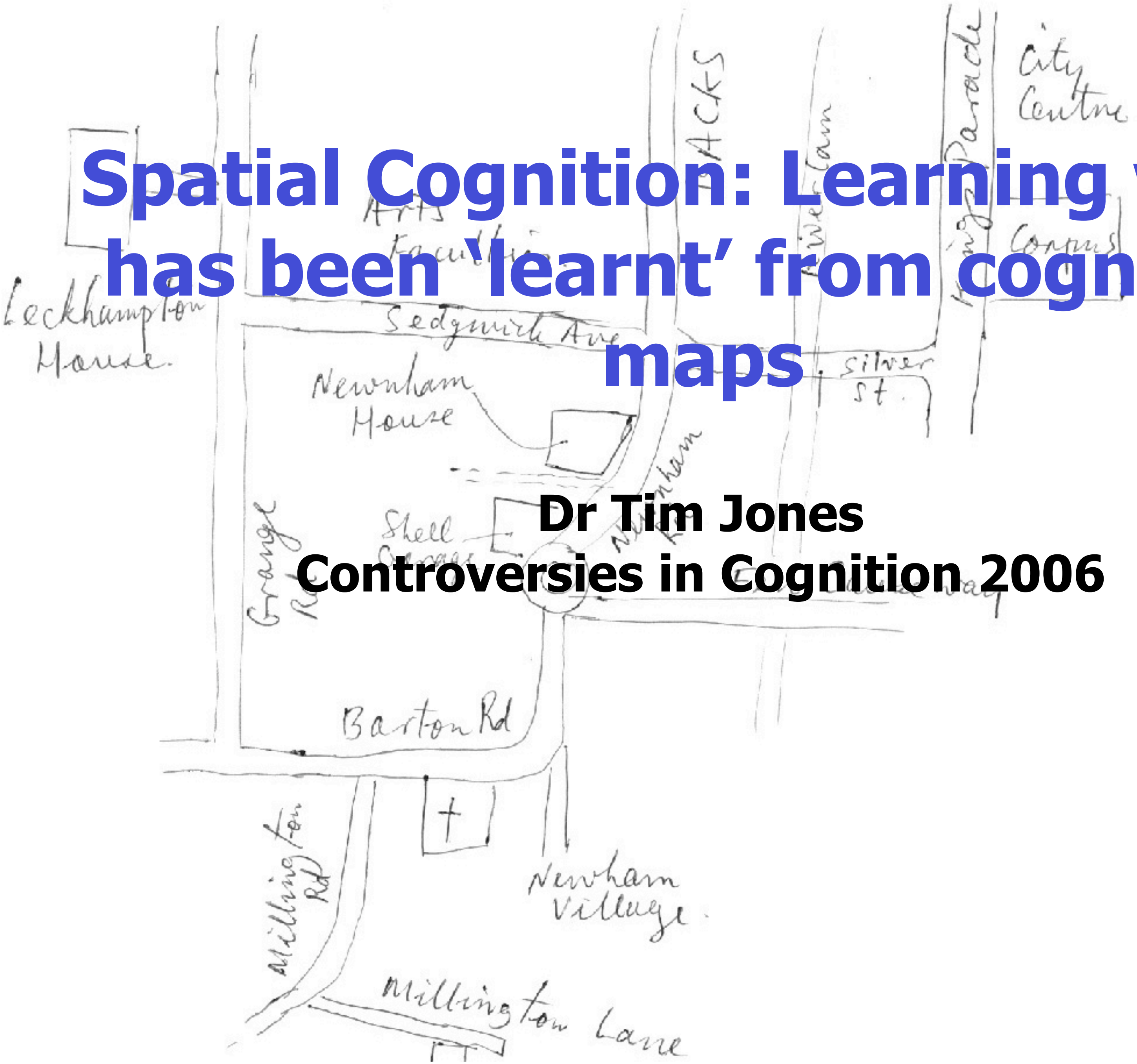
Spatial Cognition: Learning what has been ‘learnt’ from cognitive maps



Dr Tim Jones

Controversies in Cognition 2006

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Lecture 2: Overview

- Controversies in Cognitive Map Research
- Cognitive Map Overview
- Map Formation
- Map Representation
- Maps in the Absence of Vision
- Measuring Cognitive Maps (Methodology)
- Mental Structure of Cognitive Maps
- What has been ‘learnt’ from Cognitive Map Research - Synthesis
- Future Direction

‘Mobilities’

The concept of 'mobilities' encompasses both the large-scale movements of people, objects, capital, and information across the world, as well as the **more local processes of daily transportation, movement through public space, and the travel of material things within everyday life**. Recent developments in transportation and communications infrastructures, along with new social and cultural practices of mobility, have elicited a number of new research initiatives for understanding the connections between these diverse mobilities.

(Centre for Mobilities Research - http://www.lancs.ac.uk/fss/sociology/cemore/)

Cognitive Maps = Theoretical Controversies

- Gibson (1966,1979) - information required for perception is obtained from the retina and is more passive Vs. Marr (1982) computational approach in which perceptual information is made explicit.

- Methodological controversies - how are cognitive maps structured, measured and used?

- Route Vs. Survey Knowledge (Piaget & Inhelder, 1967 Vs. Siegel & White, 1975)

- Imagined self movement Vs. Imagined object movement (Wraga, Creem & Proffitt, 2000).

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The Cognitive Map

Gibsonian ?

"An observer experiencing a novel environment will begin to construct a cognitive representation of that environment"

(Lynch, 1960; Aragones & Arredondo 1985)

"Cognitive mapping is a process by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in their (everyday) spatial environment"

(Downs & Stea, 1973)

Marr ?

Experience is context dependent and is multi-sensory including emotional response…

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Cognitive Map Representation

Acquisition → Coding → Storage → Recall

Decoding

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Storage & Recall = Memory

- Analog Representation - Mental analogy map of the real world based on imagery or pictures (Cornoldi & McDaniel, 1991; Glicksohn, 1994)

- Propositional Storage - Meaning-based storage where environment is represented as concepts and ideas linked by associations (e.g. colour, name, height). Associations are searched to form an image (Pylyshyn, 1981)

- In practice, cognitive maps are *probably* a combination (Searleman & Herrmann, 1994)

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Cognitive Map Features

- Lynch (1960) - Categorisation features of cognitive maps:
  - Paths (shared travel corridors e.g. streetscape)
  - Edges (linear and enclosing but not functioning)
  - Districts (large spaces with common features)
  - Nodes (major points where behaviour is focussed)
  - Landmarks (distinctive features used for reference)

- Appleyard (1970) draws the distinction between sequential maps and survey knowledge based maps or spatial maps.

- Movement between states is dependent on changes in detail knowledge - therefore more interaction leads to more detailed route and spatial knowledge.

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Sequential Vs. Spatial Maps

Location Knowledge

Location Duration

Location Context

Emotional Context

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Cognitive Maps Without Vision

- Direct theory of perception states that optic flow information (including depth, texture and gradient cues) is passively used in perception of the visual array (Gibson, 1979).

- Cognitive map development requires *movement* through and *experience* with the environment. The more times these happen = the better the cognitive map (Jacobson et al. 2001).

- Can the visually impaired construct cognitive maps?

- The visually impaired (depending on extent of impairment) have little residual vision, therefore visual cues are exceptionally limited - which senses are utilised?

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Visual Impairment Overview

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Cognitive Maps Without Vision II

- Passini & Proulx (1988) - Visually impaired poorer than sighted at learning new places - lack of learning hinders cognitive map acquisition.

- After several encounters with a novel environment the visually impaired are able to construct scale models of landmarks and accurately estimate distances between them (Ochaita & Huertas, 1993).

? - No Sighted Control Group

-**Individual Performance NOT reported!**

- **Only One Urban Area (Madrid)**

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Cognitive Maps Without Vision III

- Many studies criticised due to:
  - Familiar environment choice (fear of falling/ethics)
  - Unfamiliar environments are often small and laboratory based, therefore lack of ecological validity
    - Auditory Cues
    - Wind Direction
    - Auditory Cues
    - Gradient Changes
    - Tactile Sources
  - Methodology (Echolocation)

- Visually impaired poorer at making mental transformations (spatial inferences about objects and routes not previously taken) than the sighted (Rieser, Lockman & Pick, 1980)

- How are cognitive maps measured?

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Sketch Maps

- Hand drawn sketch maps as a measure of environment knowledge (Appleyard, 1970; Devlin, 1976; Thorndyke & Hayes-Roth, 1982).
- Quick and relatively 'easy' cognitive map measure
- Failed to provide consistent results about the structure or development of spatial knowledge due to:
  - Differences in structure and complexity of study areas
  - Classification of sketch map accuracy (Ishikawa & Montello, 2006)
  - Lack of control over participants prior knowledge
  - Variation in drawing ability (Blaut & Stea, 1974)
  - Cartography experience (Beck & Wood, 1976)
- Inconsistent perception perspective - 'birds-eye' view.
- Cognitive maps are context dependent - analysing context and therefore accuracy is difficult

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Preference Mapping

- Landmarks are ranked rather than sketched in order of place preference or place attractiveness (Gould & White, 1982)
- Provide preference of over greater distances than (sometimes) limited cognitive maps.
- Regions of a map can be shaded as preferred or not preferred depending on the features in the environment.
- High level of individual difference - constitution of place remains debatable across and within disciplines (Allen, 2004a, Allen 2004b)
- Recall can be inaccurate and preference hierarchy can ‘shift’ with further experience.
- Useful technique for the visual impaired or physically disabled?

Recognition Tasks

- Rather than relying on memory, individuals are asked to recognise landmark images (Lynch, 1960; Milgram & Jodelet, 1976)
- Removes cognitive load on the individual.
- Can provide added information to sketch maps but does not tell us about landmark orientation or geographical distances between spatial elements. Difficult to determine 'where it fits' on an individuals cognitive map.
- Landmark identification is only one component of a cognitive map.
- Could measure landmark identification reaction time to make method more empirical

Can you recall a landmark from Rio?

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Recognition Tasks

- Recognition reaction time is likely to be significantly faster than recall reaction time.
- Recall however is a key component of a cognitive map e.g. Downs & Stea (1973)

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Distance Estimation I

- Measurement of the distances between locations in large scale environments - demonstrate a knowledge of spatial awareness and orientation.
- Kosslyn (1983) - Supports analog model as routes are 'scanned' in memory to provide information about distance. The more **similar** distances are between pairs of landmarks/spatial objects, the longer the reaction time to make a decision (Evans & Pezdek, 1980)


15 Miles = Slow Reaction Time

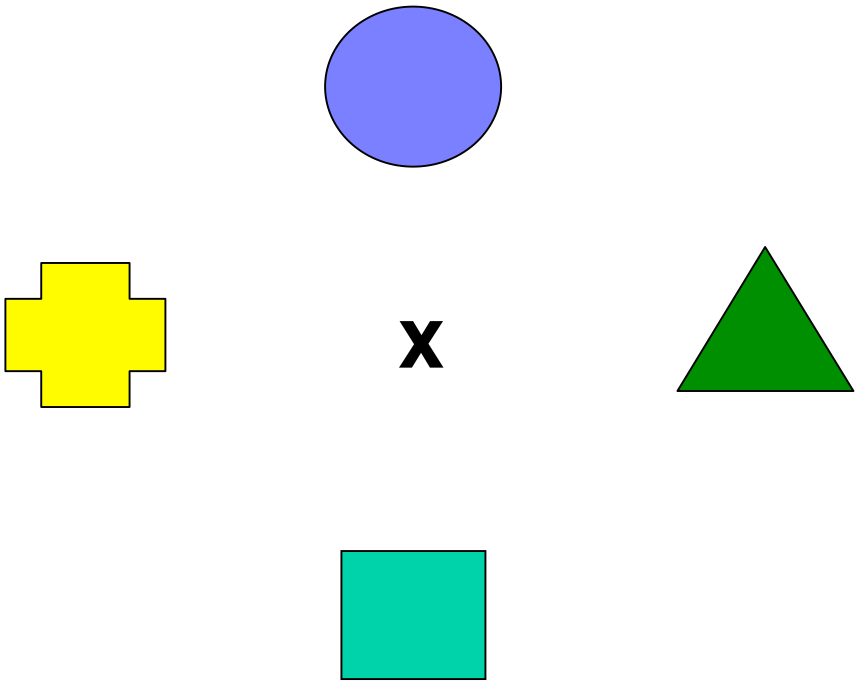

100 Miles = Fast Reaction Time

Distance Estimation II

- Memory scanning must surely involve more than scanning for routes?
- Familiar named paths (George St.) are judged as longer than unfamiliar paths (Abigail Place) as individuals have more *experience* of the familiar named path (Sadalla & Staplin, 1980a)
- Propositional storage? Experience and previous association are used when estimating distances.
- Distance from point A to point B is not necessarily judged as the same as point B to point A (Foley & Cohen, 1984).
- Tendency to overestimate (close) distances (Jones, 2004) - survival!?

Imagined Movement I

- Individuals observe an array of objects from one particular viewpoint and imagine themselves as either rotating around the objects or as the objects rotating around them (Creem, Wraga & Proffitt, 2001)



Green Triangle

Yellow Cross

Imagined Movement II

- Reaction time and error advantage when imagining self-rotation versus object-rotation for both single and multiple object movement, and clockwise/anti-clockwise movement (Amorim & Stucchi, 1997; Wraga, Creem & Proffitt, 2000)
- The advantage also holds for real self movement versus real object movement (Simons & Wang, 1998)
- Is this intuitive though? As we constantly move through our environment we change direction and orientation - landmarks remain static!
- What does this tell us about cognitive maps?

- Advantage also holds for physically impossible imagined self-rotations (e.g. looking upside down floating) **but** geometry is more important than gravity (Creem, Wraga & Proffitt, 2001)
- Cognitive map components (landmarks, routes and nodes) must be organised with geometric sense

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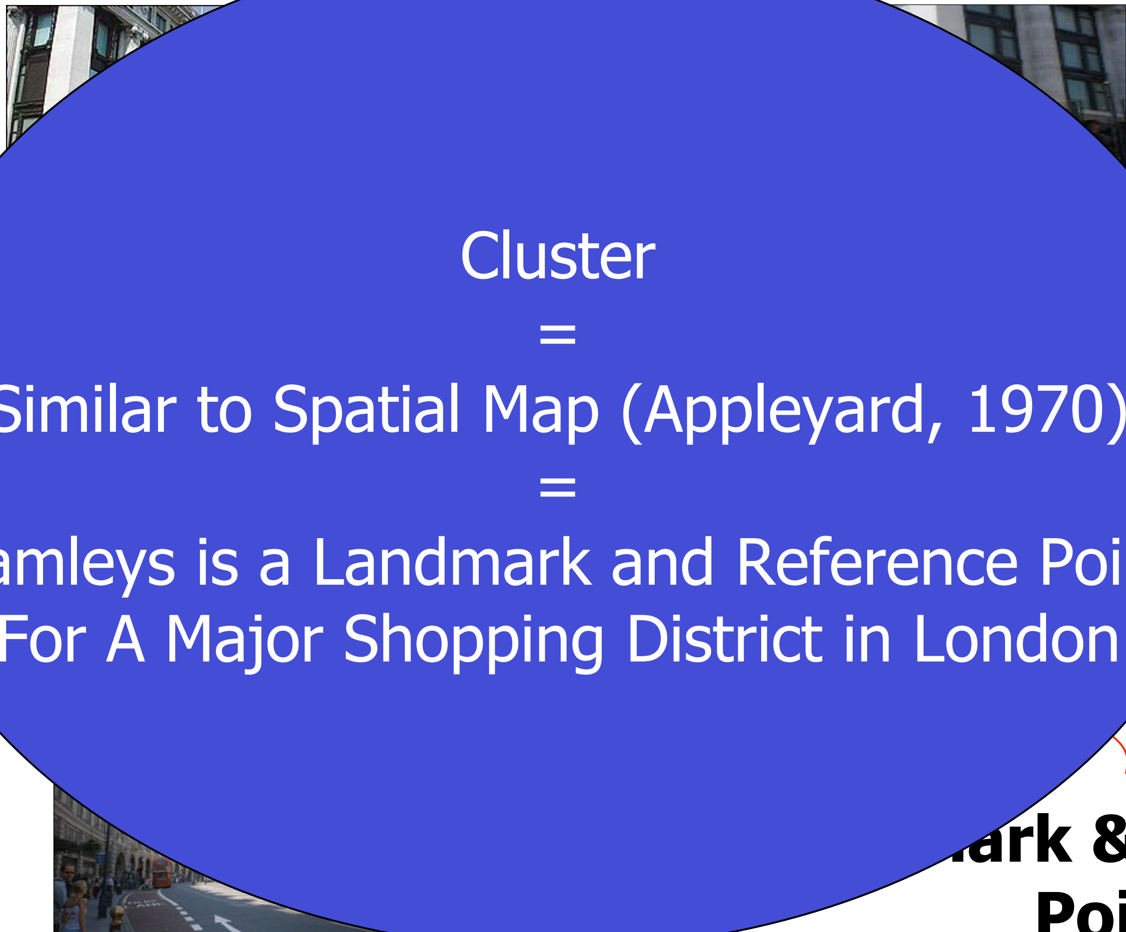
Mental Structure

- Distance and imagined movement work hints towards some defining (mental) structure of cognitive maps.
- Perceptual and attentional demands of the environment could lead to cognitive overload.
- Scanning memory is a timely process and could not be tolerated in the real world - spatial memory must be organised?
- Spatial information could be ‘chunked’ (Allen, 1981), landmarks that are near to each other and similar in architecture and use are likely to be chunked (Holding, 1992)
- Chunking leads to more accurate distance estimations and enables reference points (best example of all locations within a cluster)

Mental Structure: London



Cluster

=

Similar to Spatial Map (Appleyard, 1970)

=

Hamleys is a Landmark and Reference Point
For A Major Shopping District in London

t

ark & Reference Point

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Semantic Networks

- Information in semantic memory (memory for concepts) is sometimes ordered hierarchically (Collins & Quillian, 1969)
- This links to propositional storage (meaning based storage)
- Semantic networks can reduce the load on memory, which for spatial memory may be limited (Tversky, 1981), as information common to all members of a spatial cluster is stored once.
- Recall of information however may require scanning through the hierarchy and is subject to error (Stevens & Coupe, 1978)

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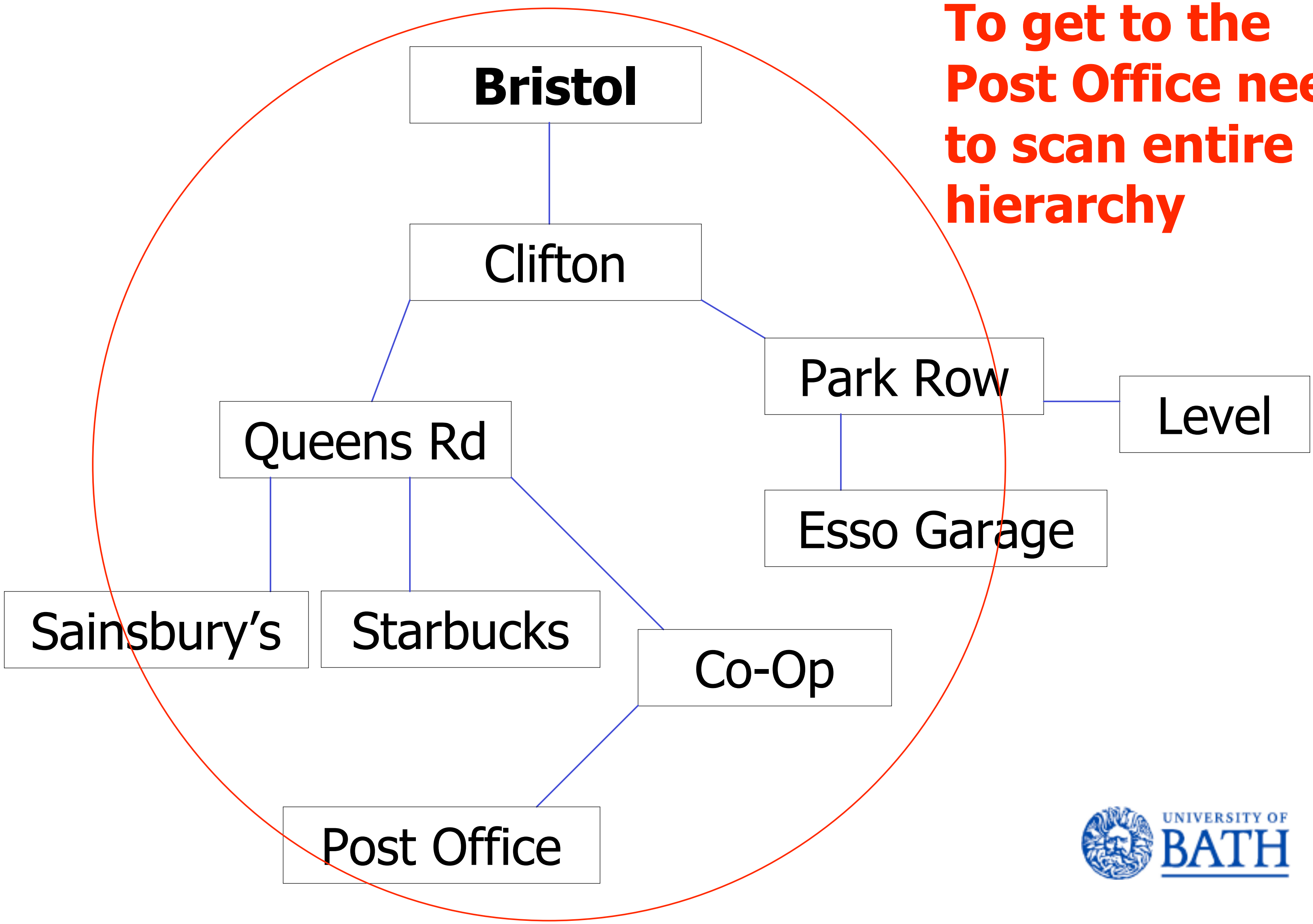
Semantic Network: Bristol



To get to the Post Office need to scan entire hierarchy

What have we learnt from Cognitive Map Research?

- Experience plays an important role in the acquisition, development and accuracy of cognitive map development.
- Experience does not have to be visual, in the absence of vision however haptics and auditory perception may be insufficient for accurate mental representations…
- Methodologies used for measurement of cognitive maps are varied. Sketch maps are easy recognisable as a ‘map’ and begin to explain something about storage mechanisms but are difficult to interpret and subject to individual difference error (based on drawing ability and previous experience)

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What has been learnt II

- Recent research (Creem et al. 2001) suggests that cognitive map features can be tested empirically using rotation methods.

- Geometric properties of cognitive map features must be organised with geometric sense to facilitate observer rotation - This hints towards a hierarchical (semantic network?) and mental map structure of the physical environment.

- Theoretically there appears to be a combination of acquired information (either visually or non-visual) **but** also some organisation and categorisation of that information.

- Experience, interaction and map development is transient - The greater the interaction the more detailed the map and the more heuristics can be applied (chunking of landmarks and spatial information)

- Greater experience however may result in slower distance and scanning times.

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Cognitive Maps: The Future

- Sporadic interest from Psychologists, Sociologists and Human Geographers over the past 40 years.

- Enjoying a resurgence of interest with a shift in focus to virtual environments and combined environmental interaction with technological devices (mobile phones, PDA's and Satellite Navigation).

- Studying and interpreting cognitive maps is the basis for understanding how people move their environment and wayfind.

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