Interacting with Technology

Lecture 6: Case studies: Aiding spatial cognition in children

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Unit structure

1st part of course lectures

Topics include :

- Children and technology
- Space cognition
- Evaluating 'in the wild'
- Case studies

2nd part of course presentations by students

Please note 20 minute presentation, followed by 10 minutes of questions

Overview

Introduction & Lecture 1: Children, schools and technology
Lecture 2: Mobile technologies and sensors
Lecture 3: Mobile and tangible technologies for children
Lecture 4: Case study: Children and technology
Lecture 5. Exploring spatial cognition with novel technologies
Lecture 6: Aiding spatial cognition in children
Lecture 7: Evaluating 'in the wild'

Content

Reviewing experimental work examining the way children encode spatial information from exploration of virtual environments:

- A novel paradigm for investigating configural learning
- Transfer of spatial information
- The effect of repeated exposure to virtual environments
- Evidence for vertical asymmetry in spatial memory

The Cognitive Map

"in the course of learning something like a field map of the environment gets established in the rat's brain" (Tolman, 1948, p.192).

- The quality of childrens' cognitive maps is dependent on familiarity with the environment (repeated exposure, provision of landmarks, locomotion allowing self initiated exploration).
- Children with restricted mobility less chance of exploration of environment and thus develop poorer spatial cognitive maps
- E.g. Foreman Orencas et al (1989) children with physical disabilities significantly worse at spatial tasks
- Kozlowski and Bryant (1977) concluded that for people to show a good sense of direction it was necessary for them (a) to make a conscious effort to orientate themselves, and (b) to provide them with repeated exposure to the test environment.

Why Virtual Environments?

- Virtual environments (VEs) have as their core the simulation by computer of three dimensional space. The first defining feature of VEs is that they can be explored in real time with similar freedom to real world exploration. The second defining feature is that the user may interact with objects and events in the simulation.
- VEs particularly suitable due to: Egocentric viewpoint, visual flow, safe to explore independently..
- Desktop with tailored interfaces

1. Background to Shortcut studies

- Few studies looking at the development of internal spatial representations in disabled children (Foreman et al, 1989b; Simms 1987). Neither of these studies included a shortcut task.
- The ability to take shortcuts demonstrates the formation of an effective internal representation of space (Chapuis, Durup and Thinus-Blanc, 1987).
- In the present series of studies the experimental environment used by Chapuis et al (1987) was created as a 3-D simulation and this was used to test human participants.

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The Shortcut study

- 24 able-bodied children with a mean age of 13.6 years

- 34 physically disabled children, with a mean age of 14.1 years, was divided into two sub-groups based on their history of mobility (rated by their teacher as more mobile when they were younger or less mobile when they were younger).

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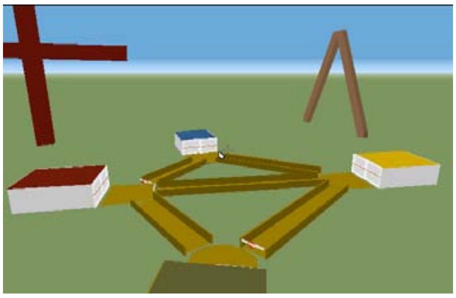
The environment consisted of five pathways connecting four rooms that appeared identical from the outside.

- *N.B. A series of pilot studies had established that 4 large cues were optimal for spatial orientation within this environment*



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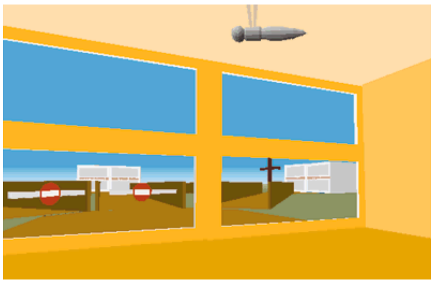

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- children explored a simulated "maze" comprising four rooms linked by runways. In a subsequent test, they were asked to take shortcuts between target room locations.

- For example, they were asked to explore the route between room A and room B (all other pathways were blocked by no entry barriers). They were then asked to explore the path between rooms C and D, and then between rooms A and D. In the testing phase all the barriers were removed and participants were placed in room C and asked to find room B by the shortest route available.

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Results

- In the first shortcut test the probability of choosing a correct path by chance alone was 33%, while the probability was 50% on the second test.
- Approximately 70% of the able bodied group selected the shortcut correctly on both tests, significantly exceeding chance levels.
- The 'more mobile group,' while not performing better than chance on the first test (approximately 45% correct), scored better than chance on the second test with 80% correct.
- The 'less mobile' group only scored approximately 45% correct on both tests and therefore did not perform better than chance on either test.

Conclusion

- These results add further weight to the argument that early independent exploration is essential for the development of cognitive spatial mapping ability in children, and suggest that these early influences persist at least into the early teenage years.

2. Studies of Repeated Exposure

- examining whether repeated exploration of several virtual environments promotes better encoding of virtual environments in general.
- A series of studies, including 3D vs 2D training
- skills disabled children acquired using virtual environments improved with exposure to successive environments
- However did not show an improvement in general spatial skills (assessed by Money Road test and Shepard and Cooper tests adapted for children).

3. Background to Transfer Studies

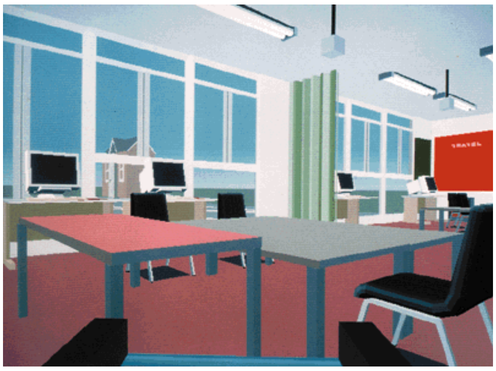
- the acid test for VE efficacy as a spatial training medium is whether children can make practical use of VE training in a real situation.

- The first study to examine transfer of virtual environment knowledge to real life training in physically disabled children was carried out by Wilson et al (1996). They asked their participants to explore a simulated building in the form of a game.

The AshField study

- Experimental group were 7 physically disabled children, 6 boys and one girl. They had a mean age of 12.3 years. The control group consisted of 7 undergraduate students, 2 female and 5 male with a mean age of 25.6 years.

- The primary section of Ash Field School in Leicester was created to-scale. The environment consisted of an entrance door with a corridor leading into a central area and nine rooms.



Procedure

- Experimental and control groups were subsequently taken to the real Ash Field school. Pointing accuracy was measured from two relative locations from which the children had completed computer pointing tasks in the simulation, along with a third untrained location. They were asked to estimate the direction of target objects from each of these locations using a hand operated pointing device.

- Finally, each participant completed two route tests. They were taken to a room and were asked to move directly to a target room. The first route was identical to the one trained within the simulation. The second route taken was between two different rooms.

Results

- Children were more accurate than controls in pointing to landmarks that were not directly visible from three separate testing sites ($F(1,12) = 67.54$, $p < 0.01$). They not only completed the tasks previously trained in the virtual school, but they also completed spatial tests that had not been trained in the virtual environment equally well.
- their way-finding ability (to adopt the shortest route between two locations) was also found to be more efficient than that of the control group (Mann-Whitney U test, $z = 2.01$, $p < 0.05$).

Conclusions

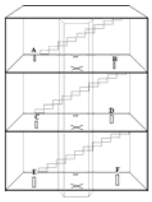
- These results support the conclusion that the children had acquired flexible, effective internal representations of the environment from the virtual simulation, enabling them to orient themselves from a number of different positions within the real environment.
- They add to the accumulating evidence that VE training transfers effectively to the real world and that this effect is evident even for people with physical disabilities whose spatial proficiency may be limited.

4. Background to vertical studies

- Previous studies have demonstrated that spatial knowledge can be acquired from VE exploration alone and that such information can be transferred to equivalent real world environments
- However most studies use single storey buildings and spatial measures in the horizontal plane
- Buildings designed for those with disabilities are often single storey, in daily life encounter many multi-level environments
- Wilson et al (1997) found that accuracy pointing to objects on other floors was poorer than when pointing to objects on the same floor

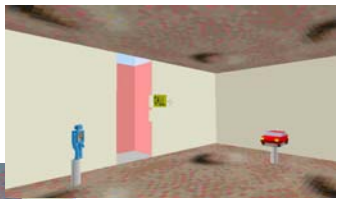
Adults Vertical Encoding

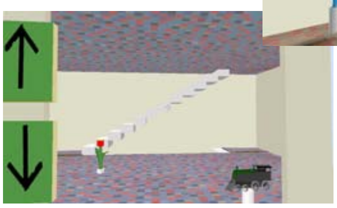
- 27 able-bodied participants (mean age 25yrs, 2mths)
- Practice environment – open space with a raised platform and 2 objects
- 3 vertically aligned rooms, forming a 3-storey building



3-Storey Simulation

3 vertically aligned rooms, forming a 3-storey building





Connected by a staircase and lift

Six target objects, two on each floor (counterbalanced)

Procedure

- Tested individually
- Explored practice environment, pointing to target objects when obscured
- In 3-storey building explored 3 rooms and asked to remember the location of the 6 objects
- Pointing tasks in the same environment with no objects. Tested at six locations - tilt and rotation errors recorded

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Results

- Poorer performance when pointing to upper rather than lower floors $F(1,56)=10.71$ $MSE=383.01$ (Ms 31 and 19 degrees error respectively)
- First experiment to demonstrate a bias in accuracy of spatial representations in the vertical dimension, favouring spatial arrays that are lower rather than higher than the horizontal plane

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Children's Vertical Encoding

- Importance of VE as training medium for those with limited mobility
- Hypotheses:

Vertical spatial asymmetry in children, learning this bias early in life

A difference in vertical orientation ability between able-bodied and disabled children due to differences in self-controlled exploration

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Study

Two groups of participants:

- 12 physically disabled children with mobility difficulties from birth
  mean age 8yrs, 2mths
  10 males
- 19 able-bodied children
  mean age 9yrs, 5mths
  12 males
- Environment and Procedure as in Experiment 1

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Results

- Absolute tilt errors revealed an asymmetry with more accurate judgements to lower than higher floors $F(1,65)=8.07$, $MSE=537.33$ (Ms 42 and 31 degrees respectively)
- Significant main effect of group revealing greater overall errors in the disabled group (Ms 37 and 31 degrees for disabled and able-bodied respectively)

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Conclusions

- Two studies using simple multi level VEs provide novel evidence for a vertical asymmetry in spatial memory, in adults, able-bodied children, and children with physical disabilities.
- Novel finding needs to be considered when using VEs for training

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Discussion

- We are accumulating evidence of the positive effect of exploration of virtual environments on spatial navigational skills.
- We continue to examine whether skills learned in virtual environments transfer effectively to real world environments.
- The challenge is not only to examine transfer from a simulation to it's real world equivalent, but also to examine more generally whether spatial skills in the real world improve after virtual environment experience.
- Ultimate goal is to improve quality of life

Selected References

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