係得
phenotype is, only one, that is, should be, this one [point to the axial] ha.
一個, 咁就係應該, 依個, 嗱[指題目的axial]

哦, axial.
I: Ho, axial.

而genotype [寫] 得一個R同埋一個細r. 而F2嘅呢, 就
S: and genotype [writing the conclusion] a big R and a small r. For F2, the, the
phenotype 就係, 三個係axial, 而係, 得, 一個係terminal. 咁而
phenotype is, 3 axial, and, have, one terminal. Then, for genotype, it is, is 2 big
genotype 呢, 就係兩個大R比大R細r再比兩個細r, 等於1比2比1.
R, to, a big R and a small r, to, 2 small r, equal to 1 to 2 to 1. Yes, it is.
吓, 係嘞.

Q2 MS2-LONG

咁, 就 red eye fruit fly cross to fruit fly with white eye. 咗紅同埋
S: Then, it's red eye fruit fly cross to fruit fly with white eye. That is red and
白吖. 咁就, 係F1有就60個紅色眼睛.
white. Then, in F1, have 60, red eyed

呢度嘅意思係F1總共有60個, 都係紅眼
I: It means, there are totally 60 progeny in F1, all of them are red eyed.

咁, fruit fly in F1, 然之後, 個紅眼嗰個 fruit fly 又再同白眼嗰
S: Then, fruit fly in F1, after that, the red eyed fruit flies cross with white eyed

個fruit fly一齊。咁就係F2 generation嗰度就有178個red-eye fruit
fruit again. That is F2 generation, there are 178 red eyed fruit flies and 180
flies同埋180 white-eyed fruit flies. 咁呀,...唔...睇先..咁這話,可以
white eyed fruit flies. In this way... hum ... let' see ... that means, we can see,
睇到,由F1係F1嗰度呢,睇到佢所有出黎嘅都係red-eye啦,
as in F1, see that all produced are red eyed, so, Ai, that is dominant character
所以,既,就dominant 個character應該係red-eye,咁這係red-eyed
should be red eyed. Then it should be red eyed [answering 2(a)] . . . and because
[寫ans.]而因為喺F1嗰度所有60個generation都係red-eye [寫至2a完]
in F1, all 60 generation, are red eyed … [answering 2(a)] …. Then, then in F2,
咁,咁就喺F2嗰度呢,可以睇到係會有,既,[再看題目],
it can be seen that , Ai, 178 [are] red eyed, [yes it] is red, 180 are white eyed.
178 red-eye,係red啦,180係white eye,咁這話,案估及parent plant
That is , guess about the parents flies …. [read the question] then it is, because
…[看題目]咁就因為red呢,我估佢係dominant character啦.
red, which I guess is dominant character, then it will, Ai, yes ? Hum ……. it
咁就會,既,吓,Hum…….咁就,我估其中一個佢red eye呢就
will, I guess, one of them, [I] guess [the] red eyed, may be a, should, Ai ….
可能會係一個,應,既……純種.
pure.

Hum,你係講parent嗰個呀?
I: Are you talking about the parent ?

係呀,因為拿,如果佢兩個都係純種嘅話呢,咁出左黎呢,
S: Yes, because, if both of them are pure,. then it will produce, may be, a big R
咁就係會,一個大R同埋一個細r啦,咁然之後再同…
and a small r, and then again, it …

你嘅意思這話呢F1係大R同細r囉.
I: You mean, F1 is a big R and a small r.

係呀,係呀.
S: Yes, yes.

點解你覺得F1係大R細r呢?
I: Why do think that F1 is a big R and a small r ?

因為,佢係講,佢係話係F1個generation呢,所有都係紅眼加
S: Because, it said, it said in F1 generation, all are red eyed. And then, I said

嘛，咁就，我講係紅眼係dominant character吖嘛，咁就估
red eyed is a dominant character, then, [I] think it is [a] big R and [a] small r.
佢係大R同細r囉.

跟住呢，繼續囉
I: Then, you can continue.

跟住就，佢再同白色，咁即係話…依….咁再同白色，再生嘅話….
S:Then, with white again, that means … Ye …. then white again, produce ….
咁即係…咁做左F1先啦.
that means … better to complete F1 first.

好呀，好呀，你做左F1先啦.
I: O.K., O.K., you may solve F1 first.

F1呢，咁做，F1……. 咁樣啦，咁佢出左呢兩個，咁，跟住佢再
S: F1 is, then, F1 …….. this way. Then it produces these 2, then, after that, it
同white eye then this再生嘅話….
crosses with white eyed again, may be ….

點解呢個你覺得係兩個大R呢?
I: Why do you think that this is 2 big R ?

既，因為佢….如果佢係，既，一個大R一個細r嘅話呢，咁，再同
S: Ai, because it …. if it is, Ai, a big R and a small r, then, with white eyed
white eye呢，所產生個D呢就會出現white eye囉.
again, will produce white eyed.

即係話，一個大R一個細r就會出現有白色囉喎?
I: That means, a big R and a small r will produce white eyed ?

唉，係呀.
S: Yes, it is.

咁，點解呢個你會覺得係一個大R同一個細r呢?
I: Then, why do you think this one is a big R and a small r ?

欸……因為，因為呢，欸，因為呢，欸，佢再咁樣呀嘛，喺F2個
S: Ai …. because, because, Ai, because, Ai , it does this again. In F2, with the
度呢，佢再同白色㗎嘛，咁，如果我估呢係一個大R同一個細r呢就話
white again, then, if I take this as a big R and a small r, then it produces, will
呢，咁出到嚟就可能會，即係可能會喺呢個result嗰度，[做F2 cross]
fit into this result …. Ye .. [make F2 cross] …… then it is …. F2 ….. let me
咁就……F2……睇先。
see ….

你依家諗緊D咩嘢？
I: What are you thinking now ?

嗄？
S: What ?

點解你又睇返條題目？
I: Why do you read the question again ?

因為發覺，好似唔對路，嘻。
S: Because, I find out that, may be, something is wrong, Ha.

哦，點樣唔對呢？
I: Ho, what's wrong ?

因為呢，呢度R，即係，唔，大R，有一個有兩個大R啦，同埋有三個
S: Because, here R, that is, hum, big R, one with 2 big R, and 3 with big R
係有一個大R同細r啦，咁照常理應該係紅色比白色多㗎嘛。
small r, then, normally it should be more red than white.

即係你話兩個大R，同埋大R細r個D都係紅色。
I: You mean both, 2 big R, and a big R a small r, are red.

係呀，咁，嘻，爭在少少囉，佢就，因為呢度……同埋另一個係180。
S: Yes, then, Ha, there is some differences, it is. Because here … and the other

is 180.

咁你睇返,就是你覺得你有度唔妥嘞.
I: So when you look back, you feel that something is wrong.

係呀……
S: Yes …. [look at the question and think again]

依家諗緊邊度呢,你諗緊邊一代呢?
I: What are you thinking now, which generation ?

諗緊,呢個.
S: [I] am thinking [of], this one.

哦.
I: I see.

咁就.....
S: Then …..

即係住你睇返F1啦嗎?
I: You are thinking about F1 ?

係呀,咁就係下低諗返上去.
S: Yes, then thinking back.

唔,唔……係F1黎講呢,點解你決定呢個大R細r,呢個兩個大R嘅.
I: Hum, hum …… Why do you say in F1 there is, a big R small r, and, a 2 big R ?

呢個兩個大R係呢舊,係白色嘅.
S: This one, 2 big R, is white.

咁呢個呢?
I: Then, how about this one ?

呢個係呢度.
S: This is here.

咁即係話,呢個你認為有兩個可能性,所以你要分開兩個
I: You mean, as you think this has 2 possibilities, so, you make 2 cross to study.
cross嚟睇佢啦.

係呀.
S: Yes, it is.

咁然之後呢度你加埋,應該一樣[於與題目個result一樣]
I: Then, [you think] adding up [the number of progenies in] these 2 crosses should be the same [as the result in this question].

咁,但係而家我知,我估錯左啲.
S: Then, now I know that I have made a wrong guess.

吓,邊度錯呀?
I: Ha, what is wrong ?

我估呢度本來既,白色眼個度呢,我估佢係大R同埋細r呀嘛.
S: I guess, here it is, Ai, this white eyed, I take it as [a] big R and [a] small r.
咁依家,如果估佢係兩個都係細r既話呢,再推埋落去既話,
Then, now, if I take it as 2 small r, deducing downward, then it should fit in that
咁就應該符合到呢個度.
one.

你依家就再做過啦.
I: So you are doing it again now.

係呀.
S: Yes.

如果你覺得擦咗佢D,你咪擦左佢係佢後面做,因為即係時間
I: If you feel rubbing off is more convenient, just rub it off and do it again, as
寶貴D,哈.
time is precious, Ha.

嗱…… 咁就呢個係…

S: Ha …… [make another cross] … then, this is …

通常你做完睇返個比例，覺得唔妥，你就係下面睇返上去嘅

I: Usually after you have finished, you look at the ratio of the result. You will deduce upwards when you feel something wrong.

係呀，係呀。

S: Yes, yes.

唔。

I: Hum.

而呢個就應該兩個都係純種，咁就出左F1係大R同埋細r，咁然後佢再同白色，係F2個度再同白色…

S: …. and this should be both are pure, then, it produces F1 with a big R and a small r, then after that, it does with white again, in F2 ….

唔，唔。你就咁同呢個係呢度cross埋落去就得嚟，擺埋少少，以示唔同。

I: Hum, hum. You can just do it after this cross, just a little bit further inward, to show it's different.

咁就係呢度啦，咁就出左一個大R同埋一個細r啦，而白色就淨係出一個細r。F2就會有大R細r，哎吔，同埋一個，兩個都係細r嘅，咁就會比例上同佢係差唔多嚟，因為佢係一個係178而另外一個係180。

S: … then here, it produces a big R and a small r, and the white produce only a small r. F2 will have a big R and a small r, Ya, with a , 2 small r, then it will, with a similar ratio, because it is one 178 and the other 180.

大約係幾多呀佢？

I: About how much ?

1比1度，所以就出左咁樣啦。

S: About 1 to 1. So its' what produced.

哦咁呀. 點解你估呢兩個係兩個大R?
I: I see. Why do you think these two are 2 big R ?

唔.因為如果佢係一個大R同一個細r,就好似頭先我講囉,
S: Hum, because if it is a big R and a small r, things will happen as I just said,
就會可能出白色囉.
it produces white.

點解白色呢次你會估佢係兩個細r呢?
I: What about the white, why do you think it's 2 small r now ?

因為如果估佢係大R同細r,就會出到唔同嘅呢個比例
S: Because, if take it as a big R and a small r. It will produce a different ratio.

咁呢個, 你估佢係咩顏色呀!
I: How about this, what color is it ?

呢個係估佢紅色嘅.
S: This is red.

咁你寫返喺側邊呀.
I: You write it [red] next to it.

哦.
S: Yes.

咁呢度你都寫返個 phenotype 係度啦.
I: You write its' phenotype here also]... So, it is.

第三條啦.
S: The 3rd question.

即係你做完呢題?
I: Is that mean you have finished this question ?

Q3 MC-LONG

咁就佢就講啦，紅色花同埋白色花呢，即係純種嘅，係F1呢就產生左粉紅色嘅。
S: Then, it said, red flower and white flower, that means pure, in F1 it is , it gets pink.

佢有講明佢係純種？
I: Does it tell you it's pure?

係呀，有講明純種嘅…咁就，然之後佢，個個粉紅色嘅花再同佢自己嘅，咁就產生左紅色嘅花，白色嘅花同埋粉紅色嘅花，咁個ratio就係1比1比2.
S: Yes, it stated out … and then, the pink flower then, [cross] among themselves again, Ai, produces red flower, white flower and pink flower. The ratio is 1 to 1 to 2.

唔，唔.
I: Hum, hum,

係啦，因為佢一早就講左係純種啦，咁let佢個個dominant係，嘅，大R啦，兩個個recessive就係細r……咁……吱吔.
S: That is, because it said that its' pure, then let its' dominant be, Ai, big R, and the recessive be small r, … then …Ya.

點解"吱吔"？
I: Why do you say "YA" ?

串錯字. 咁就佢，嘅，個紅色花同埋白色花都係純種，一個係大，兩個都係大，係大R，另外一個就係兩個細r，咁就...
S: [I've made a] wrong spelling …. then, suppose, Ai, red flower and white flower are pure. One is big, 2 big, is big R. The other is 2 small r, then…

我發覺你let完又睇返題目，係咪呀？
I: I observed that you read the question after writing the let statement, is it true ?

唔知呀，慣左，所以我唔覺……一個就係紅色嘅……咁我
S: I don't know, may be it's my habit, so I don't notice it …. one is, red … and
估紅色就係，當佢係dominant囉，因為佢出嘅係粉紅色囉。咁
I guess red is, take it as dominant, because it gives out pink. That is, should
即係應該會有一個大R同一個細r，應該一半半倒囉……咁呢個
have a big R and a small r, should be, half half … then this is pink, then after
係粉紅色喋嘞，咁然後，佢話粉紅色再同粉紅色，出黎……會
that, it said pink with pink, gives out … it gives a big R [and] a small r, and the
出倒一個大R，一個細r，而另外嗰個邊都係啦。咁然後，佢就
other side is the same. Then, it said in F2, there is red, white and pink flower
話佢F_2嗰時就會有紅色啦，白色啦，同埋粉紅色啦……咁，咁就，
… then .. then it's.. the ratio is, 1, red to white and to pink, is, 1 to 1 to 2. I
……既……個ratio係1，紅色比白色同埋再比粉紅色係1比1比
said 2 big R is red, that means it produce only one red, it has 2, Ai, big R and
2吖嘛，咁我就話兩個大R係紅色呀嘛，咁即係話佢衣家淨
small r, that is pink, and this 2 small r is white. That means, Ai, fits the ratio.
係出左一個紅色，就會有兩個大R同細r，即係粉紅色啦，而兩個細
That means it, Ai, is right.
r就白色咁即係話，既，符合返佢個ratio囉，咁即係話佢，
既，係嘞。
即係你做完啦？
I: Have you finished ?

係呀。
S: Yes.

Protocols of subject R1

(i) In the first interview:

Q1 MS1

S: 嗱呢個fruit flies, grey colour係dominant, 咁即係grey係大R啦. [做Let statements] 跟住呢, 呢個呢, 呢個象牙色就係細r啦. 跟住呢, generation of heterozygous grey body flies, 呢個呢, 呢個"he"呀嘛, 即係唔一樣啦一個大R一個細r啦.

I: "he"即係heterozygous?

S: 係啦. "he"呀嘛, 跟住一個大R細r, 跟住cross自己呀嘛即係大R細r [做cross] parent啦, gamete啦, 係囉, 咁囉, 分開啦.

I: 吔物嘢呀?

S: 唔駛抄多次啦!

I: 寫返D phenotype啦.

S: 唉, 即係要抄多次... 唉, 呢D唔識㗎啦.

I: 唔得㗎, 我唔識㗎.

S: 唉，粉灰狀，咁，呢個grey呀嘛，呢個grey grey呀嘛，呢個寡牙，係咁樣，為埋三比一。

Q2 MC1

S: Codominance，即係一樣一樣… plant with pink flower, self-pollinated [邊看邊講邊做]，咁樣個pink好應該係兩個gene組成嘅。跟住呢，pink即係大R細r啦，self-pollinated，即係又係食自己啦，即係大R細r…跟住呢出左，分開啦，gamete啦，[做完個cross，重看題目] 五，五，十….跟住呢，phenotype …genotype 呀….唉，呢個係red，呢兩個係pink，呢個codominance，應係pink…係啦得啦。

I: Hum. Hum.

Q3 MS1

S: 係咪咁猛咁講嘢呀? Brown hair, recessive. Let啦，唉，簡單啦…… brown hair man喎，brown hair recessive 㗎嘛，man即係兩個細r，woman he，即係一個大R一個細r啦，heterozygous呀，…… make diagram，即係cross啦… genotype 呀，大R細r，咁 black hair dominant，即是black hair啦，呢個brown啦1比1.

Q4 MS2

S: One of the five offsprings of … a pair of white, a pair of white rabbit，即係兩個白色兔仔，生五個呢，五個有一個黑色嘅，即係兩個都唔係純種啦，跟住呢…which is the dominant characteristic，咁其實係白色啦，一隻係黑色嘛，白啦，因為呢，因為個ratio係三比一啦 [答4(a)]. b. using symbol 大W細w…[開始答] 即係white 咩物嘢呢，white rabbit 呢個細w，即係recessive 嘅呢，recessive 應該係 black…兩隻都係white，即係大W細w同大W細w cross….跟住呢…呢張紙…呢個點讀呀！

I: phenotype.

S: phenotype，咁樣呢，抄番出黎先，大W大W，呢個white係 dominant，唔駛講white啦，純種嘅white啦。呢個大W細w兩隻呢，都係呢個白色啦又係dominant呀嘛，咁呢個細w細w，咁純種呀嘛，黑色啦，白比黑咁即係三比一啦，好，做完呢條，係未做完嘅…呢度下既，parent . Parent，唉，因為多次，做番一先呢度，兩隻白色，唔係純種，咁即係大W細w，大W細w，genotype 黎，phenotype 呢，咁就一早得左你嘅啦，兩個都係white.

I: 如果這兩隻只係生一隻那隻係黑的出來，你會估佢是咩物嘢？

S: 只係生一隻，係黑色的，我會覺得佢呢，係，你話如果呢個冇變呀？

I: 唔.

S: 係，a pair of white rabbit，咁佢淨係生一個嘅，係黑色的，

咁佢地兩個都不是純種的囉，就係咁樣囉。

I: 點解呢？

S: 點解呀，咁佢地兩個白色吖嘛。如果有一個係純種的話呢，咁即係大R大R，同大R細r，咁佢地得出來嗰個結果應該呢，全部係白色，咁佢地依家有隻黑色吖嘛，咁佢地兩隻都唔係純種，先有黑色架嘛。

Q5 MP1

S: 哦，呢個捲脷呢，咁dominant gene 操縱嘅，咁呢就係大R，係啦，係啦，recessive 就係細r，咁就Diagram，一、二，呢，一、2、呢，白色嘅呢，就係捲得脷嘅，捲得脷同捲得脷生出來，有兩個捲得脷，一個唔捲得脷，咁即係一、二，不是純種啦。又係咁啦。[再看 p.2 題目的接續]...... state and explain, genotypes, a part，第一個個genotype，咁state 先啦。[寫下 5 i a (1) genotype = Rr] 嗰個個原因呢 [寫 reason = one of] 呢個一係 [看題目] 女人來的 [寫 her...... 寫完]

I: 佢自己捲到脷，生左不捲脷的仔，你估她 Rr？

S: 係跟住三、四呢，四捲不到脷，捲唔到脷即肯定是純種，如果不是純種就捲到脷啦。因為捲脷係dominant 呀嘛，所以，啦，四呢一定係rr 啦，唔記得寫啦。[寫 b.4. genotype rr ......] 咦吖，不是什麼，哎，是但啦 [看完4]......哎，我今做緊呢個，第四啦，唉，第四做左，做三先，

三、第三嗰個個呢，呢個佢嘅，呀，佢就即係non，唔係，佢即係tongue roller，tongue roller同一個non-tongue roller得出一個tongue roller，捲得到同唔捲得到，呢個唔捲得到肯定係rr，生左一個，生左一個捲到到嘅……咁呢三呢就好麻煩啦，三如果係RR嘅話呢，生出來嗰個個呢，一定呢捲到到吖，因為大R呢，係dominant啦，咁呢，若果三呢係Rr呢，咁佢係tongue roller啦，咁用呢個四係rr，得出來一個捲到到，一個捲唔到到，都係有可能喎，咁點算呢！唉！為睇佢啦！……跟住(ii)，5(ii) what is the probability that individual 五係一個he，咁睇吓呢個individual五啦，咁佢係由一、2嗰個度走出來嘅啦，咁一、2生出一個，嗰個個四呢，non-tongue roller嘅，一、二就係tongue roller，咁，一、二就唔係純種啦！一、2係Rr，跟住生出來嗰個，劃個diagram，劃左出來先[寫個cross]呢，好嘞，呢三個，有三個機會係tongue roller，有一個機會係non-tongue roller，但依家五呢就係tongue roller啦，五係tongue roller，咁即係一定係呢三個啦，呢三個可能性啦，呢三個可能性裏面呢，有一個係純種，兩個係雜種，這係三份之二囉。

I: 咁你點樣點去考慮五同六嘅？

S: 五同六，唔，咁呀，哦，咁樣，咁要考慮，埋佢同六，咁五同六呢五同六得出黎嗰個『冷板凳』，唔係tongue roller，佢，佢，咁五有可能係純種，六又係有可能係純種，如果五同六都係雜種，咁實有一個係non-tongue roller嘅，咁呢，如果五純種，如果五係純種，六係雜種，生出來一樣係咁嘅，咁呢，即同個六冇關係，咁樣呢，咁我就唔考慮啦，我都唔記得考慮。。唉，咁跟住呢，哎吖，就咁考慮，呢個得唔得吖你

做咩呀，2/3啦，咪定錯咗，錯左係咪呀！

I: 我都話我唔會講比你聽㗎咯。

S: 你係咪咁呀，咁以，唉，我上次都係咁嘅。

I: 哦。

S: 嚟左啦，呢度，你記得㗎囉啊。

I: 嗯。

S: 好啦，唔寫啦。

Q6 MC&MI

S: A man with blood group，哦，呢條好難嘅，我上次都唔係幾識嘅，... A man, blood group A, married 個 blood group B，咁 A, B, AB, O，咁有個O字，咁但係 A同B ... 都應該唔係純種啦，因為O係 recessive 㗎嘛，我諗，咁我問過，A有兩種 A和AO兩種，咁一定有一個 gene，係AO。咁我 Let 左先，Let A係 dominance gene, give group A blood，B係 dominant gene give group B blood，組O係 recessive gene, give O blood，咁咩呢，咁咩呢，跟住呢 [寫出 cross] 同你俾個D野一樣，即係冇錯啦，咁，genotype，你明啦。

Q7 MP2

S: Human, short sight, 遺傳character, normal woman married short sight man, 冇講邊個dominant喎……邊個dominant, 要睇圖啦. 兩條同normal, 生出黎呢兩個都係normal喎咁, 咁理論上, 唔通生理論上, 睇埋格離, normal同normal生出來多數都係normal, 應該估都估到normal走dominance啦. Explain呀! 你都識啦!

I: 點解normal多, normal dominance呢!?

S: 因為, 呢個, 近視同normal生兩個都係normal. 跟住再睇呢度. Normal同Normal生出來三個normal, 一個近視. normal同近視3:1, 咁normal應該dominant啦.

I: [Cover左三個normal progeny] 如果佢淨係生一個呢?

S: 如果係淨生一個, 咁詳細講, 咁呀. 唸唸, 一個normal同normal得一個近視, 咁肯定, 係……係呀, 一定normal, 咁一定係雜種嚟, 雜種normal, 唉, 得啦, explain, 識啦[寫答案]唉, 呀, 咁麻煩, reason, 冇俾人聽到呢餅嘢吖. [繼續寫]……跟住第(ii), state and explain, 一、二, by diagram, by diagram, parent冇 — [寫] genotype, short sight, recessive兩個組r攪錯呀, 做唔到要用diagram, 就咁唸得唔得呀, 咁我唸左一先啦.

I: 唔.

一呢，genotype Rr，二呢，genotype又係Rr。咁reason呢，喺嘅和以前的一樣喎[做cross]呀，得啦完左。

Q8 MCT

S: 21 seed，6個長stem，11中報，4呢就細啦，咁咩嘢。咁我估佢嘅ratio呢.....[寫，tall：inter.：short] tall比int.嘅冇比1就1:2:1，咁咩係咁情況下，呢個tall同short [寫tall：R，short：r]一定係codominant，因為無端端有一個中間高度啦[寫，R and r codominance，跟呢，叫你explain啦parent，parent，咁parent嘅個個，好啦，好啦，咩樣，咁我首先寫返佢，咁我衣度呢就話6個長，11個中間，4個就細嘅嘛，咁我係tall let左大R，細細r，咁即是話offspring genotype就應該係[寫off.gene：RR；Rr；Rr；rr]應該係呢4個你咁咩啦，跟住咁樣推斷返上去，呢個pro嘅的genotype就係呢個囉，pro.咩。

I: progeny.

S: 唔，progeny，跟住，phenotype of progeny [寫phenotype of pro.：tall：int.：short]我寫左先，因為佢俾你，即冇嘢啦，跟住呢，我再推翻上去，咁咩parent，哦，with the help of diagram，parent咁咩，parent應該係，呀，RR和rr嘅，咁劃一次出來看看對不對，唔啱呀，唔啱...，咁呢的應該係大R，parent應該Rr，Rr咁咩先有機會[寫整個cross]咁得出個機會就和我估的一樣，和你的data一樣啦，[寫parent phenotype 到完]。

(ii) In the second interview:

Q1 MS1-LONG

S: Gardenpea terminal flower is recessive, 咁呢度第一句 gardenpea terminal flower 唔識解嘅, 不過, 是但啦, 跟住呢, pure breeding, 既...

I: 你唔識解邊度吖?

S: 唔識解咩叫 terminal 吖, 咩叫 axial 吖嘛?

I: 哦,

S: Pollinated with a pure breeding 呢個呢個, 咁兩個 pure breeding, 咁樣佢跟住就 The seeds resulting from this cross are collected and sown when these plant, 睇下先, 咁呢, 兩個 pure breeding 啦嘛, 咁如果一隻係 recessive, 咁第一個呢個個 pure breeding breed plant 呢, 係 terminal flower 嘞, recessive, recessive 就即細r細r 嘞, 跟住 pollinated with pure breeding, pea plant with axial flower, 就這係大R 大R 嘞, 個 cross 呢, 劃出黎呢, 就應該係咁樣嘅, 跟住呢 [再看題目] these plant 呢就有 flower, when these plants have flowers they are self-pollinated, seeds are collected, sown again, 咁F2 啫, 這要劃 F1, F2 啫得啦 [再看題目] show the crosses the possible, parents..... 得啫, 好啦, 做吖, [做] parents [寫parents], 第一, 2句計

比你聽啦，大R大R，細r細r，咩phenotype，嗰個個genotype，洗唔洗吖，genotype.

I: Genotype. 係.

S: 呀，唔係，唔係A，調轉，唉，太耐冇做嘞，既genotype 一考完試已經唔記晒，parents 就會，一個就terminal.

I: 邊個呀？

S: 邊個？

I: 大R大R定細r.....

S: 大R大R，咪咪咪，細r細r吖嘛，terminal...

I: 但係呢個，係...

S: 哎吖，咁，調轉之嘛.

I: 係.

S: 咁都冇咁清楚㗎，要咁清楚㗎，唉，terminal flower，細r細r，跟住呢，axial flower [咳一陣，因為R3不舒服] Ham，就大R大R axial flower 吖，跟住parent 最尾啦，跟住依家F1唔啱，F1 這要畫個cross啦，咁首先呢，呢個parent呢，就，大R大R，細r細r，跟住呢，就，咁樣一步，唔記得左點劃嚹，呢個細r，呢個大R，呢個係咩，

gamete [繼續寫]得出，係咪咁樣，見佢噱，咁這咁，大R細r，全部都大R細r吖，呢個就F₁噱.

I: 咁，佢個 phenotype 係點吖?

S: 衣家寫囉.

I: 咁你係隔離揾住寫落去就得啦.

S: 衣，我喺住寫整齊D咋.

I: 哦，唔混.

S: Phenotype 就係呢個，all 呢個大R細r，咁呢，就係 axial flower 吖，個 genotype 呢，就全部都係大R細r. 跟住呢，又再劃噱啲，咁呢個 F_1，self-pollinated，咋係呢，自己同自己拿，呢個大R同細r，又分開噱啲，咁呢，唉，大R大R，細r細r. 呢個又 gamete，咁又出左個 F_2 噱啲.

I: Hum.

S: 咁 F_2 呢度呢 genotype，係呢度先，genotype 就係大R大R比大R細r比細r細r 就等於 1比2比1，跟住 phenotype，phenotype 呢，係，Ham....

I: 你想揾 tissues?

S: 係，唔使，我有.

I: 哦.

S: Ham. phenotype就呢，既，terminal flower比axial flower就係等於1比3㗎. 唔駛解釋㗎係咪吖? 畫左圖嗱嘛，第二題.

Q2 MS2-LONG

S: 第二題呢，第一句就話呢，紅眼嘅個個烏蠅就同一隻，既，a fruit fly, white eye. 第一個就係紅眼同白眼嘞，攪埋一齊，跟住呢，就係，既，60隻烏蠅喺F_1就係紅眼嘅，60隻，跟住紅眼嘅呢，紅眼嘅烏蠅喺F_1嗰度就白眼嘅又攪過，衣，咁深嘅. 睇下先，F_2 178隻紅眼，180隻白眼，which dominant character. 咪，character explain your answer. 嘩，好難啊，吟，紅眼同埋白眼，60隻，all the 60隻flies in the F_1就係紅眼，全部都紅眼咁咪，red eye dominant囉. [寫]跟住呢explain because, because in F_1 [寫] all fruit flies [Ham] are red eye，全部都紅眼嘅，咁樣樣，全部都紅眼嘅，咁呢，駛唔駛畫圖㗎，全部都紅眼咁都唔得㗎. 係嘛，得唔得. 咁，白眼同紅眼就全部都紅眼，咁 所以呢就話佢係dominant嘞，所以呢就話佢係dominant嘞.... 得唔得㗎，我知我錯㗎我，得唔得㗎... 得㗎，咬吖麻煩. 咬劃圖咁麻煩嘅.... 嗱，[一路寫] red eye就係dominant character, because in F_1 all fruit flies are red eye. 得唔得㗎.

I: 得唔得㗎!

S: 哦and吖, and the parents, Ham, one, gen, red eye flies, red eye flies, red eye flies. 咁佢係呢, 佢個parent就係一個紅眼一個白眼, 佢係生出嚟全部都係紅眼嘅, 咁樣呢, 就可以証佢, 應該係dominant嘅掛, 唉, 重有, 唉, 麻鬼煩, F₁有60隻, 唉, 60隻, 係吖, 一個大數目字嚟嘅啫, 所以就可以當佢係啦, 得啦, 跟住呢, 第2(b) usings bots R, 呀......, 唉, 咁parent嘅, 個genotype呢, 就係大R大R, 細r細r啦.

I: Hum.

S: 唔駛explain嘅掛, 又要吖, 唉; [咳!]

I: 我呢, 上次聽錄帶呢, 都聽左好多麻鬼煩吖, 哈.

S: 第個係咪咁嘅, 哈......

I: 都冇咁多麻鬼煩.

S: 唉.

I: 哈, ...同埋唉, ..

S: 唉, genotype呢就係, Mm, ... 咬吖, genotype咬吖.

I: 哈.

S: 咩?

I: 冇嘢，你繼續啦.

S: 一隻呢就紅眼，red eye，and，既，唔駛寫哂佢，white eye [咳] 呢D given，跟本冇得解既，跟住呢個呢，呢個就係，因為呢，because all F1 is red eye [寫在answer sheet].

I: 你對返個because呀!

S: 呢個嘛.

I: 對大R大R，同我對細r細r，....

S: 唉，...哎吖，咪，我解比你聽咪得囉.

I: 哈，唔得㗎.

S: 你明知我識㗎嘛.

I: 係呀?

S: 點解唧!

I: 你做出黎啦!

S: 做出黎，講出黎得唔得呀，唉，嗱，genotype，parent呢，genotype就係大R大R，細r細r，即如果我頭先話左俾你聽呢red eye係dominant㗎嘛.

I: 唉，是佢啦.

S: 唉，要劃出添，好麻煩吖，以吖.

I: 最後三題咋，小姐.

S: [劃個 cross] F1，呢個應該係 red eye，跟住呢個 gamete.. F1，嗱，咁樣 show 左出黎啦.

I: Hum.

S: 咁如果你大R大R，細r細r 先可以得出呢個結果㗎嘛，明唔明呀?

I: 哦，明啦.

S: 明啦嘛，.. 跟住 B，跟住第二就係 Hieo in F1... F1 吖嘛，F1 未解，F1 genotype 大R細r，你都睇到啦，跟住 phenotype，嘻，就係呢，red eye 啦.

I: 唔，

S: 係啦，跟住呢，F2，即再劃過啦 [劃個 cross]......F2. gamete，哝，[塗去已做的]，哦，咁樣樣呀! red eye，in F1 就 cross with white eye，white eye 即係細r細r啦，double recessive 㗎嘛.

I: Hum.

一樣，唉，大R細r，細r細r，咁樣既[做個cross]，F2就係咁既，佢genotype呢，就係大R比細r比細r細r等於1比1，phenotype呢[咳]就係red eye比white eye就係1比1，嘅啦。

I: Hum.

Q3 MC-LONG

S: 跟住第三題，挨過張紙… flower color of plant control by pair of alleles，哦，coincident，咁唔係，唔係呢個，codominance. Codominance, a pure breeding red flower plant cross with a pure breeding white，corn，唉，codominance，共轉左codominance，咁樣吖，all F1 are pink color, The pink flower plant in F1 cross between themselves, red flower plant. 嘩，呢條，好難，咁難既，唉，咁樣好啦，佢首先就話codominance啦，咁我一樣要Let佢，咁我Let佢，Let大R呢就係，就係[寫]，from，Let大R大R就係genotype咁大R大R，Let佢係，Let佢係red flower啦。

I: Hum Hum.

S: 細r細r就係white flower，收吖，pure呀吖，pure white flower plant，咁樣呢，咁F1呢，genotype呢個啲parent咋嘛，parents，parents自己Let喍之嘛，衣之，費事寫，parent個genotype[好弱咀]咁呢個phenotype就係white flower，red flower[寫着] Ha，跟住呢，劃圖啦Wa，大R大R，細r細r，得出大細r，呢個就F1啦，F1得出大細r，咁樣呢個

genotype呢，佢寫唉explain，genotype就係大細r啦，phenotype就係pink啦，佢呢條題目比左你加嘛。

I: Hum.

S: 咁佢codominance嚟嘛，咁跟F_2啦嗎，F_2呢，跟住呢，嗱，呢D F_1呢，then cross among themselves，哦，即F_1同F_1再cross，咁，這係，這係，得出咁樣呢個就係F_2啦，F_2個genotype，就係，睇吓先［再看題目］produce red flower，white flower，in the ratio genotype呢就係，呀，RR比大R細r比細r細r等於1比2比1的嘛。phenotype呢就係，佢，就係，red，佢係吖，大R大R係red既，red比pink比細r細r，細r細r就係white。

I: Hum.

S: 咁吖等於1比2比1，係吖，做完嗱。

I: 哦。

S: 係吖，息機係咪吖。

Protocols of subject R2

(i) In the first interview:

Q1 MS1

Grey body color，咁就dominant拿啲.
S: [Reading the question.] Grey body color, that is dominant. Ebony color that
ebony color，咁就…generation of heterozygous grey body is cross
is….generation of heterozygous grey body is cross among themselves, that is
among themselves. 咁就. Grey body 哎吔，死，呢個係grey，咁
[writing the solution.] grey body…Ya, ..this is grey, and this is ebony…[the
呢個係ebony …[答完整題]
cross is finished and phenotypes are determined.]

點解你寫"Gg"呢？
I: Why do you write "Gg" ?

咁我睇到呢個字囉[指住heterozygous]係咁啦.
S: Well, I see this word [point to heterozygote] that's it.

呢度到呢度都係grey？
I: Are these all grey [point to GG and Gg in the F1 genotype as subject's answer is not very clear.] ?

係呀
S: Yes.

I: O.K.

Q2 MC

flower color of a plant is controlled by a pair of allele, when a plant with pink flower is self pollinated, 五個red (red大聲D), 五個white (white大聲D), 十個pink (pink大聲D) flower plant, found in F1 generation……咁就……

S: [Reading the question.] flower color of a plant is controlled by a pair of allele, when a plant with pink flower is self pollinated, 5 red(stress), 5 white(stress), 10 pink(stress) flower plant, found in F1 generation…that is…

依家你諗緊啲咩嘢呢?

I: What are you thinking about ?

我諗緊呢, 應該個parent係啲咩嘢啦, 個parent呢, 應該係, 我唔係好清楚吖, 諗下先……

S: I am thinking: What should the parents be ? The parent, should be, I am not sure, [let me] think about it……

你根據D啲物嘢黎諗個parent嘅?

I: What do you base on when thinking about the parent ?

跟據條題目囉, codominance囉!

S: The question itself ! It's codominance !

即係搵吓D字眼有冇講囉?

I: That means [finding] the key words [which] gives you the hints ?

係呀!

S: Yes……[a very long pause]

諗唔諗到?

I: Can you think a little further ?

諗到DD啦.

S: A little bit.

諗到啲咩呀?
I: What can you think about ?

Codominance 囉.
S: Codominance.

你覺得佢俾左D資料你?
I: Do you think it gives you some information ?

係呀!
S: Yes, it does.

重有呢?
I: What else ?

跟住 咁,睇埋呢度囉.個 plant with pink flower is self
S: Then….look at this, a plant with pink flower is self pollinated. Ha, there
pollinated. 依,咁又好似唔同啦喎.... 咁個 plant with pink
seems to be some differences…. that's a plant with pink flowers. That means
flowers,即係....
[write the genotype and made the cross for the problem]

點解你會咁樣寫呢?
I: Why do you solve it this way ?

我都唔知呀!哈!哈!
S: I don't know, Ha! Ha!

唔知呀!
I: You don't know !

Codominance 吖嘛,跟住佢話揸個 plant with pink flowers 呀
S: It's codominance, and then, it said that a plant with pink flowers, it produces
嘛!佢出嘅係大R同細r嘛,唔係. pink plant 啦,咁即係係
big R and small r. No. Pink plant, that is, yes, red and white, that means
囉,red 同埋 white,即係呢兩隻 gene 都有,係啦,咁即話,
having both two genes. Yes ! That means it contains these 2 genes.
呢兩隻 gene 都有囉.

唔、唔，好呀，咁樣.

I: Hum, hum, O.K. so you do it.

[找題目的 phenotype 抄落 F1 genotype 度]

S: [Look at the question to find F1 phenotype for copying]

你要搵返個D黎寫落去喋.

I: You have to find it (phenotype) for copying.

係呀.

S: Yes [writing].

個 parent 呢！你又唔寫明係咩物 [冇 phenotype]?

I: What about the parents! You haven't written it [phenotype] ?

呀！係喎.

S: O! yes [writing the parent's phenotype].

唔.

I: Hum, hum.

啱唔啱喋?

S: Is it correct ?

吓?

I: Ha ?

這，啱唔啱呀?

S: Is it right or wrong ?

哈！我唔話俾你聽啱唔啱.我其實想就咁睇你點諗！

I: Ha! I won't tell you whether it's correct or not. As I want to know your own opinion.

但其實，唔同㗎喎，你有讀過同冇讀過差好遠㗎喎！
S: But actually, it's different, [performance] depends on whether you have or haven't revised it.

吓
I: Ha.

你有冇溫做起嚟差好遠.
S: There is a big difference if you haven't revised it before doing the exercise.

係，但，我想睇...你繼續做落去啦！得㗎啦. 我知㗎啦.
I: Yes, but, what I want to see…you just keep on trying and that's O.K. I'll know.

Q3 MS1

[閱讀] brown hair係 recessive, brown hair... married woman ... black hair... 好啦，個 woman 呢，就係 black hair [寫]，跟住呢個 man 呢，就係，brown hair [寫 brown hair 之後即寫 bb 在下面].
S: [Read] brown hair is recessive, brown hair … married woman…. black hair….O.K. The woman is', black hair [write parents, black hair], and then this man, is, brown hair [write brown and also write bb under brown hair]

Brown hair 你就即刻寫細b細b㗎?
I: You immediately write bb for brown hair ?

因為，咪囉，因為 brown hair 係 recessive 㗎嘛！
S: Because, that's it, because brown hair is recessive !

嗯，嗯.
I: Hum, hum.

跟住呢個 black hair,硬係有大B細b啦.
S: And then, this black hair must have B and b ….[continue to finish the cross]

做咩嘢 ?
Anything wrong ?

冇嘢呀.
I: Nothing.

哎吔,係呀,我寫錯左呀![個 cross bb 出兩個
S: [doing the solution] Ha, yes, I made a mistake [she has given 2 b genes for bb.
b,塗左,當一個 b 咁做. 做至全部完,包括 phenotype].
She rubs it off, and continues the cross as 1 b gene for bb. Then assigning
呢個就係 brown hair,呢個呢,就會係 black
phenotype by recalling] This is brown hair, this one, is black hair, I guess. This
hair,我估. 呢個係 genes,呢個係 F1.
is genes. This is F1. [read the next question]

呢度你寫返落去啦 [指塗改嗰b未補].
I: You have to fill this in [the rubbed off part].

未乾呀! 第四題 ....
S: It's [the correction fluid] still wet. The 4th question….

Q4 MS2

第四題啦. one of the five offsprings of a pair ......
S: 4th question now. One of the five offsprings of a pair……

你諗緊D咩嘢呀?
I: What are you thinking of ?

我諗緊條題目點解囉.
S: I am thinking about the meaning of the question.

你唔係一路睇落去嘅咩？
I: Are you reading the questions one by one ?

唔係呀，我睇到佢點解先。
S: No, I think of the meaning of the question first.

你睇緊邊度呀？
I: What are you reading ?

睇條題目。
S: The question.

唔。唔。
I: Hum, hum.

駛唔駛講㗎，睇題目。
S: Do I have to read out loud while I am reading the question?

得最好，我知你睇到邊呀嘛。呢行？
I; If you can, it'll be good, so that I know where you are reading. This line ?

係呀！我諗緊點解呀，a pair of white，跟住就問你呢個dominant。
S: Yes, I am thinking, a pair of white, then it asks me about the dominant.

你正話睇嗰行，你諗到D咩嘢呀？
I: And what do you grasp from that line ?

冇咩嘢諗到呀，等我睇多次先吓。One of the five offsprings of a pair of white rabbit is black. 咁嗰個dominant character係white [好肯定咁話]。
S: Not much, let me read it one more time. One of the five offsprings of a pair of white rabbit is black. Then, the dominant character is, white [her voice is loud and firm] !

哦，係依樣呀？
I: Is that what you get ?

等我諗多次先。
S: Let me think about it again.

冇呀，冇話你唔啱呀，只不過sure吓你講嘅咋。
I: I am not saying that you are wrong. I just want to reconfirm your answer.

唔係，諗多次，one of the five，有五個offsprings，咁有其中
S: No, let me think again, one of the five. Five offsprings, one of them is , no,
一隻，唔係，兩隻白白兔，哎吔，呢度講咩嘢呀。依，兩隻白白
two white rabbits, O, no, what is it writing about? Ye, 2 white rabbits are black,
兔係黑色嘅，of a pair of white，咩嘢呀！哈，佢個隻有一隻
of a pair of white ; what's that ! Ha, one of them, one of the offsprings, no, 5
兔仔個offsprings，唔係，五隻其中有一隻係黑色嘅，係由兩隻白
offsprings and one of them is black. They were born by 2 white . Yes ! So it
色生嘅，係啦，所以就係白色啦。
is white.

唔，點解你覺得所以就係白色呢？
I: Hum, why you think it should be white ?

因為，得一隻囉，因為佢五隻得一隻，係啦，咁佢亞媽又係白
S: As it has only one. Only one out of the five. Yes, and their mother is white,
色嘅，佢亞媽亞爸…[答4(a)，然後看4(b)題目] 大W
their parents….[write down the answer for 4(a) and read question 4(b)] big W
細w，state and explain briefly the genotype…搵個parent
small w…state and explain briefly the genotype….Find genotype of the parent
rabbit嘅genotype，咁樣呢，就係[答b(i)]大W細w啦，唔，
rabbit.. That is. It is [write the answer b(i)] big W and small w, yes, it is, both
係啦兩個都係。跟住，white and black offspring. [答b(ii)
of them are. Then the white and black offspring [write the cross and the answer
和做cross]咁樣呢，就會係…，就會係大W大W啦，大W
of b(ii)] that is, yes, it's, it should be big W big W, big W small w, big W small
細w，大W細w，細w細w，啦！
w, small w small w. Yes !

佢要你講個genotype同埋咩嘢呀？
I: It asks you about genotype and what else ?

冇呀，explain briefly the genotype，冇呀！
S: Nothing else. Only explain briefly the genotype !

睇下先，explain 吓，點解呀？
I: Let's see, explain, so why it's like that ?

點解！因為，因為佢地係 white 又 produce black 囉！
S: Why !....because, because they are both white and produce black !

佢地係 white 而又 produce black，所以你覺得佢地係大 W 細 w.
I: They are white and produce black, so you think they are big W small w ?

係呀。
S: Yes, it is.

咁點解呢度你會咁諗呢？[指 F1 答案] 個 progeny 呢點解你又認為咁呢。
I: Then look at this, why do you think it this way ? [point to F1] How about progeny, why do you make such a decision ?

點解，因為個 parent 有兩個 gene 囉。
S: Why, because parents have 2 gene.

即係話，因為佢係 heterozygous，有大細，所以你會…咁個四個之中邊 D 係 white 邊 D 係 black 呀！
I: That means, as they are heterozygous, with big W small w, so you…Then, which of the 4 progeny is white, which is black !

我寫埋，係下面寫
S: I write it down, under here.

好呀！
I: O.K.

重駛唔駛 explain 呀？
S: Do I have to explain it ?

寫係呢度囉。
I: Write it down, here. [the student has finished the solution]

Q5 MP1

第五題. Tongue rolling .... dominant gene ... 係吖, Tongue
S: The fifth question. Tongue rolling …. dominant gene … Yes, tongue rolling
rolling 嘛, 就係呢個 dominant 嘛. 跟住, State and explain the
is the dominant gene. Then, state and explain the genotype of individual 1 & 2.
genotype of individual 1 + 2. 睇過條題目先. Tongue rolling,
[I] have to read the question again. Tongue rolling, determine by the present of
determine by the present of a dominant gene 大R ...... 咁樣
a dominant gene big R ……. that way ….. It asks about the genotype of 1.
呢...... 咁佢問 genotype 1 吖, 咁呢, 就會係呢! 呢個嘅,
Then, it would be, this, this big R small r… [write the answer].
呢個嘅大R細r啦. [寫......]

點解呢?
I: Why ?

因為, 因為跟住另一個 parent 所生嘅有個, 唔係捲利嘅,
S: Because, because [1 cross] with another parent produce one [progeny] that
即 non-roller 嘅.
cannot roll tongue, that is non-roller.

另外一個 parent?
I: Another parent ?

唔係, 咪即另外一個 female 吖.
S: No, another one, the female.

即話佢同2.
I: [You] mean [individual] 2.

係, 一同二生, 即 produce 一個呢, 唔係 roller 嘅. 依, 唔係呀, 唔
S: Yes, 1 and 2 produce, that is produce one non-roller, Yi, No, no. I make a
係呀, 錯左啲.
mistake.

點解吖?
I: Why ?

因為佢話呢個大R係dominant吖嘛,係噉,如果一個大R一個細r都係roller吖嘛,所以兩個都係細r.咪呀,係呀,係
S: Because it state that the big R is dominant. That is, if [one has] a big R a small r, [he is] also a roller. So two small r .... No, it is, it is, is big R and
呀,係大R同細r,係吖,跟住b.
small r. Then [come to question] b.

你要解釋喎,呢度state and explain吖嘛.
I: You have to explain. Here [stated that] state and explain.

[寫 because ......] [再看題目] 三同埋四,咁樣
S: .... [write down the explaination]. [read the question] 3 and 4, That way,
呢,依,三係non-roller.
Yi, 3 is non-roller.

四娶左三吖,咁三同四係咩呢?
I: 4 married 3, what are 3 and 4 ?

係夫妻,睇下先,依家四係細r細r,三就會係......應該呢
S: Husband and wife. Let me see, now 4 is small r small r, 3 will be ...... It
就會係......諗下先......諗下先......依,呢度生左個喎,又係
should be ...... [let me] think about it ..... [let me] think about it ..... Yi, here
roller喎,咁...R係dominant,這話呢,Hi,寫左四先,噉咁就
[they] produce a roller, then ... R is dominant, that means, Hi, [let me] answer
[寫四的答] 四就係rr三呢,就會係,都唔知吖.
4....[write the answer of 4] ..... 4 is small r small r. What about 3, should be,

[I] don't know.

點解唔知?
I: Why you don't know ?

依咁佢有兩個可能生咁點呀?
S: Yi, What should [I] do as she has two possibility ?

咁咪兩個都講囉，點解佢會有兩個可能性呢？
I: Why [do you think that] she have two possibility ?

咁因為大R係dominance吖嘛，咁如果佢一個大R一個細r，咁，佢都可以做到roller。係，係嘅，如果兩個大R都可以做到。
S: As big R is dominant, if she has 1 big R and 1 small r, then, she can still produce roller. Yes, it is also possible if she has 2 big R.

你咪將兩個可能性都寫出嚟，兩個圖都劃埋出嚟囉。
I: You can write down both possibility, draw both 2 diagram as well.

圖呀？
S: Diagram ?

係吖，你要解釋㗎嘛，state and explain吖嘛。Ha.
I: Yes, you have to explain, [It requires you to] state and explain.

咁就［寫答案］，就係咁樣吖。
S: …..[write the answer] Then it should be like this.

所以有兩個可能性。
I: So [you believe] there is two possibility.

係吖，第二題嘞。
S: Yes, [I try] problem (ii) now.

依家得一個咋嗎？
I: But here they have only one [progeny] ?

依家得一個，咁呢個囉，咁，咁佢唔生之嘛，可以生多幾個㗎。
S: They have only one [progeny], it is this one [point to one of the F1 in her diagram], well, it's just because they don't produce. They can produce more.

係。
I: O.K.

咁這點呀？
S: What do that mean ?

繼續啦.
I: You may continue.

What is individual 5, 係, 呢個係點解?
S: What is individual 5, Yi, this one is, what does that mean ?

What is the probability that
I: [read the question statement] What is the probability that individual 5 is
individual 5 is heterozygote.
heterozygote.

咁要自己劃圖 ？
S: Then I have to draw the diagram ?

得.
I: It's O.K.

睇先, 一同二, 咁呀, 二呀當大R細r, 這係大R細r.
S: Let me see, 1, 1 is with 2, then it is. Take 2 as big R small r. That means
[寫個 cross 在 answer, 鉛筆個2, 完]
big R small r, big R small r …. small r small r [finish the cross which is correct]
有…有咪, ½囉.
have … have 1/2.

點解 ½ 嘅?
I: Why [it is] 1/2 ?

咁佢有四個, 咁佢得兩個係呀嘛.
S: They have 4, with 2 of them is [heterozygous].

哦.
I: I see.

Q6 MC&MI

跟住, a man with blood group A married a woman with blood group B, 咁有4個細路和, blood group AB, show the, 吖 Ha, 這話.

S: Then, a man with blood group A married a woman with blood group B, then [they] have 4 children, blood group AB, show the,.... Ya Ha,

"吖 Ha" D嘢呢?

I: What make you said "Ya Ha" ?

這話, 佢地個gene, 重有O喫, 唔好嚟, 重有 ... 依, 依,

S: That means, there are also "o" in their genes. And ..... Yi ..... Yi, ...

你個腦諗緊咩嘢, 點解你"依"喫?

I: What are you thinking about ? What make you said "Yi" ?

一片空白呀, 我試試... 可唔可以, 可, 可以多過兩個gene嘅? 有冇得咁嘅?

S: [My brain is] empty, let me try ... Could it be, Would there be more than 2 gene ? Is that possible ?

有冇得咁, 你估囉. 人家要你自己估吖嘛.

I: Is that possible ! You guess. It's you who have to think about it.

我估, 有喫.

S: I guess, there is [such possibility] !

點解你估有呢?

I: Why do you think so ?

咁, 又可能冇喎.

S: It may not has such possibility.

咁, 你估有嘅原因係邊度呢?

I: Then, what is your reason for has [such possibility] ?

因為佢有個O係度囉.

S: Because there is a [person with blood group] O.

哦，點解會冇呢?

I: Then, what is your reason for not having [such possibility] ?

冇呢係因為,可能單係得A同埋B囉. 咁係,都唔係好清楚吖,做左先囉.

S: The reason for not having [such possibility] , may be there are only A and B. That means .. [I am] not sure, [I'll try to] do it first.

點解你會有大A細a,一個大B細b呢?

I: Why do you think that one is big A small a, and [the other] one is big B small b ?

唔係嘅係?

S: It is not so ?

點解唔係呢?你唔駛咁快擦,我冇話你錯.

I: Why it is not ? Why are you rubbing it ! I am not saying that you are wrong !

既,因為我覺得錯左.

S: Because I think that it is wrong.

唔係,你話比我聽點解你覺得錯?

I: Why do you think that it is wrong ?

因為如果一個大A一個大B,咁,都...[做]...咁咪搵唔到有個A有個B囉.

S: Because, if a big A and a big B, then, it still .... [try to make the cross] ..... Yi .. then [I] can't find a [blood group] A and a [blood group] B ....

你依家想點試?

I: What are you doing now ?

我依家，唔知架…… ……我都唔知…… ……吓，又啱啱.
S: I am doing, [I] don't know, I also don't know .... Ha! It's correct!

係咩？點解會啱呢？
I: Yes ? Why you think it's correct ?

加埋，咁呢個可以有blood A喎，呢個blood O，呢個blood AB喎，吓，真係好.
S: Then, adding them [together], then this one will have blood A, this one is blood O, this one is blood AB, Ha! It's wonderful [she have given a correct answer] !

點解個細ab你會話佢係blood O呢？
I: Why did you say that [the person with] small ab is blood O ?

咁兩個都係，兩個都唔係dominant囉.
S: They both are, both of them are not dominant.

咁即係，你覺得個兩個recessive gene在埋一齊就會係O喎.
I: That means, you think O appear when there are two recessive genes.

又唔係喎．諗吓先…… 諗……點諗呢，會唔會有O架gene [做] 依，又得喎.
S: It is not. Let me think [about it] .... think ..... how to think [about it] ? Will there be an gene O ? ..... [write another cross] Yi, It's also O.K.!

點解AO個時你話佢blood A呢？
I: Why do you think that AO is blood [group] A ?

A係dominant囉.
S: A is dominant.

B呢？
I: What about B ?

dominant 囉. O係recessive.
S: Also dominant. O is recessive [gene].

咁呢個呢? AB呢?
I: Then [how about] this ? This [blood group] AB ?

AB, 兩個都係 又好似唔係喎, 好似冇得咁喎.
S: AB, they both are [dominant]. It also seems not [possible]. There seems no such way.

哦, 有冇得咁㗎?
I: Ha, Ha. Is there such possibility ?

好似冇㗎, 又好似有㗎, 哎, 係咁㗎, 係咁㗎啦. 佢係唔係
S: There seems no, there also seems to have [such possibility]. Ya, that is it, it's
都有個咁啥, 哎, 就咁啥, O.K.
that way. It will somehow has such possibility ! Ya, take it as [the answer]! O.K. !?

Q7 MP2

第七條, in human, 依咪做過, 呢份嘢, 依 short sight. 一
S: Question 7, in human, Yi, [I] have done this before, Yi, short sight. A
個正常女人, 就嫁左俾個 short sight man. 等我睇下先, 有斜線
normal woman, married a short sight man. Let me see, [those] having shaded
就short sight, 呢D正常㗎喎. 應該係正常個D係
line are short sight. These are normal. It should be …… normal is the
dominant.
dominant.

點解呢?
I: Why ?

因為,佢produce嗰D都係normal嘅.
S: Because, what they produce are all normal.

佢produce幾多個?
I: What is the number of their progenies ?

兩個.
S: 2.

所以你就覺得佢normal㗎嗱.
I: So you think it's [the dominant gene] normal.

所以我就覺得咁.
S: Yes, I think so.

如果佢只係生一個咁點算吖?
I: What will you do if they have only one progeny ?

生一個? 咁都係normal㗎嘛,咁佢生嗰D都正常嘛
S: One progeny ? It's still normal. [As] their progeny is normal.

咁如果我淨係得呢個,咁你點睇?
I: Then, what if it has only this part ? [left only the part with two normal parents and one short sight progeny]

呢兩個都有唔正常嘅gene.這,short sight gene.
S: They both carry gene that are not normal, I mean, short sight.

邊個係dominant呀?
I: Which is the dominant ?

我都係覺得white係,這normal [寫]
S: I still think that it's the white [symbols]. That is the normal …. [write the
點樣explain呀?睇下先,等我諗下先,可唔可以畫[畫
answer] ….. How to explain ? Let me see, think about it, Could it be …. [make

cross] 依，咁奇怪嘅。等我睇埋佢下面先。[睇1&2]… 咁呢
the cross] .. Yi, so strange, better finish reading the question first …… Then this
個一定大R細r，咁樣呢，explain 嗱喎，因為呢……因為呢…可唔
must be big R small r, then, [I have to] explain, because…. because … Could [I]
可以咁講㗎，因為呢度有 [做 ii] The genotype of 1 [畫 cross]
explain this way ….. Because there is …… the genotype of 1 …… Yi, Yi. It is
依，[做 cross 2] 依，原來唔係吖，佢衹係呢個咋。
not so, He only has this ….

咩呀？
I: What ?

係呀，係呀。
S: Yes, Yes.

點解呢？
I: Why ?

因為如果咁樣呢，如果咁樣呢話，佢就冇一個係呢個啦。
S: Because, if it is , if that is , they couldn't have this [progeny with rr].
[指細 rr]

唔，唔。
I: Hum, hum.

所以 [因做完個 cross]
S: So! [she has answered Q7]

Q8 MCT

跟住第八題，21 seed. It was found that 6 of them have tall
S: Then it follow Q8, 21 seed. It was found that 6 of them have tall stem, 11 are
stem，11個係 stem with intermediate height and 4 with short stem，
stem with intermediate hight and 4 with short stem. Then, [I have to] explain
咁樣呢，就 explain 佢嗱，咁就要畫嗱喎，首先，佢有 6個 tall, 11
them, [I] have to draw, first of all , first of all, they have 6 tall, 11 intermediate,

intermediate, 4個係short. 這係呢, parent 呢, 就應該係, 大L同
4 are short. That means, parents are, should be, big L and small l, is that so, yes

細l嘅, 係咪呢係呀, [畫個cross... assign phenotype]
.......[complete the cross] ... [finish the solution]

跟住呢個, 跟住呢個就會係short [做完] 係咪噉, 好似唔係
then this one, this one will be short! Is it this way ? It seems not correct ?

咁嘅.

點解好似唔係呢?
I: Why do [you] think that's wrong ?

我都唔知佢邊個dominant, 又可能係tall, 又可能係short.
S: I am not sure which of them is dominant, may be tall, may be short.

Hum, 咁個parent你覺得佢大L細l, 咁個phenotype呢?
I: Hum, You write big L small l for the parents, what are their phenotype ?

Phenotype? 應該係, 應該係intermediate 囉.
S: Phenotype ? Should be, should be intermediate.

點解你覺得佢係intermediate呀?
I: Why do you think they should be intermediate ?

因為, 因為, 佢produce左11個intermediate囉, 佢有6個
S: Because, because they produce 11 intermediate, 6 tall, 4 short.
tall, 4個short.

跟住呢種dominance叫做乜嘢呀?
I: What do we call this kind of dominance ?

哎吔, 係咪呢個呀? [指住個L e intermediate] 係咪呀
S: Ya! Will it be this ? Is it so ? [she point to the word intermediate in the question]

Ha, 係咪呀?
I: Is it ?

[再看題目一次] What is the name of the kind of dominance.
S: [read the question again] What is the name of the kind of dominance. I don't
我都唔知吖,我係識呢個咋.
know, I only know that [intermediate].

即你唔識佢個名?
I: You can't remenber the name ?

係咪呢個吖?
S: Will it be that [intermediate] ?

你唔記得佢個名,但係呢種dominance個特徵你記唔記得吖?
I: You can't remenber the name ? Will you remenber the characteristic of that
吖?
[kind of dominance] ?

我唔記得喎.佢,佢呢,我唔吖,真係唔知吖。
S: I can't remenber. It's, It's. I can't, really don't know.

咁點解你會話大L細l係intermediate?
I: Why do you say that big L small l is intermediate ?

因為,因為好似紅花溝白花出個pink咁.
S: Because, because it's like [crossing] red flower with white flower produce pink

[flower].

(ii) In the second interview:

Q1 MS1-LONG

In garden pea, terminal flower, recessive to 咩吖,咩嚟㗎呀?我睇下
S: In garden pea, terminal flower, recessive to what, Ai, what's that ? Let me
先, terminal flower, a pure breeding plant with terminal flower, 哦!咁
see, terminal flower, a pure breeding plant with terminal ...... Ho! Then the

the seeds result from this cross are are collected, 咁樣啦, when
seeds result from this cross are collected. [It appears] that way. When this plants
this plant have flowers, they are self "哦" pollinated. 咁樣吖. The
have flowers, they are self Ho! pollinated. [It appears] that way. The seed are
seeds are collected and shown again. F2. 咁就劃圖啦, 咁我
collected and shown again and this are F2. Then [I have to] draw diagram, [I
劃喋啦?
am] going to draw, I draw diagram ?

Hum, Hum
I: Hum, Hum.

駛唔駛let?
S: Do I have to [write the] let [statement] ?

隨你啦.
I: As you like.

咁唔好啦 [做] 這係, Let 個 flower 呢 AA, 另外一隻呢, 就 aa,
S: Well, I won't do [the let statement]. That means, let the flower be ... AA,
咁樣呢大AA同細aa 就一齊啦, 咁呢個呢, 就係 parents, 跟住有
then, the other flower, is aa. Then, big AA and small aa come together, and
個A有個a, 呢個就係genes, 跟住呢個就係Aa, 呢個就係F1,
these are the parents. Then, there is a [gene] A, there is a [gene] a, these are
跟住, 有佢自己又再黎啦喎, 咁佢自己又再黎啦!?
gene. Then this one is Aa, this is F1. After that, they [cross with] themselves

again, it will be. They [cross with] themselves again !?

Hum.
I: Hum.

咁我喺側邊劃?
S: [May] I draw beside it ?

好呀好呀.
I: It's O.K.

係咪咁㗎?
S: Is it really so ?

Hum
I: Hum.

大A細a大A細a…… genes F2，跟住，呢個大AA，呢個大A細a，呢個大A細a，呢個細細a，呢個就F2，跟住佢又問呢……咩叻?係咪個個genotype……死啦，寫呢度?
S: Big A [gene] small a [gene], Big A [gene] small a [gene] ….. genes … F2 .., then this is big AA, this is big A small a, this is big A small a, this is small [a and] small a, these are F2. After that it ask ….. What's that ? Is the genotype .. Ho, no! [May I] write it here ?

好呀!
I: It's O.K.

衣 我冇嘢講叻.
S: …… Yi …. I have nothing to say.

點解冇嘢講嘅?
I: Why ?

咁我家寫低呢D之嘛.
S: Well, I am just writing all this down.

哦.
I: I see.

駛唔駛pause住佢呀?
S: Do [we] have to pause it [the recorder] ?

唔駛啦，大把帶.
I: No need, there's lot of tape.

In the F1 generation 呢，就係Aa，而呢個F2 generation呢就係
S: … In the F1 generation, is Aa, and this F2 generation, is, Yi, AA, Aa and this
依，AA，Aa同呢個aa，係啦，跟住呢，依，死啦！
aa. Yes, then, Yi, Ho No!

咩死呀，死啲嘢呀？
I: What [made you say] Ho No ?

喂，呢個同呢個有咩分別？唔記得左呀，呀！記得啦，咪咪咪，
S: Hi, what are the different of these two ? [I] can't remenber… Ha! I remenber
唔係呀！哎吔，死呀，攪亂左呀。
now, no, it's not correct, no, I mixed them up.

Hum, Hum.
I: Hum, Hum.

F2就係，呢個嗱，同呢個嗱？"係咪㗎？"
S: .. F2 is, this one and this one. Is that so ?

哈！哈！你最鍾意問"係咪㗎？"
I: Ha! Ha! You like to ask "Is that so ?".

咁要諗吓㗎嘛。
S: Well, [I] have to think about it.

哦，你問親係咪㗎？就諗吓㗎嗱？
I: Are you thinking when asking "Is that so ?" ?

係啦。
S: Yes.

哦。
I: I see.

跟住呢 [做]　　唉！得啦，第一題做完。
S: Then it follow …….. Ho, it's O.K., finish Q1.

Q2 MS2-LONG

第二題啦喎?
S: [I do] question 2 ?

好呀.
I: O.K.

你唔好望住我做啦
S: [Please] don't look at me while I am solving [the problem] ! [I will be] nervous !

唔緊要啦! ... 咁你會認真D嘛.
I: It doesn't matter! ... You will be more carefull then.

我好認真.
S: I am very careful.

係咩.
I: Really.

A red eye fruit fly is cross to a fruit fly with white eye, 咁樣呢 就發現呢, 60隻fruit fly呢, 180個白眼嘅, ... in the F2 generation, 178紅眼呢, 180個白眼嘅, 就produce左啲喎. 邊個係dominant呀? 係咪錄緊呀?
S: A red eye fruit fly is cross to a fruit fly with white eye, then it follow, [it] discover, 60 fruit fly, are all red eyed, ... in the F2 generation, 178 red eyed, 180 are white eyed, [they] were [the progenies] produced. Which is the dominant ? Are [you] recording ?

係呀.
I: Yes.

邊個係dominant？嘩！睇吓先，all the 60 fruit fly in F1
S: Which is the dominant ? Wa! Let me see, all the 60 fruit fly in F1 generation
generation……，好啦，就Let啦[做] fruit fly，點解呢，因
…….. O.K., do the let [statement] first….. fruit fly … explain..because,
為，因為，啊，all the 60 fruit flies in the F1 generation.
because, Ai, all the 60 fruit fly in the F1 generation … red eyed.

[閱題目] b! using symbols, R and r, state and explain
S: [read the question] b! using symbols, R and r, state and explain briefly the
briefly the genotype of the parent flies, the flies in F1 and the flies
genotype of the parent flies, the flies in F1 and the flies in F2, Hum, symbols R
in F2, Hum, symbols R and r, 咁樣呢，等我諗吓先，red eye
and r … that is, let me think about it. Red eyed fruit flies, all, Ai, Ya, let me
fruit flies, all, 哎吔，等我諗吓先，咁樣，咁樣，咁樣，呢個，
think about it,… this way, this way, this way, this one, all, this one is white, that
all，呢個white，咁樣呢，等我諗吓先，呢個應該係大R大R啊，
is, let me think about it. This one should be big R big R, red eyed, Hum, big
red eye，Hum，大R細r，呢個gene，大R細r F1，咁吖全部都係
R small r, this is the gene, F1 is big R small r, then all are red eyed. Then, the
red eye，跟住，咁個F1 generation呢，就cross to the white eye
F1 generation is cross to the white eyed fruit flies again. That means this big R,
fruit flies again，這係呢個大R，呢個F1，呢個大R，就white eye，
this F1, this big R. Then, white eyed [fruit fly] will, Ai Ya, then it's F2, this big
就會，哎吔，咁就是就呢，F2，呢個大R細r，呢個細r細r，咁樣
R small r, this small [r] small r, then, it asks, the genotype of the parent flies.
呢，佢就問呢個genotype of the parent flies，咁[做cross]，就
……. It's big R big R, small r small r. Here, [it is required] to explain briefly
係大R大R細r細r，仲要explain briefly…哦，parent就[為]大
… O! parents is … ……. big R small r, big R small r. Is that so ? [turn to look
R細r，睇吓係咪先[看前面]得啦，做完啦第2題。
at previous solution] Yes, finish question 2.

第二題呢，我發覺你呢，係呢，咪係你，睇完晒條題目啦？
I: In question 2, I observed, you are, is that you go through the whole question

first ?

係吖。
S: Yes.

但係呢，我發覺呢，你後尾呢，又再睇返呢 it was found that all
I: But, I find out, after that, you study "it was found that all the 60 fruit flies in

the 60 fruit flies in generation 係 red eye 嘅, 點解?
the F1 generation are red eyed" again. Why ?

咁, 我要睇吓佢呢個, 係點嚟, 咁如果佢有D係白嘅, 咁, 咁
S: Well, I have to know what this is, Ai, well, if it has some white, then, there
呢個咪可能有呢個細 r gene 嚟.
may be a small r gene.

Hum, 咁所以你睇完到後尾你要決定嗰個係 red eye, 係點你
I: Hum, so after first glance, when you have to decide what the red eyed [fruit
又再睇返下個 genotype.
fly] is, you will confirm about the F1 [phenotype] again ?

係呀.
S: Yes.

哦, 咁樣, 咁樣.
I: I see. I see.

係咁樣嘅, 第3題.
S: It's like that. Question 3.

Q3 MC-LONG

嗰個 flower color of a plant, control by a pair of allele, which is,
S: The flower color of a plant, control by a pair of allele, which is, codominant!
codominant in inheritance pattern. When a pure breed red
in inheritance pattern. When a pure breed[ing] red flower plant, is cross, with
flower plant, is cross, with a pure breeding white flower plant, all
a pure breeding white flower plant, all the F1 plant are pink! flower, the pink
the F1 plant are pink! flower, the pink flower plant in F1 is
flower plant is cross between themselves .... Then, show the phenotype and
cross between themselves............ 跟住 show the phenotype &
genotype of the parents, F1 and F2. O ! [I have to] draw again, how ? [Let me]
genotype of the parents, F1 & F2, 哦, 又畫嘢, 點呢, 睇多次先......
read one more time .... Yi [start to write the answer] let the red, Yi, gene of

依[開始寫答案] Let the red，依gene of red flower be RR
red flower be RR. It's correct. This white flower is small r small r.
啱啦。呢個white flower就係細r細r，

哦，哦。
I: Hum, Hum.

parents呢，依等我諗一下先，係嗰啦，有個大R大R，呢個red
S: As for the parent, let me think about it, that is. [The one] with the big R big
呢，細r細r，呢個white嘅。
R is the red [The one] with the small r small r is the white [eyed fruit fly].

Hum, Hum.
I: Hum, Hum.

有個大R細r呢個就係genes，跟住大R細r呢個，依，pink嘅，
S: [There] is a big R a small r, this are the genes. Then, this big R small r
pink嘅F1，跟住呢！自己又雜多次。
[flower], is pink ! Pink [are the] F1. Then, they [cross] again, among themselves.

Hum.
I: Hum, Hum.

依，咁有genes啦，咁呢個genes呢就係，大R細r，大R細r，
S: Yi, then, there are genes, this genes are, big R small r, big R small r, big R
大R大R，大R細r，大R細r，細r細r，呢個就係red，呢個就係
big R, small r small r. This is red, this is pink, this is white! This is F2. I have
pink，呢個就係white！呢個就F2，我show完啦。
shown all [the answer].

做完晒喇啊？
I: Finish ?

係呀。
S: Yes.

係啦，你Let呢個度諗左幾次呢，你諗呢個時會點㗎？
I: Yes. When you are doing the let [statement], you seems to be thinking. What are you thinking of ?

我諗吓同咩符號好吖.
S: I am thinking about what symbols are the most suitable.

你成日話"等你諗多次"呢個時你會點㗎?
I: What are you doing when you said "let me see" ?

睇多次囉.
S: Read [the question] one more time.

你會睇多次，哦我睇多次有咩幫助？
I: You will read it one more time. O! Will that help ?

我唔係睇吖. 佢睇友開始咁咪開始寫囉，咁要sure係咪㗎嘛.
S: I am not reading. I look at the beginning and start to write. Well, [I] have to be sure.

哦好啦，得啦.
I: I see. It's O. K.

Protocols of subject R3

(i) In the first interview:

Q1 MS1

S: Grey body 既 color 係 dominant……唔. generation of heterozygous body flies. 即係兩個唔同, 兩個雜種既搞埋一齊……睇吓先……(估)grey body 係 GG, 嗰個"唔知咪物嘢"係 ee.

I: 你叫嗰個 recessive 做 ee?

S: 係呀. 咁, 兩個雜種, 就即係 Ge 同 Ge 搞埋一齊. 咁, Ge, 每樣嘢出D. 顏色, 三類. 咁跟住劃左個 D 圖囉…咁要左三個有大 G, Gg, 唔係, dominant 嘅嘢, 一個係 recessive 既嘢. 咁樣嘞.

I: 咁嗰三個會係點樣樣?

S: 灰色囉, 呢個就"唔知咪物嘢" body [寫 phenotype].

I: Hum, Hum.

S: 咁, 得喍啦.

I: 得喍啦, 不過你指明邊個係 F_1 啦.

S: 哦, 哦, 呢個係 F_1, 呢個係 gamete, 呢個係 parent.

Q2 MC

S: Flower color of... controlled by... pair of... codominance, 即係, 兩個, 都係, dominant 嘅, 咁樣啦... with pink... self-pollinated... 當, 當 pink flower 係, 嘅, 啲物嘢好呢, pp, p 啦, 兩個大 p [寫] 咁, 啲個, 啲個, 唔係呀, 係 red flower, 兩個大 R, white flower 係兩個大 W [放和寫好 Let statement]. 咁呢, 咁樣樣, 如果......五個 white, 十個 pink flower... 唔識做添.

I: 唔?

S: 呢題唔識做添. 嘻.

I: 試吓啦.

S: 嘅, 嘅... pink flower, O, 我知啦, 知啦, 知啦.

I: 唔.

S: 咁, 即係話有兩個 pink flower, 有兩個叫做 RW 嘅嘢啦, 加埋 RW 嘅嘢啦, 咁樣整出黎啦......要左咁樣...四個 [做完 cross]

I: 你點解會決定佢係 RW 嘅呢?

S: 嘅, 因為, 咁, 白色加紅色粉紅色, 同埋因為兩個, 兩個 gene 都係 dominant 囉, 咁...咁要左呢有, 一個紅色, 一個白色, 兩個粉紅色.

咁样嘞. phenotype... 寫左啦, 寫左.

Q3 MS1

S: Brown hair recessive to black hair, 得啦. black hair 係 dominant 啦咁, black hair BB 啦, 咁細b 啦, 啲個 brown 就 [寫下] 咁, brown hair 同一個雜種嘅 black hair 一齊, 咁, 即係一個大B一個細b既就揹埋兩個細b既嘢嘞.

I: 唔, 唔.

S: 咁样, 一個大B出一個大B, 哎吔, 唔識講啄, 兩個b就出一個細b既嘢嘞. 咁样呢, 係咪劃錯呢... 得, 咁應該會出, 一個呢就係有 black hair 嘅, 一個 brown hair 嘅.

I: 邊個 black, 邊個 brown?

S: 大B細b係 black 囉, 因為大B係 dominant, 呢個, 兩個都係細b, 即係, 咁就 brown 啦.

Q4 MS2

S: One of the five offsprings of a pair... white rabbit, 咁為之一個, 一對, 依, 一對 parent 就出左一隻, 有五隻就有一隻係黑色, 唉!... 五隻有一隻係黑色.

I: 唔.

S: 咁即係白色係dominant，係咪，如果黑色，就應該出黑色啦，咁應該係白色嘞。

I: 你正話話，黑色應該出黑色啦，係指啲物嘢？

S: 如果黑色係dominant囉，咁offspring個大多數，應該係既，黑色囉。

I: 你即係話你睇progeny個比例囉喎？

S: [點頭]

I: 咁你睇唔睇父母㗎？

S: 我多數睇F1個數目。

I: 好少考慮父母？

S: 咁，但係如果依家咁樣，個父母係白色既吖，咪喎，可以係白色係dominant，有黑色既，即係，即係父母都可以有個大W，細black既，即係，家睇個父母，但係都應該係白色。[答4(a)] 啱大W係白色，細w係黑色，咁個parents就係一個大W一個細w，出左呢D，呢個，一大一小，一大一小，兩小，咁突左呢，有三隻呢白色嘞，係有一隻黑色啦，駛唔駛點反一二？

I: 唔駛㗎啦，係啦，寫明邊個F1得。

Q5 MP1

S: 咁第五題，咬，最唔店呢個．family tree! 咬吖…哈，tongue rolling is dominant gene… recessive gene… dominance係大R，recessive係細r喎．咁樣樣就，睇先…state and explain genotype of individual 一，第一個female roller，roller即係roll tongue，即係有大R嘅嘢，唔，有大R，咁我估佢就應該係，咁，係可以roll tongue，得一個gene，咁應該係RR囉，genotype．

I: 點解你估佢係RR呢？

S: 嗰因為佢可以roll tongue囉，咁，嗰，我估佢出得一個gamete，即，出得一個大R嘅gamete出嚟囉，所以我唸佢係兩個R．

I: 哦，roll tongue就出大R gamete，所以就係大R？

S: 唔［寫吓答案］咁第三，第三個個可以roll tongue，呢個係，即係？［指"═"呢個個符號］

I: 結婚，呢係生落去，囉．

S: 呢個，呢號non-roller，同一個roller，就出左個可以roller嘅，我夠知係recessive啦，唉，可唔可以睇，譬如，睇呢個先，咁樣估佢答案之後咁樣再估落去．

I: 嗰，你覺得呢？

S: [冇反應]

I: 正話你點估一？

S: 我估佢出一個大R.

I: 咁你點睇？

S: 我其實係咁估，我估，即係呢，我估呢個出大R啦，咁[指…]出大R組D啦，咁就可以要左呢D嘢出黎囉.

I: 咁依家你想點樣估三同埋四呢？

S: 唔識估，...即係，我唔識點樣睇，即係，唔識點樣估佢的囉，即係，無從着手.

I: 咁，比如上次我test你，你一定要試㗎，你會點試.

S: 都係，都係撞撞比咪，咁睇吓邊個多D囉，即係dominant多D囉，我上次睇埋male，即係female同male添啦. 係咪，即係，有冇作用呢？

I: 你覺得male同female有冇作用呢？

S: 係咪會，即係出一個，我唔知呀，我估佢male出一個，female出一個，咁睇囉，跟住，推論落去就好似推論唔到，唔記得我推論左D啲嘢啦.

I：咁今次你試吓啦，吓，你試吓睇下你會點估呀？

S：呀，先，我如果開始話，female，咁一呢個，咁呢個，依，咁出左兩個，得三個出嚟。

I：哦，如果個cross有兩款，即係兩個，有三個，你咁諗。

S：係呀，我係咁諗，唔……依……咁得…呢個係female，會唔會呢個係，兩個細rr，呢個係兩個大R，咁會變左係啱啱一個，咁樣。[寫 rr RR
Rr]

I：哦，你覺得如果呢係兩個細r，三係兩個大R，就會係出一個Rr，所以就一個？

S：係呀，又好似幾牛，貼貼咁樣…[看(iii)] what is the pro… 係問題即係問…要計probability呀，哎吔，我最差呢樣嘢喎…三份之，哎吔，計埋maths嚟吖。

I：試吓啦。

S：哦……呢度有……

I：唔。

S：三，三個，即係，三份之二，依……

I：點解你會懷疑佢係三份之二呢？

S: 既，出三個有兩個係roller...... roller有可能係大R. 咁啥，囉，暫時咁係. [寫 2/3]

I: 呢度要唔要你解釋?

S: 吓，要解釋嘅啦，要以，要以，要以. [再寫].

Q6 MC&MI

S: 一個A型既同個B型嘅有......，哦，呢題係我知啦...咁佢有一定有A嘅啦，一定有B嘅啦，咁應該係有個O嘅啦，咪點會有O型嘅呢. 應該係AO, BO, 因為，O可以，咪，O係recessive，即，[做個cross]咁要左出嚟，有AB, AO, BO, OO，咁AO，因為O係recessive，即， A，BO即B，咁就有呢四個啦，咁所以AO同BO係parent.

Q7 MP2

S: 唉！睇先，一個正常既結婚，咁就呢個，咁係邊個character係dominance. 咁呢個，short sight 呢個...... normal......咁多數都normal囉.

I: 點解多數都係normal呢?

S: 唔，佢D下，係normal，即係，即係[指兩個後代]

I: 即係佢嘅個兩個下係normal，所以多數都係normal係dominant.

S: 唔……應該係啦，同埋佢……本身又有……呢一個normal既genes.

I: 唔、唔。正話你睇邊個係dominant、你係淨係睇下1、2，或
或你睇佢爸爸、媽媽.

S: 全……要睇……下囉。跟住睇父母有冇呢一個既，係咩囉.

I: 你點解覺得normal係dominant呢?

S: 睇佢下同埋parent嗰度有冇呢個即，normal嘅genes囉.

I: 唔係咁點解係normal呢?

S: 因為呢度係normal嘅male同female嘛[指嗰兩個下]，咁應該係normal dominance D囉。就算父母有，父母有D係short sight，都會變左做normal囉，咁樣.

I: 好啦.

S: 唉.

I: 點解你成日唏唏唉唉咁嘅 ?

S: 唔係呀，我係塞唔到氣吖，[原來R3鼻塞]呀……explain genotype of 一、2，咁樣，兩個、一個short sight，一個normal，出左個normal既，咁佢有可能係有，short sight，吓，一個，normal嘅gene同一個short sight嘅genes，咁當normal既gene係，

既、睇下先啦，大N，short sight 係，s 啦 [寫] 咁样，即係一我諗，有可能会係，既，大N細S，既，[寫一：NS]

I：咁點解呢？

S：咁佢係都係 normal 嘅，咁佢有可能係大N細S，因為如果係大N細S都会係 normal 嘅，因為N係，dominant 既，既。

I：咁點解唔係兩個大N呢？

S：大N，… 應該係，… 哎吔，我唔識呀！Hum ………… 呀，係咪先，parent，睇開 … 睇下先，係個 parent 睇起，咁其中一個係，應該会係兩個都S，因為佢係 short sight 啦，咁，short sight 係兩個都 ss，咁如果有個N嘅係度，咁佢一定係 normal 嘅，咁即係當啲個係 ss 先 [開始做第一個 cross] 咁 normal 嗰個，有可能係 NN，有可能係 NS，如果係 NS，即係變左呢D出現啦 [做 cross]，如果佢係 NN，如果佢係 ss，就，即 [做 2nd cross，做完] 就一定会，係白色啦，… 係咁样样，咁样，吖，咁應該係 NS 啦，如果我用呢一個，咁一係 NS 啦，係家一係知道 NS，咁係睇 … 同二所出嘅下，呢就有 short sight 嘅，即係無論點都係要有個 SS 喺度，係喺佢地兩個其中嗰個度。

I：喺佢地兩個其中嗰個度你個意思係。

S：即佢地兩個目單一個，都要有個S嘅 gene 啦。

I: 哦，即係單一個有.

S: 或者兩個都有都得嘅，總之要有呢個 S 嘅嘢，咁样. 如果兩個都係 NS [做 3rd 的 cross]... 如果一個 NN, 一個 NS 即係咁样啦，咁就会出，咁样. [做 4th 的 cross] 咁呢個就一半机会 [在寫 4th cross 的 F_1 時]

I: 你講一半机会係咩呀?

S: 即一半机会係 normal，一半係近視 [指四 cross] 呢個就四份一机会係，近視 [指三 cross]，咁即係，我估会係 NS 多 D 啦，因為一同二既 offspring 都係多 D 有 normal 嘅 gene 嘅. [寫二: NS]

Q8 MCT

S: 6個係 tall stem，6個係 intermediate stem，4個係 short stem，即係話主要係有 tall stem 既 gene 同埋 short stem 既 genes，咁其中，咁一個極高，一個極矮，加埋有 D medium 既嘢囉，咁我......我當，呢個，parent，咪，我當 tall 係 [再睇題目]...都冇講到，即 parent 冇講到 tall 定 short，要自己唸.

I: 但應該係冇講.

S: 唉，如果 parent 係 tall，一個係 tall 嘅，TT，SS 先拉兰化 [做個 1st cross] 吖，咁咪出晒所有都係 TS......咁囉......如果一個係...T...，TS，Hum，兩個都係 TS 就会有 D 咁

哏既嘢出黎[做個2nd cross]TT, Ts, Ts, SS, 似唔似呢, tall stem 依, 都似, 但係,如果我覺得係呢個既呢, 咁呢個係 tall 呢個係 short 啦, 咁呢個可以當佢係, 如果我當 TS 兩樣嘢都係 codominant 既就應該得啦, 咁囉, 就應該會成題囉, 因為兩個都係 Codominant 就變左會變左係會 intermediate high 啦, 但好似要揾一個 dominant 喎.

I: 係咩.

S: What is the name of the kind......

I: 呢題其實就係問你依家呢度所顯現既 dominant 其實係咩名.

S: 哦!!!!!哦! 咁, 即係, 應該係呢個啦[指Ts, Ts 嗰個 cross][X 1st cross]呢個係[F1 寫埋 D phenotype] tall 啦, 係 inte. 呢個係 short sight 啦, [完成]咁樣樣, 如果要呢個 intermediate, 咗就要 Codominance, 所以b 就[寫 b, 答案][X 1st cross].

Q1 MS1-LONG

S: 既. terminal flower 係 recessive to axial flower. 即係
axial flower 係 dominance 嘛. 咁個 terminal 係 recessive
啦. 咁 axial flower 係大 F 嘅啦, terminal flower 就係
細 f 兩個啦. 咁, 點解係, 一係, 係佢哋 parent 係純種啦
所以 parents 就, 點講呢, 點講呢, 一個係兩個大F, 一個係
兩個細f 啦. 咁佢 low 出嚟, F1 整出嚟呢就係要左呢, 既
一個大F 既 gene 加一個細f 嘅 gene, 咁佢嘅 phenotype
就係係, 既 with axial flower 啦.

I: Hum.

S: 既因為既, 大F 係 dominant 啦, 咁跟住再 low. 即因自己
self-pollinated. 即加多個另一個样, 咁跟住, 整左個 F2
出嚟嘛. 咁就要左呢係會有三個. Ai. 有一個大F 既 gene
同一個細f 既 gene 既嘢啦. 咁要左個三個就會係. Ai.
axial flower. 就係會得一個係有. 係會係 terminal
flower 嘅. 做完啦. 唔.

Q2 MS2-LONG

S: 咁跟住, 我都唔知我睇緊邊度, 咁跟住下, 係紅色眼,
呀. 又要佢頭講住, 咁呢, 就話紅色眼嘅烏蠅同一隻
白色眼嘅烏蠅張合埋一齊之后, 就有全部既 BB 女都係
紅色眼嘅咁样样, 可以話比佢聽. 話比我聽呢 red eye

係red eye fruit flies. 有紅色眼嘅 fruit flies 就有dominant 嘅character, 咁即些個係R,呀,些個係,總之,dominance啦, 咁嗰個,一隻就係recessive,因為佢出黎都係紅,Han,係, Ai,紅色眼,咁,而所以些呢個parent有一個係大R大R,有一個就 細r細r. 大R大R同細r細r兩個呢走出黎,就Ai,係左一個眼既, 咁樣,[做着的]吓,跟住係,佢[做的cross]應該一個先, 如果佢個大R大R係咁樣,做則細r嗰個cross]

I: Hum. Hum.

S: [做] Ai,衣,呢係呢,[改][即塗的野份],如果parent 之間,紅色眼嗰個係 係,個genes係一個大R一個細r 呢,咁,攞埋一齊係,佢會佢全部都係紅色眼既,所以係佢得嘅.

I: Hum. Hum.

S: 唔,咁都係,parent係一個有兩個大R既genes既野同埋一個有兩個細r既gene嘅野啦.

I: Hum. Hum.

S: 咁跟住佢,同一個white eye既flies再張合埋一齊咁咬,點解我地唔見到左佢出黎呢!咬咁,答左呢D先.

I: 你解釋左未?

S: 未解釋,咬咁,Ai, has dominant, Ai 因為因為,佢地既佢

呢，係red flic，自然呢，因为because [論]之 咗[論] 算啦，算啦，咁吖，冇佢劃孫[搞不到佢]

I: 唔，劃個D嘢！

S: 咁，跟住下面同一個有兩個紅，呢D係全埋一齊呢系咪交左，劃出黎既F2係咁嘞，交左呢，一個呢，有兩款，一款就係紅色眼既，一款就係白色嘅。

I: Hum.

S: [看題目] genotype 這，得啦，做完，有冇問題呀. Ha.Ha.

Q3 MC-LONG

S: The flower color of a plant is controlled by a pair of allele which is codominant. 哦，咁這係話... Ai，個個flower既顏色係有兩隻，兩類既genes，係一齊，一齊去控制呢. When a pure breeding red flower is crossed with a pure breeding white flower，既，Hum. all F1 have pink flower. 即係話紅色加白色變左粉紅色，Ai，between themselves，粉色再加D粉紅色，粉紅色自己self-pollinated.

I: Hum. Hum.

S: 咁样样就会有紅色，白色，粉紅色嘅flower. Show the phenotype, genotype, parents. 咁样样，当pure breeding個個red flower [論] red flower 当大R大R而white flower 就，Hum，唸唸，兩個

都recessive丢，兩個都dominant係咪要作多個，咁，是但啦，作多啦，咁樣啦，因為兩個都係dominant既character啦，咁要左既運可以出紅色係細r啦，跟出佢兩個係大W啦。

I: Hum. Hum.

S: 咁樣樣，pure breeding既red flower同pure breeding既white flower，即兩個大R同兩個大W。

I: Hum. Hum.

S: 咁要左呢整出黎就係粉紅色，咁因為佢地出黎嗰個呢，係RW，兩個一樣係dominant既咁所以就pink啦，咁呢個係F1啦，gamete啦，呢個就parent [俾佢寫在cross度]呢個F1自己再self pollinated，Ai，再混合一個RW啦，咁要左再出黎就会[做個cross] RR，RW，WR，WW要左呢，就会有眼，係呢，一個紅色，一個，咪，一個紅色，兩個粉紅色，一個白色，咁就完完好呢，同個個問題係一樣嘅ratio啦，咁樣樣就做完啦。