Tactics Choice Behaviors Represented in a Programming Language in the Map Tracing Problems

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Abstract. Various kinds of method that decrease the language effects have been tried for understanding the spatial cognition of hard of hearing students. An experimental method and its application are proposed that uses a programming language in this article. The communication using a simple language and graphical interface is expected to give us a useful way for students' understanding the question and expressing their ideas. The navigation problems in the experiments were built using the programming language. Operational indications of the subjects were described and collected using it as well. Comparable records of both hard of hearing and hearing students' reactions were obtained and analyzed.

Keywords: tactics choice, programming language, map tracing.

1 Introduction

Hard of hearing students are said to have their difficulty of developing spoken and written languages' performance because of the disability of audio channel. Extracting the meaning of questions and expressing replies may depend on each respondent's language handling competence in the ordinary natural languages [2], [3], [5].

Programming languages have less expressional flexibility generally, compared to that of natural languages. However they have clearly defined syntactic rules and semantics in turn [1], [6]. The authors expect to be able to decrease the effects of competence difference if such programming languages can be utilized as a tool.

Hyperlogo is a mathematically enhanced member of the Logo language family [7], [8].

Outline of the study and experiment itself was reported previously [9]. On the way of analyzing subjects' response, the tracing tactics choice problem for map was found. In this article, this expanded problem is discussed that is the behavior of subjects when they had to modify their navigation actions on a route.

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It was planned to understand the subjects' general behavior when they happened to be in the situation where they had to solve the problem for continuing their navigation [4]. Two kinds of tactics were extracted from the preliminary experiments: adjustment and retrial. The adjustment tactics denotes that the succeeding steps make the difference smaller. The retrial tactics denotes that the inappropriate commands are canceled and the new commands that serve his purpose are issued. It was also the interesting item that which coordinate system was preferred to use for directions.

2 Overview of the Experiment

2.1 The System

Hyperlogo is the language system which the authors designed and implemented for their research work. It is based on the function programming paradigm. The three-dimensional (3D) graphics is equipped as the interface tool to the Hyperlogo. Usage and commands of the graphics follow the original Turtle Graphics invented by Seymour Papert.

The turtle in this system is made by a computational object programmed by the Hyperlogo language, i.e. the functional closure, that stores the location and posture information in it such as present place coordinates, heading direction, tilt angles of the body and drawing-pen status. The activity control of a turtle is performed by the message passing method to the objects.

The graphics of the system treats three-dimensional (3D) world. All figures are generated in the 3D virtual space. The traditional two-dimensional (2D) world is represented by the handling of view.

Figure-1 shows the schematic structure of the graphics system.

The implemented movement commands consist of two groups, commands based on the turtle's local coordinates such as "right-turn" and commands based on the global coordinates of the virtual world such as "head".

The erase command cancels the last action and returns to the former state.

2.2 Subjects

Two groups of the subject have provided their input data.

- Group-A: ten hard of hearing students
- Group-B: seven hearing students

They are university students of the same age bracket and have not much experience in handling computers.

2.3 Problems for the Experiment

Shows a bird-eye view of the simple model area, in which some streets, crossings, some shops, mountain and pond are located. Asks students to drive a turtle from the given

Table 1. Movement commands

<Local group>					
right <d>	left <d>	up <d>	down <d>	roll-cw <d>	roll-cc <d>
<Global group>					
move <p>	roll-reset	head <t>	north	south	east
west	northeast	northwest	southeast	southwest	
<Common group>					
forward <s>	backward <s>				
<Erase operation>					
rewind					

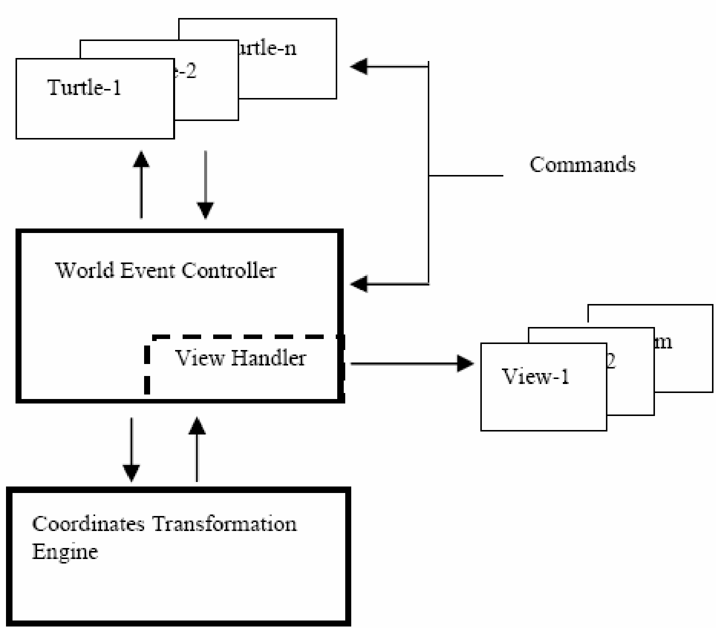

Fig. 1. Schematic structure of the graphics system

start point to destinations. The students' commands and their issue sequences including withdrawals are recorded entirely.

Figure-2 shows the model town map. It has the compass points, and a few landmark spots are located along the street. Every street intersects at right angles with each other except some crossings, so as to coincide with the compass directions. The mountain and the pond can be in sight at a certain places on the street. Different set of the target places are drawn at every problem.

Instruction

"This is a map of the Nowhere Town. You are asked to go on errands. Now you are at the start point on the map. Drive your car and drop by the places in order."

Four routes on the map are presented for the problems. Initial directions on the starting points are chosen to vary. Problems were prepared in sequence from Problem-1 to Problem-4.

Problem-1: Starting Point 1 → Hamburger Shop → Post Office → Movie Theater → Railway Station

Problem-2: Starting Point 2 → Market → Hamburger Shop → Post Office → Movie Theater → Railway Station

Problem-3: Starting Point 3 → Movie Theater → Bank → Post Office → Gas Station → Market → Dental Clinic

Problem-4: Starting Point 3 → Dental Clinic → Post Office → Laundry → Gas Station → Market → Hamburger Shop → Mountain

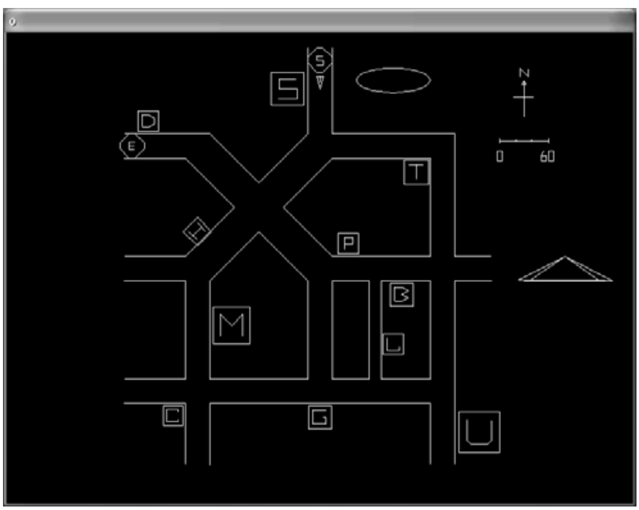

Fig. 2. An example of Town Map

3 Analysis of the Subjects' Response

The locations on the map were classified into two groups: corners and straights. Subjects' indications were grouped in accordance with the location. Grounds are that changing direction commands are mainly issued at a corner, and proceeding commands on a path.

Every input of subjects was recorded in sequence including inappropriate operations and retraction commands as well.

The use of commands based on the local coordinates and commands based on the global coordinates in the situation are also examined.

The map on the display stands vertically. Everyday sense of direction such as upward, downward and rightward may have some effect on the choice of tactics on the two dimensional plane. To estimate this bias, two relations were examined in the preliminary experiment: relation between the tactics choice and the specific locations on the map, and relation between the tactics choice and the approach directions at the corners. The characteristic trend could not be found from it.

3.1 Outline of the Subjects' Response

Table-2 is a partial example of input records. The whole elements were sorted out and arranged to the Table 3.

Table 2. A part of subjects' input records (corner)

		subject-1				subject-2			subject-3			subject-4				
		#1	#2	#3	#4	#1	#2	#3	#1	#2	#3	#1	#2	#3	#4	#5
map-1	corner-1	northeast				rt 50			southeast	northeast		rt 90	rt 45 fd 100 rt 90	rt 45 fd 100 rt 90 fd 100	fd 10 rt 55	fd 10 rt 55
	corner-2	rt 90				rt 60 rt 30			southeast			rt 45	rt 65	rt 75		
	corner-3	lt 45				north rt 60			east			lt 45 fd 10 rt 15 fd 100	lt 10			
	corner-4	north				north			north			north				
	corner-5	west				rt 120 rt 40 rt 50			west			west				
	corner-6	north				north	lt 30		southeast			north				
map-2	corner-1	east	west			west			west			west				
	corner-2	north				north			north			north				
	corner-3	northeast lt 20 rt 10 fd 80	rt 40 fd 70	rt 10 fd 80	lt 5	east			northeast			northeast				
	corner-4	rt 90				north rt 80 fd 20 north fd 5 rt 120 fd 10 east			southeast			east rt 35				
	corner-5	east				north			east			east				
	corner-6	north				west			north			north				
	corner-7	west				north			west			west				
	corner-8	north				west			north			north				
map-3	corner-1	east				east			east			east				
	corner-2	south				rt 90			south			south				
	corner-3	west				west			west			west				
	corner-4	south				south			south			south				
	corner-5	west				west			west			west				
	corner-6	north				north rt 30			north			north rt 5 rt 5				
	corner-7	rt 40 rt 10 lt 5				rt 40			northeast			rt 45				
	corner-8	lt 90				lt 80 lt 30			northwest			lt 90				
	corner-9	west				west			west			west				

Table 3. Subjects' input summary

Group-A

corner

	subject	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10
problem-1	# of corners	6	6	6	6	6	6	6	6	6	6
	adjustment	0	0	1	0	3	2	0	5	0	0
	retrial	0	0	0	0	1	0	1	7	0	1
	global c.	1	2	0	4	3	0	7	3	4	0
problem-2	# of corners	8	8	8	8	8	8	8	8	8	8
	adjustment	0	0	0	3	1	2	0	1	0	0
	retrial	0	0	0	4	0	0	0	0	0	0
	global c.	0	1	0	8	10	0	8	8	5	0
problem-3	# of corners	9	9	9	9	9	9	9	9	9	9
	adjustment	0	0	1	1	2	1	0	1	0	0
	retrial	2	0	0	0	0	2	0	0	0	4
	global c.	0	0	0	7	6	0	9	7	5	0
problem-4	# of corners	13	11	11	11	12	11	12	12	12	12
	adjustment	2	0	0	2	3	2	0	1	1	1
	retrial	1	1	0	2	0	0	0	0	0	1
	global c.	0	4	0	11	9	0	12	7	4	0

straight

	subject	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10
problem-1	# of straights	7	7	7	7	7	7	7	7	7	7
	adjustment	8	4	7	4	4	4	4	5	7	5
	retrial	6	2	1	1	1	1	1	3	1	3
	global c.	7	0	0	0	5	0	0	7	4	0
problem-2	# of straights	9	9	9	9	9	9	9	9	9	9
	adjustment	6	7	9	9	7	7	3	7	6	6
	retrial	5	2	0	4	1	4	5	7	3	2
	global c.	0	0	0	0	2	0	0	9	3	0
problem-3	# of straights	10	10	10	10	10	10	10	10	10	10
	adjustment	8	6	10	9	7	7	6	7	12	6
	retrial	6	4	0	2	1	2	0	4	5	1
	global c.	0	0	0	0	10	0	0	8	1	0
problem-4	# of straights	14	12	12	12	13	12	13	13	13	13
	adjustment	12	6	10	9	9	8	9	7	10	7
	retrial	3	3	0	4	0	1	4	2	1	1
	global c.	0	1	0	3	3	0	0	2	2	0

Group-B

corner

	subject	b1	b2	b3	b4	b5	b6	b7
problem-1	# of corners	6	6	6	6	6	6	6
	adjustment	0	0	2	0	0	1	0
	retrial	1	0	2	0	1	0	0
	global c.	7	4	0	1	7	6	6
problem-2	# of corners	8	8	8	8	8	8	8
	adjustment	0	0	0	0	0	0	0
	retrial	1	0	0	0	0	0	0
	global c.	9	5	2	1	8	6	8
problem-3	# of corners	9	9	9	9	9	9	9
	adjustment	2	0	0	0	0	0	0
	retrial	1	1	1	0	0	0	0
	global c.	12	2	2	1	9	6	9
problem-4	# of corners	13	13	12	13	11	12	12
	adjustment	1	1	0	1	2	1	0
	retrial	0	0	0	0	0	0	0
	global c.	14	8	8	1	13	10	12

straight

	subject	b1	b2	b3	b4	b5	b6	b7
problem-1	# of straights	7	7	7	7	7	7	7
	adjustment	5	8	6	5	6	6	7
	retrial	3	5	2	3	1	5	2
	global c.	3	2	0	0	0	0	2
problem-2	# of straights	9	9	9	9	9	9	9
	adjustment	6	7	9	10	10	7	8
	retrial	2	1	2	4	3	1	1
	global c.	2	0	1	0	2	0	1
problem-3	# of straights	10	10	10	10	10	10	10
	adjustment	10	9	10	9	8	6	9
	retrial	5	4	0	2	3	1	0
	global c.	8	0	0	0	2	1	0
problem-4	# of straights	14	14	13	14	12	13	13
	adjustment	12	5	12	7	9	8	8
	retrial	3	4	2	2	2	4	1
	global c.	3	0	2	0	0	1	1

Average behaviors of the subjects are listed in Table-4.

Table 4. Medians of the subjects' behavior

Group-A

		problem-1	problem-2	problem-3	problem-4
corner	adjustment	0	0	0.5	1
	retrial	0	0	0	0
	global c.	2.5	3	2.5	4
straight	adjustment	4.5	7	7	9
	retrial	1	3.5	2	1.5
	global c.	0	0	0	0.5

Group-B

		problem-1	problem-2	problem-3	problem-4
corner	adjustment	0	0	0	1
	retrial	0	0	0	0
	global c.	6	6	6	10
straight	adjustment	6	8	9	8
	retrial	3	2	2	2
	global c.	0	1	0	1

Table-5 is the occurrence rates of the tactics at the places normalized by the number of places.

Table 5. Occurrence rates

Group-A

corner	adjustment	0.11	(c.f. 0.47)
	retrial	0.09	
straight	adjustment	0.74	(c.f. 0.05)
	retrial	1.82	

Group-B

corner	adjustment	0.04	(c.f. 0.77)
	retrial	0.04	
straight	adjustment	0.83	(c.f. -0.66)
	retrial	0.26	

And the rate of using global coordinates command is shown in Table-6.

3.2 The Comparison of Revision Tactics

When subjects are driving a car along the road on the given map, some command may cause an inappropriate action on the occasion. He/she withdraws an issued command and orders new action. The authors are interested in their revision tactics at that time.

Table 6. The rate of using Global coordinates command

Group-A

corner	0.42
straight	0.19

Group-B

corner	0.72
straight	0.12

For the whole navigation operation, it can be said that the choice of tactics depends on each subject. However at the straight in particular, the difference among subjects is significant ($X^2(16) = 39.7$, $p= 0.0009$).

It is also examined whether there is some difference between the choices on the groups.

Changes in a group. The occurrence comparison was examined between the merged result of Problem-1 and -2, and that of Problem-3 and -4 first. Then the results of Problem-1 and Problem-4 were compared.

The use of retrial tactics at the straights decreased significantly for both groups (Wilcoxon signed rank test, Group-A: T=5, N=10, $p<0.05$, Group-B: T=1, N=7, $p<0.05$). Group-B's also decreased in the test between Problem-1 and 4 (Wilcoxon signed rank test, T=1, N=7, $p<0.05$).

The significant changes on both groups were not found for the use of adjustment tactics.

The comparison between groups. The adjustment tactics was used more at the straight by Group-B in Problem-1, the initial problem (median test, p=0.026). The difference was not significant at the other places and problems for both groups.

For the retrial tactics, the difference was not significant.

3.3 The Use of Global Coordinates Commands

As a whole, the rates of use show the difference of tendency. There may be some difference between two groups on abstraction degree for handling the concept of direction on the map.

Changes in a group. The occurrence comparison was examined between the merged result of Problem-1 and -2, and that of Problem-3 and -4 first. Then the results of Problem-1 and problem-4 were compared.

For Group-A, the difference at the corners was significant between the merged results (Wilcoxon signed rank test, T=2, N=7, $p<0.05$). The occurrence in Problem-3 and -4 decreased. No significant difference was found for Group-B. However it can be supposed that the frequency of use increases slightly as the experiment proceeds for Group-B.

Comparison between the groups. Comparison was made for every problem. The significant difference can be seen at the corner's data in the Problem-4, the last problem (median test, p=0.024). Group-B is using the global coordinates commands more than Group-A.

4 Discussion of the Result

Each subject has his/her own tendency to choose tactics according to the property of locations in an ordinary sense. From the limited analysis up to the present, locations as a group has seemed to have some effect to the tactics choice. However no significant difference by each location has been found yet.

By the residual analysis, it is likely that Group-A seems to prefer the adjustment tactics and Group-B the retrial tactics generally.

As the experiment went forward, use of the retrial tactics decreased by Group-B. The tendency of Group-A's was almost the same but the rate was a little low.

It is considered that using the local coordinates is a concrete indication and using the global coordinates is an abstract one. Group-B uses the global coordinates commands more than Group-A, particularly at the corners. Group-A may prefer the indication based on the realization of everyday situations.

Change of tactics along the time coordinate is the interesting problem. The analysis is on the way now at the succeeding steps. It is expected that a tactics change can be observed which is brought about by the learning effect.

Further studies must be required for drawing the conclusion whether the cognitive difference exists between them. Collaborations with the other method such as the video review session will bring us the fruitful results.

5 Conclusion

Objective of the study was to make clear the possibility of using programming languages for interface tools. Hyperlogo was used for the presentation of problems and collection of subjects' response. For both groups, the interface functioned properly for the purpose without prominent differences of carrying out the experiments. It has brought to decrease the expressional ambiguity. The authors could compare and analyze the result impartially.

It has become clear that using the mathematical programming language is suitable for this kind of experiments for both hard of hearing and hearing students.

It may be difficult to extract the inside mental process if the appearance of subject's reaction by the observation is the only key. However, a little further clue may be obtained if such a programming language is used as a tool.

The number of subject for this research is regrettably so small at present. Attribute requirements for them such as programming experiences may have been a little strict. The authors would like to study further and show the feasibility of this approach.

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