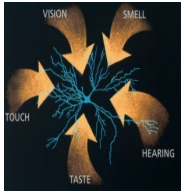




# Where does the body end & the world begin?

## - Multisensory interactions in peripersonal space -

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<http://www.psych.ox.ac.uk/xmodal/default.htm>

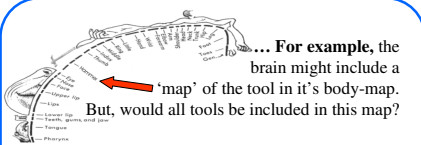
### Extending the body with tools?



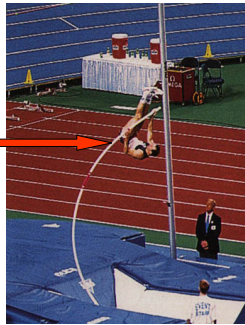
"Man [is] a machinate mammal. The lower animals keep all their limbs at home in their own bodies, but many of man's are loose, and lie about detached, now here and now there, in various parts of the world... A machine is merely a supplementary limb..."

"Erewhon", Samuel Butler, 1872

Is this true? If tools are literally 'extensions of the body,' then they should behave as the body behaves, and the brain should treat them as it treats the body...



What about the tool of this pole-vaulter?



It is likely that the brain 'incorporates' tools in more subtle ways than into an anatomical map!

Since tools change how your body interacts with the space immediately surrounding it, perhaps this 'nearby' space is extended by using a tool...

### Extending 'peripersonal space' with tools?



The space around your body (roughly, within arm's reach) is very important to your brain – information about nearby space may protect you from harmful collisions, or help you reach and grasp nearby objects.

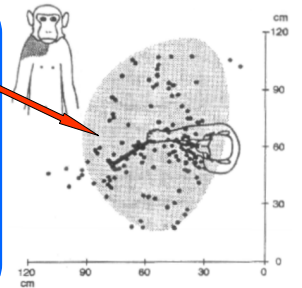
Objects and stimuli within this 'peri-personal' space affect different neurons in different brain areas compared to distant objects that are out of arm's reach.

Since tools extend one's reach, perhaps this peripersonal reaching space is also extended?

Recently, it was suggested that, in monkeys, neurons dealing with peripersonal space would start to respond before a visual stimulus was within arm's reach.

Similar experiments performed on humans with brain damage also suggested that peripersonal space was extended after a period of active tool-use.

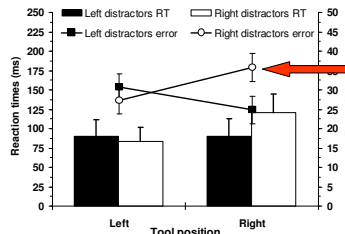
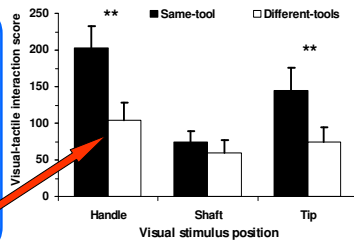
But, most of these studies only presented visual stimuli at the tips of the tools – so we don't know if the space is literally 'extended' in humans – perhaps just the tips of tools are incorporated by the brain?



### Projecting 'peripersonal space' with tools?

We asked human participants to perform two interleaved tasks: 1) A tool-use task using two hand-held tools to push buttons, 2) A tactile discrimination task. During the tactile task, visual distractor stimuli were presented along the tools held in their left and right hands.

Visual-tactile interactions were highest near the hands, lowest in the middle of the tool, and intermediate at the tool tips.



Next, we found that when a tool is crossed over, from left to right, the largest visual-tactile interactions follow the tool as it moves!

However, this only occurred when one tool was held on one side for several minutes. This suggests that various sensory, movement, and attentional factors affect tool-use. Peripersonal space may sometimes be 'extended,' but that is only part of the story...

### Extending the body or 'capturing' attention?

Rather than literally extending the body or peripersonal space, our research suggests that tools act as visually-salient objects that draw one's attention to different regions of space, particularly the tool-tip, and regions containing potential targets for tool-use actions.

When a surgeon uses a scalpel, visual and tactile information need to be integrated in order for the tool to be used properly. If the surgeon's attention is drawn automatically to the tip of the scalpel, the brain can extract the most useful visual information, and ignore less useful information from the rest of the tool.



This 'capturing' of attention helps to explain how it is possible for humans to use very long tools, without the brain needing to incorporate its entire length!

Further questions: How do tools capture attention? How do people's brains learn to use complex tools? Are both tool and limb movements controlled in the same way...?

