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Investigating the cognitive strategies of spatial thought

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Abstract

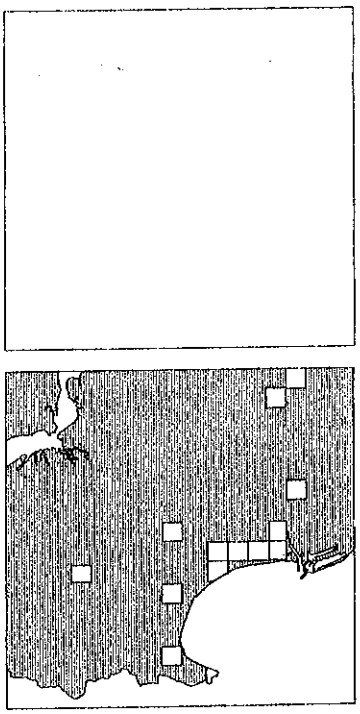
This paper investigates the different ways in which people think about geographical tasks. Individuals were interviewed whilst they tried to complete two of four different tests to try and discover the strategies of thought they were using. This was followed by a debriefing interview where respondents could express their feelings and judgments concerning the tests. Many strategies of thought were found to exist. These can be divided into common thoughts, concerning geographical knowledge, or task-specific thoughts, constrained by the nature of the task. This paper explores the common strategies of geographic, or spatial, thought.

Introduction

Cognitive mapping researchers study how individuals acquire, store, recall and decode geographic information (Downs and Stea, 1973). Foley and Cohen (1984) argue that cognitive mapping abilities differ between individuals because of qualitatively different encodings and representations. Individuals thus use different types of strategies to encode and decode their knowledge and as a result, differ in their answers to cognitive mapping tasks. They suggest that different strategies of thought or decoding will lead to radically different results, even when the knowledge base is identical. Miller (1987) similarly argues that individuals differ in their cognitive styles of thought. There has not, however, been an attempt to discover the strategies of thought used in performing geographically based tasks, and if different strategies of thought lead to different results. This paper reports some of the results from an investigation of *spatial thought*, a term first used by Liben (1981) to describe strategies used to complete cognitive mapping tasks. This term is used throughout the text.

The investigation was by means of semi-talk aloud protocol interviews conducted whilst respondents completed two of four tests. This was followed by a semi-structured debriefing interview which aimed to validate the protocol analysis, and to allow further discovery concerning the nature of the tests. The interviewer also gained evidence by watching reactions and gauging the extent of opinion. Forty first year geography undergraduate respondents, recruited from practical classes were interviewed, all resident in Swansea for approximately one term (9 to 10 weeks). These were divided into two groups of ten females and ten males, who each did two tests. The first group completed a sketch map test and a cloze procedure test (Figure 1). The second group completed a projective convergence test and an orientation specification test (Figure 2). All respondents completed the tests whilst facing north in a room where only the front of the building opposite was visible through the window. The interviews were taped and analyzed first through direct transcription and then using a series of structural frames which acted as a set of filters. Some have argued that verbal reporting of cognitive processing needs to be treated with care, suggesting that while individuals have direct access to their knowledge such control does not exist for their mental processes (Nisbett and Wilson, 1977). Ericsson and Simon (1980: 247) have, however, argued on the basis of an extensive literature review, that verbal reports are 'a valuable and thoroughly reliable source of information about cognitive processes, when elicited with care and interpreted within the context they were collected'.

Figure 1. Information provided for respondents of sketch map test and cloze procedure test

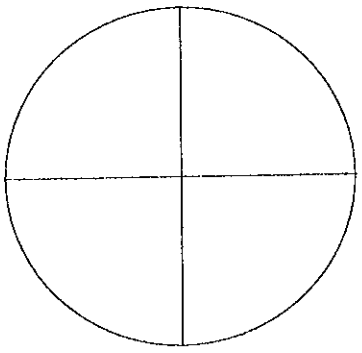


Sketch map test 2: Draw a map of Swansea inside the box. Include any places or landmarks that you think you know the location of.

Cloze procedure test 2 (cz2): Write in the blank boxes the number of the place or landmark from the fifteen listed below, that has been removed (a list was provided to each respondent).

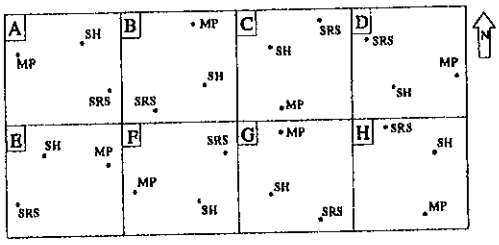
Figure 2. Information provided for respondents of projective convergence test and orientation specific test

1. Singleton Hospital to Swansea Railway Station.



Projective convergence test: The centre of the compass represents the first place. Mark with a line the direction to the second place. The length of the line will represent the distance from the first to the second place where the compass radius is equal to the striaght line distance between Mumbles Pier and Morriston Hospital, which is 8.1 miles.

1.



Square _____ is the correct orientation.

Orientation specification test: Complete the booklet detailing which box contains the correctly orientated configuration.

MP Mumbles pier
SH Singleton hospital
SRS Swansea rail station

Investigating the strategies of spatial thought

The knowledge of each individual was processed using a series of structural frames shown in Table 1. The results are displayed in Tables 3 and 4. The strategy structural frames and codes used in Tables 3 and 4 are provided in Table 2. It is clear from this analysis that there are two different strategies involved in cognitive mapping tasks. First, there are main or common strategies of spatial thought. Second, there are task-specific strategies which relate to completing the specific demands of the task required. These can be further divided into common task-specific strategies which are applicable across different tests and unique task-specific strategies which are only present for a particular test. This paper only discusses the common strategies of spatial thought. It must be noted that strategies indicated in the Tables are only those articulated by the respondents and that some respondents might have been using strategies which have not been recorded. This is almost certainly the case and it was noted during the interviews that some participants were clearly using other strategies which they were then failing to articulate to the interviewer. As a result, the findings presented in this paper only represent the information as transcribed. Nonetheless the findings are of worth as they allow an insight into the strategies used in spatial thought and their effectiveness.

Common strategies of spatial thought refer to ways of thinking which could be applied to most cognitive mapping tests, and are not constrained by the specific task demands of a particular test. Eight such strategies of thought were encountered in conducting the interviews which varied greatly in their popularity (Table 1). Throughout the text INT refers to the interviewer.

One of the most popular strategies employed by individuals to attempt the tasks was to use map imagery. This typically took one of two forms. First, some respondents tried to remember a map that they had seen, typically an Ordnance Survey map, in its entirety. It seems that they had stored this map as a complete image or as component images which they then reconstructed to perform the task. For example, respondent M20 claimed:

M20: I've caught glimpses of OS maps and the AZ of Swansea and I'm trying to think about that ... I visually perceive a picture of that map in my mind.

Secondly, some tried to construct maps which contained a minimal structure or only contained features necessary to complete the task. It was implied and sometimes explicitly stated that these maps were constructed for the purpose of the task. Respondent M11 constructed a typical minimal map which was essentially featureless, containing only those places necessary to complete the sketch map test:

M11: ... just a featureless map with the university and next point ... Well, more like a base map. There's no definition of places or residential areas, it's just a coastline, the university, quadrant and the river going up.

Respondent F18 would swap between her constructed minimal map and remembering an Ordnance Survey (OS) based map on questions that she found more difficult to answer, but in some cases the constructed map would be a combination of remembered and constructed map, intertwining elements from both. Respondent M8 could remember the road network from his road atlas and into this he would add locations that he had visited:

M8: I just remember things as they come to me. I've got a basic map in my mind and I'm just trying to put that down.
INT: When you say 'map in your mind' what do you mean?
M8: Like an Ordnance Survey map. Like a road map that I use when I drive ... and I just picture that in my mind and put down things ... and also I add to that places I've been to ... like Sainsburys and the Leisure Centre. I add them to the road network.

There were, however, some problems encountered by respondents attempting to use a mapping strategy. For example, respondent F11 found that she could not successfully 'build' the map because of incomplete knowledge:

F11: It is quite difficult trying to work out which is the furthest east of Hendre and Clyne as I can't really picture the two together on a map. I know where Clyne is and where Hendre is, but not in

Table 1. The strategy structural frames and codes for Tables 3 and 4

Code	Strategy	Description
	Common strategies	
C1		Imagining or constructing various types of maps.
C2		Referring to the coastline.
C3		Imagining the route or travelling between two locations.
C4		Using travel time to work out the separation between locations.
C5		Imagining standing at a location and 'looking' in the direction of another location.
C6		Imagining looking down vertically or obliquely.
C7		Working out where places are in relation to the current location.
C8		Just know - propositional coding.
	Common task-specific strategies	
CTS1		Elimination.
CTS2		Logical deduction.
CTS3		Draw a map.
CTS4		Where the sun sets.
CTS5		Look back at former answers.
	Task-specific strategies	
TS1	Cloze procedure	Look at square, decide what is located there and check to see if on list.
TS2		Look at list to see if recognise any, then go to the map to see if a square is free where you think it is.
TS3		Swap strategy.
TS4	Projective convergence	Work out the direction between two locations by working out the direction from each place to a third place. e.g. for A to B work out direction from A to C, and then C to B.
TS5		Imagine flying as a crow would between two locations.
TS6		Instead of working out the route from A to B, work out B to A.
TS7		Draw a route map across the projective convergence circle.
TS8		Imagining a map directly in front of yourself and lining a pencil up between the two locations and moving the pencil down across the circle.
TS9	Orientation specification	Work out how it should look like then scan all the squares for one that fits.
TS10		Work out how it should look like then work systematically through the squares until one fits, choose that and ignore the rest of the squares.
TS11		Draw the coastline onto the configurations.

Table 2. The strategy structural frames and codes for Tables 3 and 4

Code	Description
s	Sketch map
c	Cloze procedure
p	Projective convergence
o	Orientation specification
x	Category response best fits into
$	Only swapped strategy when completely stuck

Table 3. Structural frame analysis for group 1: Sketch map and cloze procedure

Respondent	C1	C2	C3	C4	C5	C6	C7	C8	CTS1	CTS2	TS1	TS2	TS3
F1	sc	c	sc							c	x		x
F2	sc		s									x	x
F3	s		s					sc	c	c	x		x
F4	s		s					c		c		x	
F5	s		s		sc			c				x	x
F6			sc							c		x	
F7								sc				x	x
F8	s	s	sc	s	sc			c		c		x	x
F9	c		sc			c						x	x
F10	sc		sc		sc			sc				x	
M1			sc									x	x
M2								sc				x	x
M3			s							c		x	
M4	c		sc	c				sc		c		x	x
M5	sc		s		sc			c		c		x	$
M6			sc	s	c							x	$
M7			sc		s					c		x	$
M8	sc											x	$
M9	sc		c					s			x		$
M10	c		s								x		x

Table 4. Structural frame analysis for group 2: Projective convergence and orientation specification

Respondent	C1	C2	C3	C4	C5	C6	C7	C8	CTS1	CTS2	CTS3	CTS4	CTS5	TS4	TS5	TS6	TS7	TS8	TS9	TS10	TS11
F11	po	p	p					o	o	o				x							
F12	po	p	p			po	p								x				x		
F13	p	o	p											x					x		
F14	po	o																	x		
F15	po					p		o	o	o									x		
F16	po								o	o											
F17	po	o	p		p	po			o							x					
F18	po	o	p		p			p	o	o									x		
F19			po		o					o	o						x				
F20	po	o	p	p					o									x			x
M11	po	o				o			o												
M12	p	o	p		p						p									x	
M13	p	o	p											x							
M14	po		p					o	o	po				x							
M15	o		p		p									x							
M16	po	p		p				po						x					x		
M17							po														
M18	po	p	p						o	o	o										
M19	p	o			o	o			o												
M20	po	po	p	p	p				o			po	po								x

relation to each other.

Respondent F20 was conscious that her own constructed map was not in fact aligned along a north-south axis and as a result she was having to rotate her answers to fit the options provided in the orientation exercise. She was aware that she was rotating the coast to an east-west alignment:

F20: ... because on the map it's directly ... you know ... it's almost directly straight to the west but the edge of the map isn't parallel to east/west so I'm trying to orientate my map to get the line right ... north's that way so it's more north-westerly.
INT: So you're having to rotate everything back?
F20: Yes, but I haven't because I can't work it out.

Throughout the interviews it became clear that the coastline is the dominant anchor for residents in Swansea. This anchor is so dominant in fact that some respondents when explaining how they had completed tasks suggested that they had worked out locations solely in relation to the coastline. Their base maps were so minimal that the coastline was the only feature it contained and the responses were plotted in relation to it before being transposed onto the spatial product (the externalised form of the knowledge of an individual). Respondent M18 explains:

M18: Basically, all I am thinking about is the coast and then the locations in relation to the coast to get my directions and the angle and how far it is.

This strategy was used to some extent across all the tests, but the salience of the coastline can be best seen on the orientation test. Two respondents completed this task by drawing the coastline onto the configurations to see which was correct. Both used this cue to check the answer. Others mentally drew such a line over the configurations as expressed by respondent M13:

M13: I was thinking of the line of the bay. That's the nearest ... but it seems a bit ... if you had a curve going round ... that seems too far but it is the closest I could get.

Another of the most popular strategies of spatial thought is imagining travelling along a route. Typically respondents expressed the notion of imagining a journey between the two places. This expression took two different forms. Most respondents declared a route strategy best described as a 're-playing' of a route travelled. For example respondent F9 explains:

F9: I'm thinking in terms of when I walk down the street and what I notice ... and I'm trying to think of what I saw going down there in terms of colours ... I suppose I'm running the route as I would at a one hundred miles an hour, speeding down it picking out the information.

Instead of imagining a journey between two locations some respondents constructed a minimal map which only contained the route between two places. In the main these types of route maps were created not by remembering a map, but by constructing them, converting route knowledge into configurational knowledge. Respondents would imagine travelling along a route and then simultaneously transpose this knowledge onto a 'mental' base map of the area which would then be used to answer the question. One respondent, F1, explained that she used the two methods of travelling a route and using a map strategy to validate the results from one with another to provide a composite answer.

F1: Well, actually when you think about travelling it on a bus you do sort of go up to it ... basically along a road. The road's there ... but I don't think this in relation to my actual map. It's not as far down there as it looks ... I don't think so in any case. In my mind I am trying to trace the roads, and going along those roads and looking around ... to see what's happening.

Like the map strategy some respondents experienced difficulty using the route strategy. Respondent F1 used this combination strategy because she did not possess enough map knowledge for a particular question. Equally she found the route strategy alone too taxing.

F1: I was trying to imagine as if I was going down along a road but that wasn't too good because I was still thinking 'is it before or after the leisure centre or Guildhall?' because when you come in on a bus you don't actually go along that road and I haven't got a car, so I don't see that.

The route travelling strategy proved to be a popular choice because it corresponds to the real-world interaction that the respondents perform. It was not reliant on memorizing details from a map or an abstract concept of thought but on information actually experienced first hand.

A few respondents used their knowledge of travel times to work out the separation or distance between places. This was exclusively based upon first-hand walking or cycling experience, where the amount of time taken to traverse between the two places was mentally converted into distances using an individual conversion standard. For example, one might convert an half hour walk into two miles, someone else into a mile and a half. Respondent F20 provides an example:

F20: I'm also thinking of how fast it would take to walk there. Mumbles Pier is about 35 minutes from Clyne so it must be an hour from here.

Approximately a third of all respondents used the strategy of imagining being at a location and 'looking' in the direction of another location, at some point during one of the tests. Typically the respondent would describe standing at a location within Swansea, mostly Mumbles Pier, and looking across the space in front of them to judge either distances, directions, or where two places were in relation to each other. The strategy is fairly limited in that it needs an area which allows viewing of such panoramas, but proved to be an effective strategy for judging the spatial relationships of places located along the coastline. Respondent M7 details its use by describing why he had located the university in a certain position along the bay:

M7: Because it is sort of opposite on the other side of the bay. If you stood on Mumbles Pier it is right over the other side ... and that's my conception of where it is really and it's part way between the town centre and Mumbles Pier but closer to town.

Some respondents constructed answers using abstract strategies that were based upon an amalgamation of real-life route knowledge, and that gleamed from a map, so that they tried to solve the task using a strategy never experienced. One of the ways they attempted this was imagining looking down onto Swansea as if they had a bird's-eye view from either vertically above or at an oblique angle. Respondent F9 provided a good example of an oblique view:

F9: I kind of get a plan view going that way ... so I get a kind of perspective view ... the Guildhall is there and the road kind of widens and you can just sort of ... you're kind of looking down at it I suppose in your memory.
INT: So you're looking down at it, but not from directly above?
F9: Yes, as in imagination.

One respondent worked out the positions of other locations solely in relation to where he was currently located. So for example, a respondent might work out where Mumbles Pier is by thinking 'if I am here then it must be over there'. Although only one respondent used this strategy it is one that could be potentially used on all of the tests. Respondent M17 was unusual in that he only used this strategy on both the tests he performed. He explained he used a chaining process and imagined being at each place:

M17: Mainly it is in relation to the university. It's central and where I go the most and I sort of work outwards ... and when I get to another place I map out from there. Does that make sense? ... I think I know they're over that way in relation to where we are at the moment.
INT: So everything's in relation to where we are at the moment?
M17: Yes ... that's right.

As a consequence of this egocentric knowledge respondent M17 had to orientate the test to the way he thought north was. This was at 90 degrees to its true direction and so he had to rotate the test 90 degrees to the right to be able to attempt the tasks. Even when rotated he had so much difficulty with the orientation specification test that it was eventually abandoned. Although M17 had problems using this strategy it has the potential to be a successful strategy if a bearing is known before the test starts. If the test is done when the respondent is disorientated then it will inevitably lead to results that do not reflect the true knowledge of the respondent.

A certain number of the respondents claimed to 'just know' the answer to a task. They did not need

to employ any strategy of thought because they automatically knew where certain places were in relation to each other. Many implied some type of propositional coding, where by information was coded in the form 'along the sea front then in a bit' with respondents knowing the directions and distances instinctively. Propositional statements such as 'near to' or 'left of' were common with no references made to any imagery. For example, respondent F3 was typical, with the use of 'I know' followed by reasoning:

F3: I know it's in the city and I know it's further north, back into the land rather than towards the sea.

It is difficult to validate this strategy in that the respondents could in fact be describing the answer resulting from another strategy. For example, a respondent may know that the hospital is next to the university because they had just consulted a map image strategy. However, the definite impression given by respondents was one of 'just knowing', and some when asked whether they did just know or whether they had used another strategy such as thinking of a map most replied that they 'just knew'. Propositional coding seems a plausible way of encoding configurational knowledge, as long as the spatial relationships are encoded, and other researchers such as Foos (1980) have found that propositional data can be encoded and processed into cognitive map knowledge.

Conclusions

It is noted that the results from this study are tenuous, because they cannot easily be validated, as there are alternative possibilities for outcomes. For example, the relationship between the amount or form of knowledge and the strategies of thought is not clear. It maybe the case that using different strategies of thought upon the same knowledge base will not cause any differences, but that different strategies are associated with different amounts or form of knowledge; so that differences occur because of knowledge not strategy. Also, respondents could have been using strategies which they did not report or could not fully articulate. It is also possible that the interviewing altered strategies of thought or implemented the uptake of strategies not commonly used.

The results do however, allow an introspective insight into the way in which we think about geographically based tasks. It is clear, that there is a range of common and task-specific strategies which can be used to process cognitive map knowledge whilst performing geographic or spatial tasks, and that cognitive map knowledge is held in a variety of mediums. This knowledge may be manipulated, transposed and constructed to aid the process of spatial thought. There is clearly room for more research concerning the form and structure of cognitive map knowledge and its relationship to the task demands of spatial and geographic exercises.

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