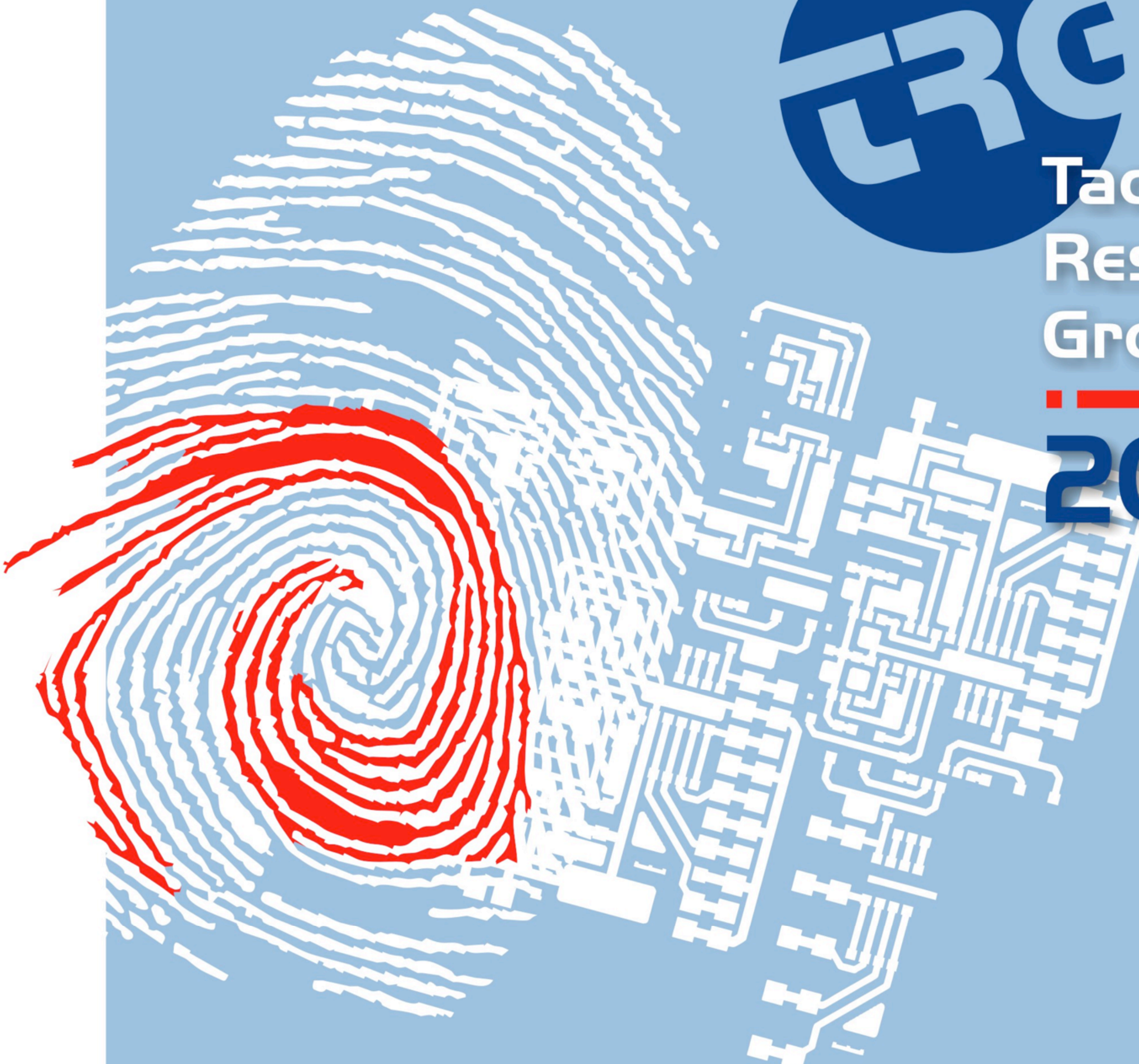


Tactile Research Group

2009

Thursday, November 19th, 2009

Boston Sheraton Hotel

Program

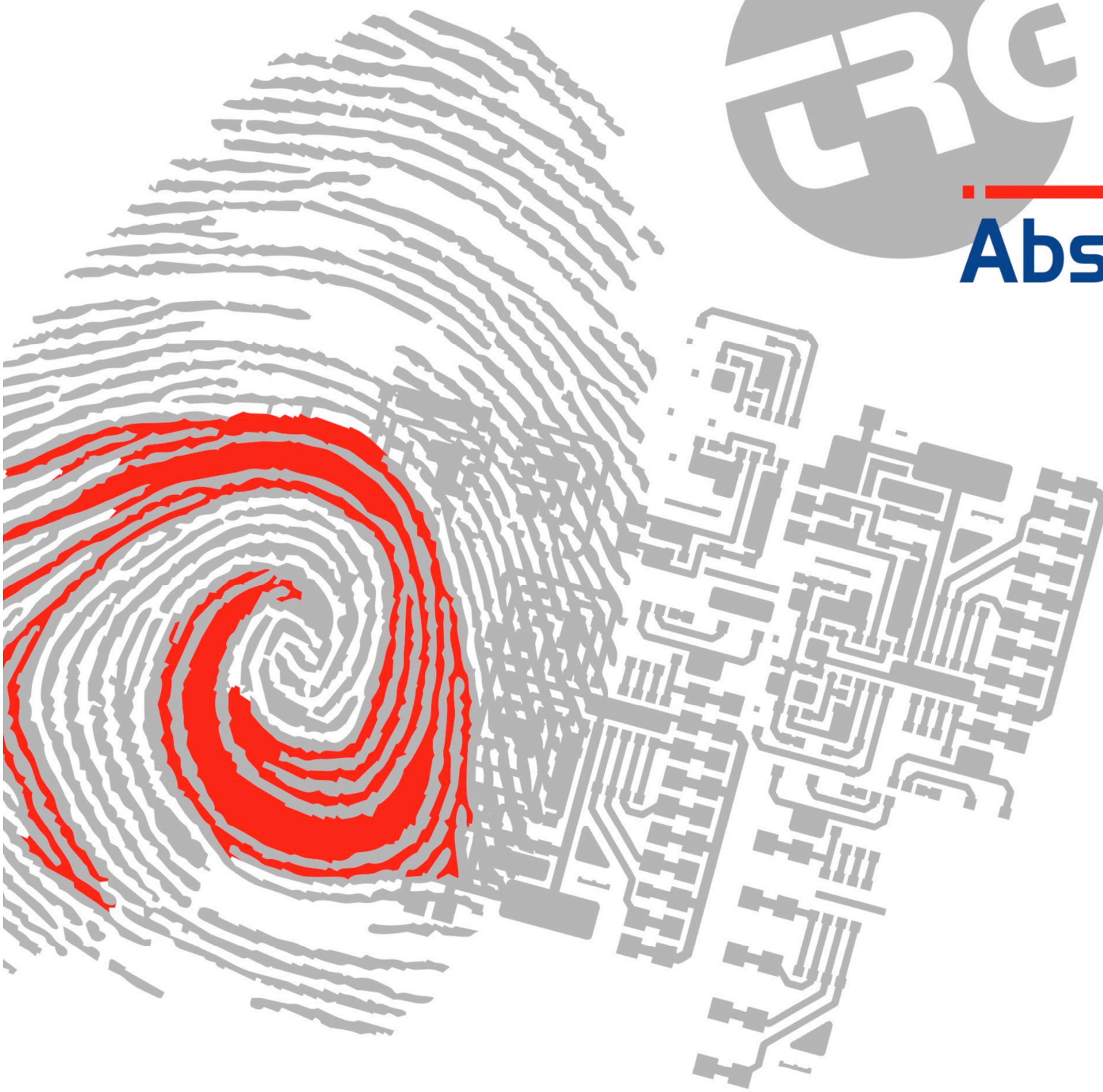
Thursday 19 November	
7:45am – 8:55am	Breakfast
8:55am – 9:25am	**S. Ballesteros, M. Sebastián, F. Muñoz and J.M. Reales** *“Neural correlates of texture perception and memory for objects explored by touch”*
9:25am – 9:45am	**George A Gescheider and John H Wright** *“Information-Processing Channels in the Tactile Sensory System”*
9:45am – 10:00am	Break
10:00am – 10:30am	**Steve Hsiao** *“Shape and Motion processing in Somatosensory cortex”*
10:30am – 10:45am	**Farley Norman & Charles E. Crabtree** *“Short-term visual deprivation does not improve tactile acuity”*
10:45am – 11:15am	**Mark Hollins & Daniel Harper** *“Stages of Pain Processing”*
11:15am – 11:45am	**John Kennedy** *“Raised-line drawings by BP and EW”*
11:45am – 1:05pm	Lunch
1:05pm – 1:35pm	**Allan Smith** *“The physics and physiology of tactile exploration”*
1:35pm – 2:05pm	**Morton Heller** *“Haptic Perception of Pictures”*
2:05pm – 2:20pm	**Flip Philips & Eric Egan** *“Crossmodal perception of 3-dimensional shape”*
2:20pm – 2:35pm	**E. Courtenay Wilson, Charlotte M. Reed, and Louis D. Braida** *“Perceptual Studies of Auditory-Tactile Integration”*
2:35pm – 2:50pm	**Ludovic Potier & Olivier Gapenne** *“Haptic guidance can be a solution to design products easier to use”*
2:50pm – 3:05pm	**Theodore M. Moallem, Charlotte M. Reed, and Louis D. Braida** *“Measurement of tactual detection and temporal order resolution in congenitally deaf and normal-hearing adults”*

3:05pm – 3:15pm	**Break**

Thursday 19 November

3:15pm – 3:30pm	**Michelle L Cadieux & David I Shore** *"A view of the room: blindfolding and the crossed-hands deficit"*
3:30pm – 3:45pm	**Ali Israr** *"Towards Standardization of Vibrotaction"*
3:45pm – 4:00pm	**David Schloerb, Orly Lahav, Joseph Desloge and Mandayam Srinivasan** *"BlindAid: VE for Trip Planning and Orientation and Mobility Training"*
4:00pm – 4:15pm	**Lynette Jones** *"Thermal cues and object identification"*
4:15pm – 4:30pm	**Sarah H. Norgate, Lisa Benton & Marcus G. Ormerod** *"Adaptive Exploration of Objects in Congenitally Blind Infants"*
4:30pm – 4:45pm	**Christopher Moore** *"Cortical Dynamics and Perception"*
4:45pm – 5:00pm	**Jared Medina** *"Dynamic shifts in tactile localization following stroke"*
5:00pm – 5:15pm	**Laurence Harris & Vanessa Harrar** *"Touch is in visual coordinates"*
5:15pm – 5:30pm	**Scinob Kuroki, Junji Watanabe, Susumu Tachi, and Shin'ya Nishida** *"Somatotopic and spatiotopic encoding of tactile timing and motion"*
5:30pm – 5:35pm	**Concluding remarks**

Abstracts



Neural correlates of texture perception and memory for objects explored by touch

S. Ballesteros, M. Sebastián, F. Muñoz and J.M. Reales
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We studied how stimulation patterns presented to the skin are processed by the brain and how memories can affect the resulting perceptions. The first series of studies investigated brain activity associated with the perception and attention of texture patterns varying in roughness using event-related evoked potentials (ERPs) while perceivers explored with the fingertip target and a non-target textured stimuli moving below under different conditions. We also studied transient modulations in tactile attention, related to physical and contextual factors. Textures were mounted on the Tactile-Spinning Wheel, a specifically designed apparatus that allow electrophysiological recordings. We found an increased P300-like component for attended compared to unattended stimuli and synchronization in the theta band (3-7 Hz) at an early 200 ms time window (around 200 ms), followed by desynchronization in the alpha band (8-12 Hz) at the 400-800 ms time window. Source analysis using LORETA showed higher neural activation when processing targets compared to standard stimuli at somatosensory, occipital, and frontal cortices. The second series of experiments investigated the brain activation patterns of repetition priming of familiar and unfamiliar novel objects explored by touch. We found behavioral facilitation for old compared to new stimuli that increased with repetitions. More interestingly, repeated object presentation induced gamma frequency (>20Hz) synchronization. The findings suggest that a new cell-assembly representing the object features is created with repetition.

*Work supported by the European Community (SOMAPS: NEST-2005-Path-IMP, grant 043432).

Information-Processing Channels in the Tactile Sensory System

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Information-Processing Channels in the Tactile Sensory System is a research monograph by G.A. Gescheider, J.H. Wright and R.T. Verrillo published in 2009 by Taylor & Francis. In this work we address the fundamental question of whether sensory channels, similar to those known to operate in vision and audition, also operate in the sense of touch. Based on neurophysiological and psychophysical experimentation we have made the case that channels operate in the processing of mechanical stimulation of the highly sensitive glabrous skin of the hand. According to our multichannel model, each channel with its specific type of mechanoreceptor and nerve fiber, responds optimally to particular aspects of the tactile stimulus. We further propose that tactile perception of objects results from a blending of the activity of the individual tactile channels.

Shape and Motion processing in Somatosensory cortex

Steve Hsiao
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In this presentation I will present recent data from my lab on tactile motion, curvature and shape. In studies of tactile motion we show that neurons in area 1 respond to both component motion and to pattern motion. Furthermore the motion selectivity increases as the coherence between moving random dots increase. The results from this study suggest that area 1 is the tactile motion processing area. In a second study we investigate the representation of curvature and find that neurons in area 2 and SII respond to curvature. The responses are similar to what is found in are V4 for curved patterns. In the third study I will present data showing that many neurons in SI are affected by hand conformation. The responses break down into two categories- those that are linear and provide information about hand conformation and those that are non-linear and are selective to object shape. The results from the three studies provide evidence that while cutaneous information is processed using mechanisms that are similar in vision, the mechanisms of object recognition are different.

Short-term visual deprivation does not improve tactile acuity

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Past research has indicated that short-term visual deprivation (e.g., for 1.5 hours) may heighten tactile acuity. In our investigation, we attempted to replicate this effect and to additionally investigate whether short-term visual deprivation affects tactile shape discrimination. One group of participants was deprived of vision for 1.5 hours, while another group was not deprived. The results showed that the performance of both groups on a grating orientation task improved across the 1.5-hour period, indicating an effect of practice.
The deprived group performed no better than the non-deprived group. Likewise, there was no difference between the groups in terms of their performance on a 3-D shape discrimination task. We conclude that a 1.5-hour period of visual deprivation is not sufficient to produce heightened performance on these particular tactile tasks.

Stages of Pain Processing

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The chain of events leading to pain usually begins with stimulation of nociceptors, but the neural signal that will eventually produce a painful sensory experience undergoes considerable modification in the receptors, the spinal cord, and the brain. Some of these processing stages have been studied in isolation, but how they fit together in a sequence is not known. We have made some progress toward this goal, by classifying several of the processing stages as "early" (impervious to cognition) or "late" (influenced by cognition). One process that belongs in the latter category is the hypervigilance-related (Rollman, 2009) perceptual amplification seen in idiopathic pain conditions such as fibromyalgia and temporomandibular disorders. We propose a model to explain when and how this amplification occurs. In contrast to this cognition-based phenomenon, a number of components of pain processing give evidence of being low-level. These include adaptation (which we show to consist of both fast and slow components), slow temporal summation, and "pain gating" (the ability of vibration to reduce pain). It is anticipated that the continued development of a stage model of pain will be of both theoretical and clinical value. (Supported by NIH grant NS045685.)

Raised-line drawings by BP and EW

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BP (Ben) and EW (Eriko), university-graduate blind adults, make drawings that show features of drawings by sighted children aged 7 to 10. Ben and Eriko do not use T-junctions to show overlap. Their drawing rule may be “show occluding edges as complete.” Elevation and plan vantage points influence the drawings. Of interest, Ben’s drawings advance several drawing-development stages in one testing session, and Eriko’s drawings include sophisticated metaphoric devices.

The physics and physiology of tactile exploration

Allan Smith
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The mechanical properties of the skin-surface interface have a significant effect on the activity of skin receptors and ultimately on the cortical processing needed for perception and action. In tactile exploration, the fingers apply forces not only perpendicular to the skin surface but also tangentially as a result of the coefficient of friction. Modulated tangential force fields, when combined with the corollary discharge arising from the motor command during active touch, is sufficient to create a perception of shape, which cannot be achieved with passive stimulation alone. The subjective sensation of textures of different roughnesses can be similarly simulated by modulated periodic force fields. A scaling study showed that friction and tangential force amplitude were significant parameters of roughness, whereas the spatial frequency of resistance was not. Single neuron recordings from monkeys performing tactile exploration shows that specific cell population in the primary somatosensory cortex are sensitive to friction and the direction of tangential forces on the skin. This cortical processing ensures that the emergent properties of texture, friction and tactile flow are available to the motor cortex for guiding successful tactile exploration in active touch.

Haptic Perception of Pictures

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Research on picture identification, picture memory, and viewpoint effects in tangible pictures show the advantage of the late blind and people with very low vision. Identification tasks provide very limited insights regarding haptic perception. Tangible pictures provide useful spatial information for blind and for sighted individuals. However, research with the sighted underestimates the potential of touch. Males and females may show differences in haptic spatial memory and picture identification, with a frequently found haptic advantage for females, as in vision.

Crossmodal perception of 3-dimensional shape

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We experience the shape of objects in our world largely by way of our vision and touch but the availability and integration of information between the senses remains an open question. The research presented examines the effect of stimulus complexity on visual, haptic and crossmodal discrimination. Using sculpted three-dimensional objects whose features vary systematically, we perform a series of experiments to determine perceptual equivalence as a function of complexity. We present the results from a set of uni- and cross-modal discrimination experiments as well as a reproduction task that was also performed using visual, haptic and bimodal input.

We find that, for the class of stimuli used, subjects were able to visually discriminate them reliably across the entire range of complexity, while the experiments involving haptic information show a marked decrease in performance as the objects become more complex. Performance in the crossmodal condition appears to be constrained by the limits of the subjects' haptic representation but the combination of the two sources of information is of some benefit over vision alone when comparing simple stimuli. This result shows that there is crossmodal transfer, and therefore perceptual equivalency, but that this transfer is limited by the object's complexity. The production experiments provide additional support of this hypothesis as well as allowing for a more systematic examination of various mental representation strategies for the various information sources.

Perceptual Studies of Auditory-Tactile Integration

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In this talk we will summarize a set of studies conducted to examine perceptual interactions between auditory and tactile stimuli. The experiments include studies of the detection of auditory and tactile sinusoidal stimuli at levels near threshold of perception, as well as studies of loudness matching employing various combinations of auditory and tactile stimuli presented at supra-threshold levels. In all the experiments, vibrotactile stimuli were delivered through a single-channel vibrator to the left middle fingertip and auditory stimuli were presented diotically through headphones in a background of broadband noise. In the detection experiments, the auditory and vibrotactile stimulus levels used each yielded 63-77%-correct unimodal performance in a 2-I, 2AFC task. Performance on combined auditory-tactile conditions will be shown as a function of the relative phase, temporal asynchrony, and frequency of stimulation within each modality. In the loudness-matching experiments, we measured the level of an auditory probe tone as its loudness was compared with either a two-tone auditory complex or a two-tone auditory-tactile complex. Results will be shown as a function of the frequency spacing of the tones in a given complex. The research conducted here demonstrates objective and subjective perceptual effects that support the mounting anatomical and physiological evidence for interactions between the auditory and tactual sensory systems.

Haptic guidance can be a solution to design products easier to use

Ludovic Potier[1,2] & Olivier Gapenne[1]
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In order to create guiding elements for gestures in a three dimensional space, it is necessary to know the constraints imposed on the movement and also the perception of a subject touching a surface. Thus, haptic navigation always associates tactile and proprioceptive informations (Overvliet, Smeet, Brenner, 2008).

On the one hand this spatial relation between perception and action has been studied with the radial-tangential effect; The over-estimation of distances in a tangential plane (in opposition with a radial plan relative to the body) is due to a reduction of the exploration speed (Wong, 1977) (Marchettin & Lederman, 1983).

On the other hand the perception of oriented texture in an active movement is possible in a horizontal plane (Lederman et al. 1988) (Hugues, 2006). In the case of gradient textures, the exploratory movement can be canalized (Smitsman, Shellingerhout, 2000).

The object of this work is to study haptic aiming with different texture fields, in different planes, especially in positioned in the back. This is representative of a very common gesture: to put on a jacket.

Measurement of tactual detection and temporal order resolution in congenitally deaf and normal-hearing adults

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To guide the development of tactile speech aids, tactual detection and temporal order discrimination by congenitally deaf and normal-hearing adults have been examined. Tactual detection thresholds for sinusoidal vibrations between 2 and 300 Hz were measured at the left thumb and index finger using an adaptive paradigm. Temporal onset- and offset-order discrimination were tested using stimuli of 50-Hz at the thumb and 250-Hz at the index finger, delivered asynchronously and varied independently in amplitude and duration. Mean detection thresholds for the deaf and normal-hearing groups did not differ significantly at any frequency tested. Temporal onset-order discrimination thresholds varied widely, particularly among congenitally deaf individuals, but no statistically significant difference was found between group means. Both experimental groups exhibited a broad range of discrimination thresholds for temporal offset-order, which were roughly twice as large as those for onset-order and mean thresholds did not differ significantly. In general, tactual temporal resolution among congenitally deaf subjects appears to be sufficient for utilizing tactually encoded temporal speech cues for displaying voicing information that is not available through lipreading.

A view of the room: blindfolding and the crossed-hands deficit

Michelle L. Cadieux & David I. Shore
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Participants were presented with vibrotactile stimuli at either hand and performed temporal order judgments (TOJs) of which occurred first. Judgments were made with hands either crossed over the midline or uncrossed, and performance was compared under three visual conditions: lights on/eyes open, lights off/eyes open, and lights off/eyes closed (while blindfolded). Four experiments were conducted.
Experiment 1 implemented the visual condition as a within-subject variable and asked observers to report which hand was stimulated first; no difference was observed. Experiment 2 replicated Experiment, 1 but with participants indicating which side of their body rather than which hand was stimulated first; performance decreased in the crossed-hands posture with this different response demand, but this decrease was consistent across all visual conditions. In Experiment 3, participants were placed in one for the three visual conditions in an attempt to give them more time to adapts to the visual environment. Again no effect of visual condition was observed. Experiment 4 used only the two visual conditions lights on/eyes open and eyes closed/lights off; however, unlike prior experiments, participants in the latter group were blindfolded prior to entering the testing chamber and were not allowed to see the room. Participants in this blindfolded condition performed significantly better in a crossed-hands posture, but only when the left hand was stimulated first. We argue that if participants are unable to form an allocentric perspective of their surroundings, they will depend primarily on information from an egocentric frame of reference, decreasing the interference of adopting a crossed hands posture.

Towards Standardization of Vibrotaction

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Vibrotactile (or Haptic) feedback is becoming common in electronically enhanced commercial devices but its use is still no more than just a 1-bit (on/off) of operation. Moreover, current standardization rules do not address user’s perceived response to vibrations, which consequently creates hurdles for artists and designers to use vibrations as a media tool. In this presentation, a synopsis of three research projects are presented with an effort to create a consensus towards standardizing vibrotactile stimulations in both research and industrial settings. In the first research, users’ subjective ratings to broadband vibrations were recorded and regressed against several frequency-weighted vibration energy functions. The strongest correlation occurred between the ratings and vibration energy normalized by the frequency related human-detection-threshold function [R>0.93] indicating the importance of human sensitivity as the standard basis of tactile perception. In the second study a benchmark example of a controller structure is presented that preserves the intensity of spectral components of a reference input signal in terms of the perceived intensity (judged by human users) when the signal passes through electronic and mechanical components. The third ongoing study focuses on answering whether force or displacement is the basis metric for tactile perception, or whether their derivative (such as mechanical impedance) is a unique metric for haptic perception. The presented research is an effort to standardize vibrotaction by utilizing the frequency related human sensitivity function.

BlindAid: VE for Trip Planning and Orientation and Mobility Training

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BlindAid is a virtual environment (VE) system that enables blind people to more easily learn about new environments on their own. The system is implemented on a desktop personal computer with a Phantom® haptic interface and three-dimensional spatialized audio. The BlindAid system was evaluated as part of an experimental study related to how people who are blind build cognitive maps of their physical environment and how recent advances in VE technology might support orientation and mobility (O&M) training. The talk focuses on the technical development of the system with some results from an initial evaluation by blind volunteers.

Thermal cues and object identification

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Thermal cues that assist in the identification of objects arise from changes in skin temperature that occur when an object is held in the hand. The thermal properties of an object, such as its conductivity and heat capacity, and the initial temperatures of the skin and object determine the heat flux conducted out of the skin on contact. As the resting temperature of the skin is typically higher than the ambient temperature of objects encountered in the environment, it is the cold thermoreceptors and afferent units that signal the decrease in skin temperature on contact. These changes in skin temperature can be used quite effectively to identify the material composition of an object even when other sources of information such as surface texture and compliance are controlled. When the thermal transients associated with making contact with different materials are simulated in a thermal display, participants can use these cues effectively to identify the simulated material. This talk will provide an overview of our research on how thermal cues are used in object identification.

Adaptive Exploration of Objects in Congenitally Blind Infants

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Before the end of the first year, sighted infants differentially adapt their manual behaviours to exploit the variable physical properties of objects (e.g. Fontenelle et al. 2007). For example, by squeezing flexible objects more than non-pliable ones or by shaking sound-producing objects more than those without sounds. Infants are also known to use selective action dependent on the relationship between objects and surfaces (e.g. Bourgeois et al. 2005), thereby demonstrating their ability to optimize the fit between manual action and what functions objects potentially afford.

To what extent do infants totally reliant on non-visual modalities also demonstrate this? Clearly, congenitally blind infants do not have the opportunity for cross-modal transfer between vision and touch. Neither do they have the scope to observe caregivers exploit objects as tools - either in terms of involving objects in simple actions, or in terms of more complex sequences involving more than one object.

Previous research (e.g. Schellingerhout et al. 2005) shows that within the context of tasks requiring high dexterity, two blind infants in a sample of three decreased finger movement speed in response to a change in texture density. Although these activities demonstrate manual adaptation across differentiated surface types, it remains to be seen whether a similar adaptation is observable in contexts where the object properties are not immediately perceivable.

For instance, we compared infant's exploratory repertoire in response to objects not differentiated by way of surface properties but which nevertheless varied in terms of an alternative functional attribute (e.g. two different sounds). In turn, we compared this with performance with whether infants differentiated action in the case of surface difference (e.g. 3 pliable vs 3 non pliable objects).

A total of ten infants in their second year - five congenitally blind infants and five matched sighted controls – were observed at home with two different arrays of objects. Infants' initial explorations with object sets were coded in the context of considering both unimanual and bimanual tendencies. Results are being coded and include comparisons between blind infants and sighted infants both within and across the two arrays. Implications of findings are discussed for perception-action development.

Cortical Dynamics and Perception

Christopher Moore
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My laboratory studies the neural correlates of tactile perception. A key theme of our work is the study of dynamics, shifts in neural representation on the time scale of milliseconds to seconds, as we believe these are essential to neural processing of sensory information. To this end, we study both sensory-driven dynamics and their impact on perception (e.g., adaptation), and internally-driven dynamics and their impact on perception (e.g., oscillatory brain states).

To dissect mechanisms of representation and dynamics at the cellular and circuit level, we employ the rodent vibrissae sensory system, specifically the primary somatosensory 'barrel' cortex. Among many advantages of this system, perhaps the most important is that it is a high-resolution sensory pathway in a mammal (mouse) where we can leverage the ongoing revolution in genetic engineering. In a targeted set of studies, we compliment these reductionistic 'model system' studies with parallel experiments on representation, dynamics and perception in humans using psychophysics and /or magnetoencephalography (MEG).

In this presentation, I will first briefly mention 2 recent studies of the neural mechanisms underlying neocortical dynamics. First, I will discuss our work using optogenetics to delineate mechanisms of internally-generated neocortical oscillations (Cardin et al., 2009; Cardin et al., in press). Second, I will discuss our work proposing that changes in hemodynamics (e.g., the fMRI BOLD response) can impact and shape local neocortical dynamics (the Hemo-Neural hypothesis; Moore and Cao, 2008).

I will then briefly describe 2 sets of human perceptual studies that address the impact of internally- and sensory-driven dynamics on tactile perception. First, we probed the impact of ongoing oscillatory dynamics on the sensory evoked response in SI and on tactile detection using MEG. We observed (Jones et al., 2007; Jones et al., in press) that the amplitude of specific components of the SI evoked response predicts tap detection on a trial-by-trial basis, and that ongoing oscillatory activity in the alpha and beta ranges predict these response dynamics. Second, in an exploration of sensory-driven dynamics, we probed the impact of adaptation on motion perception across modalities. We found that motion after-effects transfer cross-modally between touch and vision, such that the percept of the direction of motion on the skin is opponent to the direction of an adapting motion visual stimulus, and vice versa (Konkle et al., 2009). These latter findings are consistent with brain imaging studies showing activation of visual motion areas by tactile stimulation, and reveal the deep and surprisingly bidirectional cross-modal sensory interactions that govern holistic motion perception.

Dynamic shifts in tactile localization following stroke

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Research using electrophysiological methods to examine the consequences of cortical lesions in non human mammals has provided evidence of a highly systematic reorganization of somatotopic maps. However, there has been very little evidence regarding somatosensory reorganization subsequent to cerebral lesions in adult humans. Rapp et al. (2002) described two individuals with left hemisphere strokes who exhibited a dissociation between their ability to correctly detect tactile stimuli (light taps) delivered to the contralesional hand and their misperception of the locations of the stimuli. The misperceptions preserved the relative locations of the stimuli, resulting in systematically shifted and compressed hand representations. In the investigation reported here, we follow-up on this evidence of somatosensory plasticity and examine the continued dynamic properties of the remodelled somatotopic representations in one stroke subject.
Specifically, we investigate the extent to which these representations are affected by patterns of local stimulation. In one experiment we examine the shift in the perception of the location of tactile stimuli delivered to the contralesional hand when these stimuli are preceded by 0, 1 or 3 stimuli delivered to the forearm. We find a significantly greater downward (proximal) shift in location perception when contralesional stimulation is preceded either by 1 or 3 forearm stimulation trials versus when there are no such preceding trials. In another experiment we rule out the possibility that these effects result merely from a change in the spatial distribution of attention across experimental conditions. We discuss these results with regards to the lability of somatosensory representations after their initial reorganization.

Touch is in visual coordinates

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Introduction: The perceived position of auditory and visual stimuli shifts with head and eye position. Recently it has been shown that touches on the body also appear shifted when the head and eyes are not aligned indicating a coding system for touches that depend on the position of the eyes in the head. However, previous experiments that found eye position effects on localizing tactile and auditory stimuli required subjects to report the location of the stimuli in visual coordinates (relative to some visual scale). The transforms required by this method may have contributed to the effect of eye position reported. Therefore, we determined the effect of independently varying visual, arm, and body reference frames on the perceived location of touches using a novel technique that requires subjects to locate the position of touches relative to the arm itself.

Methods: Eye position was controlled by having subjects fixate one of four lights separated by 10° arranged from left to right. Subjects' left arms were placed over four tactors which were separated by 5 cm. The subject's arm was positioned in one of three different orientations relative to their body: across the body, straight out (away from the body), or stretched out to the side. We drew imaginary lines on each subject's forearm, dividing it into four equal segments, and asked subjects to report the segment (1-4) in which they were touched. This task did not require subjects to transform the touch into visual space.

Results: As the eyes moved from left to right, the segment of arm in which a given touch was reported, shifted towards the wrist (for the left arm). The magnitude of the shift was smaller when measured in body coordinates than previously reported using a visual measure. The orientation of the arm relative to the body did not have a significant effect on the amplitude or, importantly, the direction of the eye-position-related shift which continued to move towards the left arm's wrist as the eyes were displaced to the right. The perceived locations of the touches also varied with arm position: for both arm- and eye-related shifts, not all the areas of the arm were affected equally.

Conclusions: Shifts of the perceived locations of touches related to eye position indicate that touches may be coded in a visual reference frame. The lack of systematic errors associated with arm position suggests that there are no additional localization errors associated with updating the position of the arm in space for judgments made in body coordinates. A comparison of tactile localization judgments made in visual versus body coordinates will be discussed and a model for tactile spatial perception will be presented.

Somatotopic and spatiotopic encoding of tactile timing and motion

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Touch is a unique modality with regard to its spatial representation. Since various body parts move around dynamically, the tactile space can be represented in two coordinates, somatotopic coordinate defined by cortical topography, and spatiotopic coordinate defined in the environment. To study the computational mechanism of the central tactile processing, we investigated observers' judgments on the relationships between tactile stimulations at different skin locations. We have shown that simple temporal tasks, such as simultaneity judgment, motion detection, and interval estimation, are performed dominantly in the somatotopic coordinate (Kuroki et al. 2009 ECVP). On the other hand, our recent experimental results using tactile motion adaptation phenomenon indicated that motion direction judgment (spatio-temporal task) is performed in the spatiotopic coordinate.

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