The Role of Context in Spatial Region Identification

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The Problem

To collaborate with people in the real world, cognitive systems must be able to represent and reason about ***context-dependent spatial regions*** (CDSR)

The *front* of the classroom

The *aisle* of a church/theater

Behind enemy lines in a battle plan

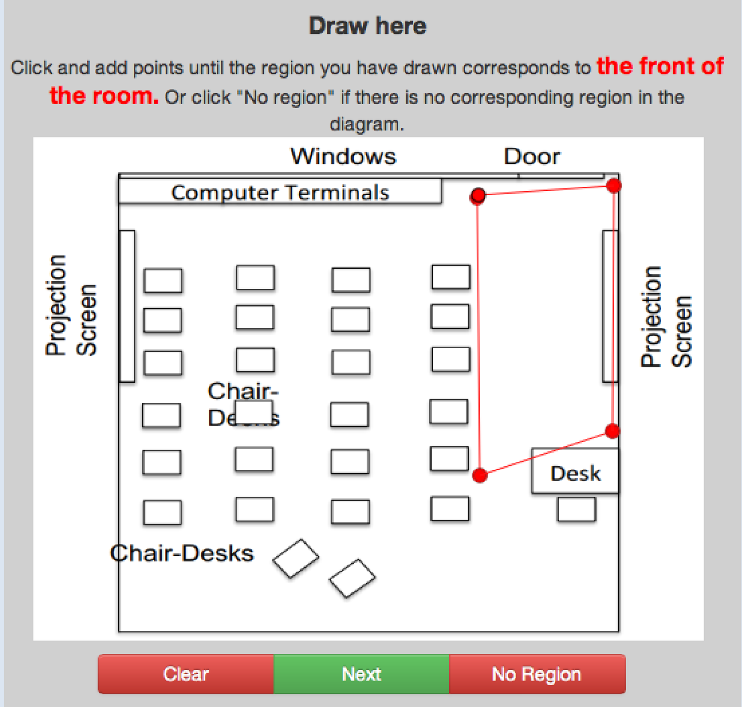
The *kitchen* in a studio apartment

A context-dependent spatial region is not perceivable using geometry alone. Instead, the boundaries of the region are defined by its functional use, implied by nearby objects and their configuration. Understanding these regions requires the integration of **geometric** and **semantic** knowledge about the **domain**.

Human Studies

We were interested in studying contextually nature of CDSRs by examining the following questions about CDSRs:

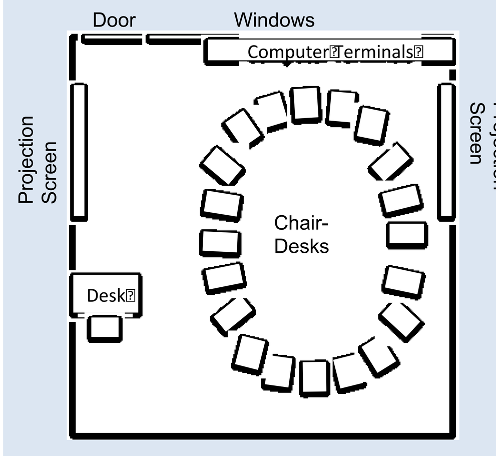
1. Given a particular context, do people agree on the location and extend of a named CDSR?
2. Does the location and extent of a CDSR predictably change in line with the variations in context (e.g., object locations and types)?



Task 1: Region Drawing

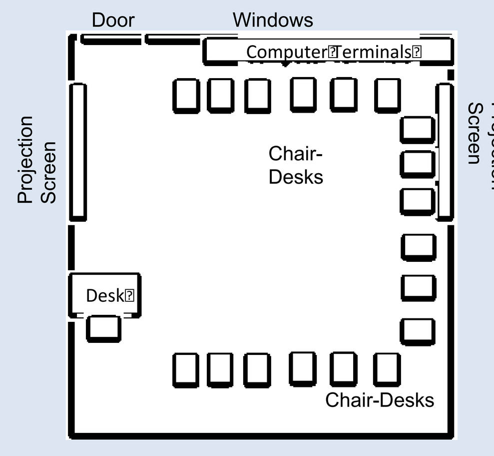
Task 2: Rating Points

Stimuli Used in the Experiments



(a)

(b)



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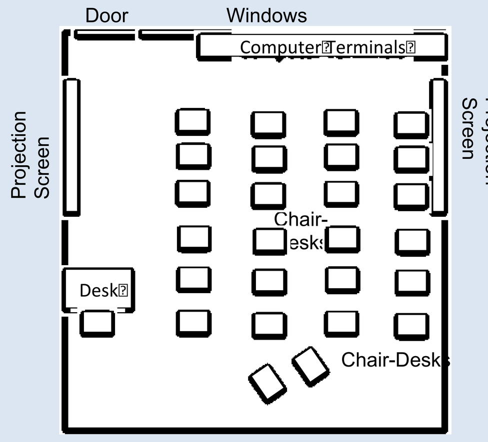

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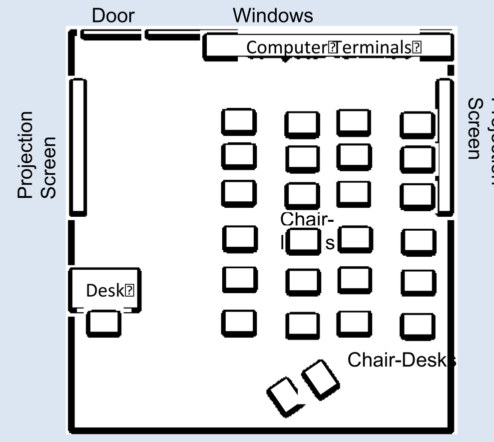
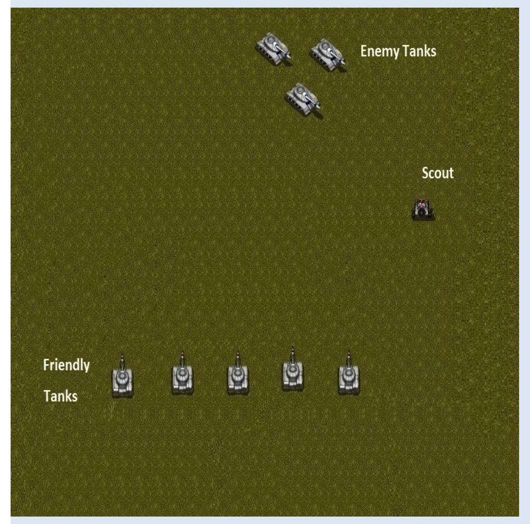


(f)

(g)

(h)

(i)



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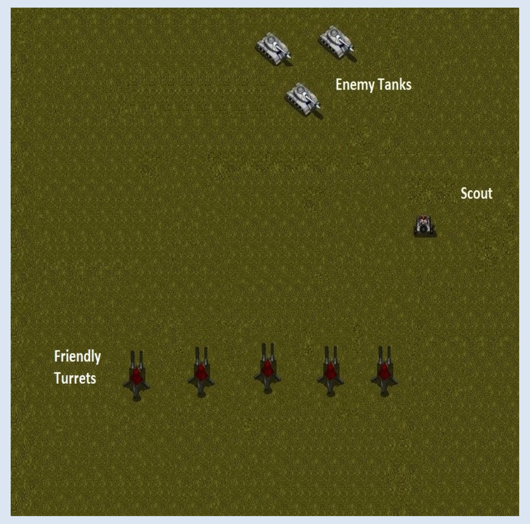
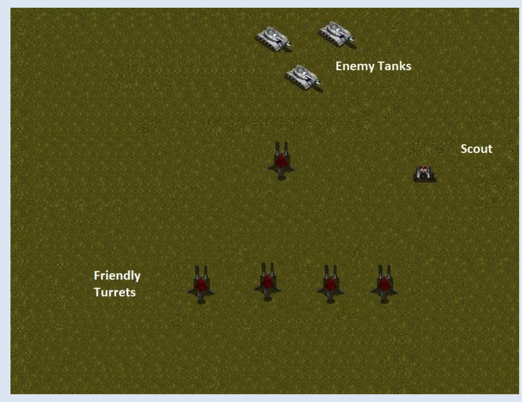
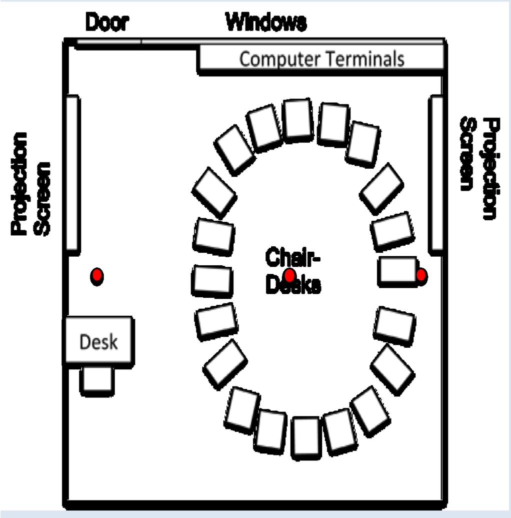


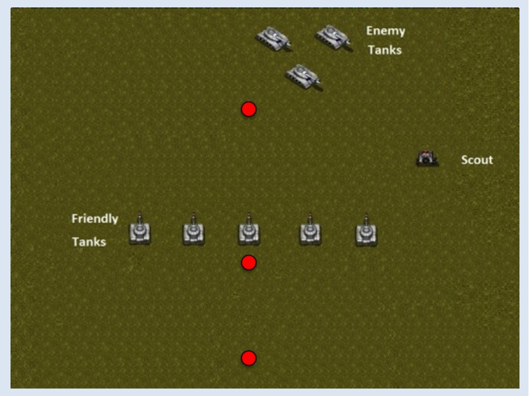
(k)



(l)

Points used in Likert Study





Task 1 Analysis and Results

Inter-annotator agreement We expected fair to good overall agreement (measured by Cohen's κ) indicating that subjects share the interpretation of the CDSRs in the given contexts. We expect less agreement in ambiguous/novel contexts.

Mean Pairwise Kappa Scores by Stimuli

Less agreement in ambiguous cases

People generally agree on CDSRs

Stimulus ID	Ambiguity Expected?	Average Pairwise κ	No Reg.
(h)	N	0.5034	0
(g)	[illegible]	0.4585	1
(k)	[illegible]	0.4548	0
(f)	N	0.3930	0
(i)	N	0.3906	0
(e-flipped)	N	0.3813	2
(j)	N	0.3787	1

Stimulus ID	Ambiguity Expected?	Average Pairwise κ	No Reg.
(f-flipped)	N	0.3720	2
(e)	N	0.3629	1
(l)	Y	0.3164	0
(c)	Y	0.2438	2
(c-flipped)	Y	0.2414	4
(a)	Y	0.0996	10

Between stimuli feature comparisons We expected that specific changes to the context would result in predictable changes to peoples labeled regions.

CDSR Features between Trials

Expected Relationship			Human Results		
area(g)	>	area(h)	291.2	>	276.2*
maxX(f)	>	maxX(e)	176.1	>	167.1
minX(e-flipped)	>	minX(f-flipped)	336.1	>	321.3*
maxY(i)	>	maxY(j)	304.64	>	265.04*
maxY(j)	>	maxY(k)	265.04	>	251.71
maxY(k)	=	maxY(l)	265.04	!=	290.03

Changing the context predictably changes the CDSR

Ambiguous interpretation depends on domain knowledge

Task 2 Analysis and Results

Sweetspots One of the three points was expected to score significantly above the other two points. This sweetspot was determined by a pilot study.

Mean Likert Scores

Map	g	h					
P1	1.1707	1.1707					
P2	**4.6667**	**4.7561**					
P3	1.85	1.585					
Classroom	a	c	c-flipped	e	[illegible]ipped	f	f-flipped
P1	**3.5122**	**4.7073**	1.244	**4.7561**	1.2439	**4.8292**	1.1463
P2	2.6341	2.9024	2.9268	2.0000	1.8500	2.0976	2.3171
P3	1.9024	1.3571	**4.6429**	1.2439	**4.7073**	1.2750	**4.6585**
Military	i	j	k	l			
P1	1.1951	1.0952	1.0714	1.2327			
P2	4.3902	2.2927	2.7804	3.1667			
P3	**4.9024**	**4.5122**	**4.6585**	**4.7073**			

Sweetspots are the highest score

P2's scores increase predictably as more desks face it

Expected mobile tanks to provide more safety to P2, and lone turret to provide none.

P2 scores higher when behind friendly tanks

Intermediate points between stimuli We also expected the scores of the intermediate points to change predictably as the context changed.

Challenge Problem for Cognitive Systems

- How can an intelligent system integrate **geometric** and **semantic** knowledge to account for these results?
  - Is **simulation** or **experience** required, or helpful?
- Cognitive systems are able to quickly learn these regions?
  - Few subjects had experience with real-time strategy games yet were still capable of agreeing upon regions within the scenarios.

Acknowledgments

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