NEST 2013

8:30-9:00 Registration, Coffee
9:00-9:10 Welcome (John Kingston)

9:10-9:35 Howie Zelaznik
Sequence Structure in Grand Slam Tennis
9:35-10:00 Michael Schutz
Does auditory feedback contribute to the effect of movement on timing perception?
10:00-10:25 *Jonathan Vaughan and Elin Lantz*
Hand Dominance, Speed-Accuracy Tradeoff, and Fitts' Law: Observations from Tool Use.
10:25-10:40 Chase J. Coelho
Comfort Trumps Hand Preference For Object Transport Tasks

10:40-11:00 Coffee and pastries

11:00-11:25 *Ramesh Balasubramaniam*
Unintentional spatial coupling between eye and hand movements
11:25-11:50 Martin Wiener
Continuous Carryover effects in Temporal Bisection
11:50-12:15 *Eve Valera*
Temporal processing in adult ADHD
12:15-12:30 *Lanyun Gong*
Cognitive Heuristics Leads to Physically Suboptimal Walking and Reaching

12:30 – 1:15 Lunch

1:15-1:40 *Julian De Freitas, Brandon Liverence, & Brian Scholl*
Visual and auditory object-based attention driven by rhythmic structure over time
1:40-2:05 *Devin McAuley*
Why are durations of deviant (oddball) stimuli overestimated?
2:05-2:30 *Scott W. Brown*
Timing, Cognitive Aging, and Executive Functioning
2:30-2:45 Chapman, K.M
One Good Turn Deserves Another: A Constraint Hierarchy for Action Selection in Bimanual Rotation

2:45-3:05 Coffee and cookies

3:05-3:30 *Psyche Loui*
Absolute Pitch: Increased Structural and Functional Connectivity
3:30-3:55 *Ahren Fitzroy*
Temporally selective attention
3:55-4:20 *Breanna E. Studenka*
Error correction in event and emergently timed tasks: further insights into the linear two two-process model

4:20-4:30 Closing remarks

Drinks: TBA
Dinner: TBA

Sequence Structure in Grand Slam Tennis

Haneol Kim, Fuwen Cai, JoongHyun Ryu, Jeffrey M. Haddad, Howard N. Zelaznik
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Abstract: When people walk and/or talk together their behaviors become coordinated. However, when performers compete, such as in dual-sport open skills, such as tennis do they coordinate or compete. In other words, is there evidence that their behaviors show evidence of an emergent property, as though the players have become linked? We report very preliminary data from an analysis of one men's semifinal tennis match (Nadal v. Federer, Australian 2012) and one women's match (Kvitova v. Sharapova, Australian 2012). We describe the long-term correlation structure of the sequence of tennis ball locations (at the point of bouncing). Based upon the alpha coefficient in a detrended fluctuation analysis (DFA) we infer that competition in these matches shows evidence of a random structure. We discuss these results relative to coordination versus competition in dual sports.

Does auditory feedback contribute to the effect of movement on timing perception?

Fiona Manning*
Michael Schutz
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Abstract: We know that moving to the beat can objectively improve the perception of timing information, particularly when auditory information is absent. When we look closely at the timing this movement we see that “better” movement (i.e., lower variability movement) may lead to better perceptual timekeeping abilities; evidence for crosstalk between auditory and motor systems. If this crosstalk is influenced by auditory feedback produced by movement, will it be disrupted when auditory feedback is removed? In a pair of experiments participants heard a sequence of isochronous beats, and were asked to identify whether the final tone after a short silence was consistent with the timing of the preceding rhythm. On half the trials, participants tapped along on an electronic drum pad, and on half the trials they were asked to listen without tapping. The beats in the sequence of Experiment 1 occurred at inter-onset intervals (IOIs) of 400ms and 600ms and the final (target) tone occurred randomly at one of five offsets (on-time, early [2] or late [2]). In the first condition of Experiment 1 the sound produced by tapping was masked using white noise and noise dampening headphones. The second condition contained regular auditory feedback. Overall, participants performed significantly better on the task when moving than listening without moving, however this effect was less pronounced when auditory feedback was masked, indicating that the feedback may play a role in timekeeping. Experiment 2 was designed to more rigorously explore the effect of movement on perception using one IOI (500ms) and two offsets (on-time and late). This experiment used similar auditory feedback conditions to Experiment 1. Again, we found an effect of movement on timing detection, however participants performed similarly with and without auditory feedback. While these initial findings seem to point to contradictory conclusions about the role of feedback in timing perception, this difference may be due to some interaction of one or both characteristics of the design. Together these experiments build on our previous work and can inform discussion of auditory feedback in sensorimotor integration.

Hand Dominance, Speed-Accuracy Tradeoff, and Fitts' Law: Observations from Tool Use.

Jonathan Vaughan and Elin Lantz
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Abstract: At NEST two years ago, we reported a quantitative extension of Woodworth's (1899) seminal observation. He demonstrated that speeded movements with the non-dominant hand (the left, for right-handers) are less accurate than movements with the dominant (right) hand at the same repetition rate, as well as being less accurate at faster repetition rates. This observation of variation in movement accuracy is complemented by Fitts's (1954; 1964) quantification of the time to move different distances to different-sized targets: Movement time is a linear function of task difficulty, expressed in terms of movement amplitude (A) and target width (W): MT = a + b log(2*A/W). Our observations on right-handers showed that the slowing of left-hand movements is proportional to the task difficulty.

We've also observed that the earlier ballistic phase of movement does not differ between hands, so that the temporal cost of moving with the left hand is confined to the later, feedback-controlled phase of moving to touch a target. Recent experiments furthermore suggest that when the task is easier, participants may mitigate the temporal cost of moving with the left hand by compromising its accuracy. The results demonstrate that participants make a sophisticated accommodation to the constraints of performance imposed by the choice of hand, consistent with recent models of hemispheric specialization.

Comfort Trumps Hand Preference For Object Transport Tasks

Chase J. Coelho [a], Cory A. Potts [a], Breanna E. Studenka [b], and David A. Rosenbaum [a]
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Abstract: Although there are usually an infinite number of ways to complete physical tasks like grasping objects and moving them to new locations, the tasks tend to be done in typical ways—for example, with the right hand rather than the left. Such consistency suggests that implicit constraints limit action alternatives. Nonetheless, a critical question is what the relative priority of the possible constraints are. Here we considered two constraints: (1) using the preferred hand; and (2) ending the object transport in a comfortable or easy-to-control posture. We asked right-handers to transport a horizontal rod whose left or right end was to be placed down into one of five targets arrayed across the workspace. In one condition, we told participants which hand to use and let them choose an overhand or underhand initial grasp. In the other condition, we told participants which grasp to use and let them choose either hand. Choices in both conditions tended to ensure comfortable or easy-to-control final postures, especially at and around the midline. However, for more lateralized locations, participants were more willing to use the ipsilateral arm in uncomfortable or hard-to-control final postures. Although comfort seems to trump hand preference for object transport tasks, these results indicate that the strength of this relative priority can be influenced by task demands.

Unintentional spatial coupling between eye and hand movements

Ramesh Balasubramaniam
Sensorimotor Neuroscience Laboratory, McMaster University, Hamilton, ON.

Abstract: Unintentional movement interference is often seen when two limbs perform spatially dissimilar tasks, such as patting one's head and rubbing one's belly at the same time. It has been suggested that this spatial interference and unintentional coupling are in part caused by motor overflow: descending motor commands interfering via projections between homologous motor areas. Here we report a spatial interference effect between eye and hand movements: effectors controlled by distinct descending motor systems. Subjects performed finger tapping to a pacing stimulus while simultaneously making repetitive horizontal saccadic eye movements. The finger's trajectory showed a lateral shift to the right when making a rightward saccade and to the left when making a leftward saccade. Said differently, vertical finger movements are unintentionally attracted in the direction of concurrently executed horizontal saccades when responses are planned or timed together. In a second experiment, subjects performed finger taps but were instructed to fixate at the center of the screen and make horizontal saccades following a target jump at unpredictable times. Here the lateral shift that accompanied the saccades was weaker and occurred only in the hand ipsilateral to the direction of the saccade. These results demonstrate that a common motor plan set up due to timing demands can produce strong movement interference even in effectors that are innervated by separate descending motor tracts.

Continuous Carryover effects in Temporal Bisection

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Abstract: Recent experimental evidence suggests that the production of temporal intervals is influenced by the temporal context in which they are presented (Jazayeri & Shadlen, 2010). A similar finding within the perceptual domain is the time-order-error, wherein the perception of two intervals *relative* to one another is influenced by the order in which they are presented. Here, we test whether the perception of temporal intervals in an *absolute* judgment task is influenced by the preceding temporal context. Human subjects participated in a temporal bisection task with no anchor durations (partition method). Intervals were demarcated by a Gaussian blob (visual condition) or burst of white noise (auditory condition) that persisted for one of seven logarithmically spaced intervals between 300 and 900ms. Crucially, the order in which stimuli were presented was determined by a path-guided De Bruijn sequence (Aguirre, et al. 2011), such that all successive interval orders were counterbalanced. The results demonstrated that performance on any given trial was influenced both by the preceding response and presented interval. Surprisingly, these two influences pushed responses in opposite directions, such that responses were both assimilated by the previous response and contrasted away from the previous duration. The degree of these two prior influences was negatively correlated, such that subjects with a larger decision bias showed a smaller perceptual asymmetry. Furthermore, auditory-marked intervals were characterized by a stronger influence of prior interval, whereas visual intervals exhibited greater prior decision bias. These findings extend temporal context to absolute perceptual judgments, and demonstrate that a single exposure to an interval can shift the perception of a subsequent interval.

Behavioral and Imaging Timing Abnormalities in Adult ADHD

Eve Valera
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Background: Attention-deficit/hyperactivity disorder (ADHD) is characterized by age inappropriate symptoms of inattention, and/or hyperactivity or impulsivity, and is estimated to affect approximately 5% of adults. A large number of ADHD individuals have been found to have perceptual and motor timing abnormalities that have been argued to be fundamental to impulsiveness, a core symptom of ADHD. Although there is an established literature on timing abnormalities in ADHD children, there are only a few studies on adults, and overall only a handful of studies examining timing abnormality neural substrates.
Methods: We used a paced and unpaced finger tapping task with functional MRI as well as the International Cooperative Ataxia Rating Scale (ICARS) with structural MRI to assess for possible motor timing abnormalities and their neural substrates in ADHD adults and matched controls.
Results: Although mean tapping rate was the same for ADHD and control adults, clock intrasubject variability was higher for ADHD adults, and ADHD adults showed several areas of reduced activation in timing networks for both paced and unpaced tapping. ADHD adults showed significantly higher scores for total ataxia, posture and gait disturbances, and limb kinetic measures. Ataxia scores were negatively correlated with regions in frontal gyri as well as the posterior cerebellum (trend level). Ataxia scores were also positively correlated with clock, but not motor, intrasubject variability of the unpaced tapping.
Conclusions: These data show that timing abnormalities in ADHD persist into adulthood and have both functional and structural neural underpinnings. Implications will be discussed.

Cognitive Heuristics Leads to Physically Suboptimal Walking and Reaching*

Lanyun Gong and David A. Rosenbaum
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Abstract: Although it is well known that cognitive heuristics lead to sub-optimal decisions in economic contexts (á là Kahneman and Tversky), in perceptual-motor tasks decisions have been found to be optimal. Here we report that sub-optimal choices also arise in simple physical actions, apparently also because of cognitive heuristics. We asked participants to decide whether to pick up and carry either a left bucket or a right bucket to a target. Participants did more physical work than needed in this task, choosing the bucket that was close to the starting point but far from the target rather than the reverse.

Our result points to tighter links between higher-level decision making and lower level perceptual-motor planning than have so far been appreciated.

Visual and auditory object-based attention driven by rhythmic structure over time

Julian De Freitas, Brandon Liverence, & Brian Scholl
Yale University

Abstract: Objects often serve as fundamental units of visual attention. Perhaps the most well-known demonstration of object-based attention is the 'same-object advantage': when attention is directed to one part of an object, it is easier to shift to another part of the same object than to an equidistant location on a different object. Does this effect apply only to spatial shifts of attention, or can same-object advantages also occur based on purely temporal structure? We explored this question using rhythmic stimuli, composed of repeating "phrases" (of several seconds each), and presented either auditorily or visually. Auditory stimuli consisted of sequences of tones (of a single frequency), temporally arranged to yield regular (and independently normed) rhythms. Visual stimuli consisted of the same rhythms "tapped out" by a moving bar on a computer screen. Subjects detected infrequent high-pitch probe tones in the auditory experiment, or high-luminance probe flashes in the visual experiment. Probes were preceded by temporally-predictive cue tones (or flashes), so that each cue-probe pair either occurred within a single phrase repetition (Within-Phrase) or spanned a phrase boundary (Between-Phrase), with the brute cue-target duration equated. In both modalities, subjects detected Within-Phrase probes faster than Between-Phrase probes - and further control studies confirmed that these effects weren't driven by the absolute probe positions within each phrase. Thus same-object advantages are driven by temporal as well as spatial structure, and in multiple modalities. In this sense, "object-based visuospatial attention" may not require objects, and may not be fundamentally visual or spatial. Rather, it may reflect a broader phenomenon in which attention is constrained by many kinds of perceptual structure (in space or time, in vision or audition).

Why are durations of deviant (oddball) stimuli overestimated?

J. Devin McAuley, Elisa Kim, and Katherine Jones
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Abstract: Durations of deviant (oddball) stimuli embedded within a series of otherwise identical (standard) stimuli tend to be overestimated. Past accounts of the oddball effect have proposed that overestimation of the duration of an oddball is due to the fact that the oddball event is unexpected. This talk will provide support for the opposite interpretation, namely that it is not the unexpected nature of the oddball per that drives the oddball effect, but rather the effect is driven (at least partly) by the increased expectation that an oddball will occur as the sequence unfolds in time. Oddballs in later serial positions compared to earlier serial positions afford greater temporal preparation; hence, they are responded to more quickly, and tend to be overestimated to a greater degree than oddballs in earlier serial positions. Converging support for this hypothesis will be provided from another series of studies where we varied the onset timing of oddball stimuli relative to a context rhythm.

Timing, Cognitive Aging, and Executive Functioning

Scott W. Brown, Meghan K. Jackson, and Tammy M. Johnson
University of Southern Maine

Abstract. Younger (*M* age = 22 years) and older (*M* age = 67 years) subjects performed timing and executive tasks under single-task and dual-task conditions. The timing task was serial temporal production and the executive task was the *number-letter task*, which invokes attentional switching and inhibitory control functions. Temporal productions for both age groups were longer and more variable under dual-task conditions compared with single-task conditions. Both groups also showed that accuracy on the number-letter task declined from single-task to dual-task conditions. However, response times (RTs) on the executive task were equivalent under single-task and dual-task

conditions for the younger subjects, whereas the older subjects showed a sharp increase in RTs in the dual task. These data demonstrate bidirectional interference between temporal and executive task performance, with a stronger bidirectional interference effect exhibited by the older subjects. The results support the idea that timing is reliant upon the same attentional resources involved in executive functioning.

One Good Turn Deserves Another: A Constraint Hierarchy for Action Selection in Bimanual Rotation

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Abstract: The essence of skilled performance is the capacity to choose and carry out actions flexibly. For such flexibility to be possible, individuals must be able to prioritize constraints for actions differentially according to task demands. Despite such flexibility, there may be a default prioritization of constraints, with some constraints being more important than others for a given task. Previous research has shown that constraints on discrete manual action selection include the comfort of the initial grasp posture, the comfort of the final grasp posture, the preference to pronate in rotation, and the preference for bimanual symmetry. The current experiment explored these constraints in three experiments using a bimanual rotation task. In each experiment, participants aligned colored squares on two wooden disks by grasping and rotating two handles. In Experiment 1, we examined the relative priority of end-state comfort, initial-state comfort, and pronation. In Experiments 2 and 3, we tested the relative priority of end-state comfort and symmetry of rotation. We found that end-state comfort and symmetry were both important constraints and their relative importance shifted in different experiments based on the task demands. Our results demonstrate the utility of a constraint-based hierarchy to understanding the way human cognition addresses the degrees of freedom problem.

Absolute Pitch: Increased Structural and Functional Connectivity

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Abstract: Absolute Pitch (AP) is a unique phenomenon characterized by the ability to name the pitch class of any note without a reference. In recent years, AP has become a model for exploring nature-nurture interactions. While past research focused on differences between APs and controls in domains such as pitch naming, little is known about how AP possessors tackle other musical tasks. We asked whether AP subjects possess different brain structure or recruit different brain resources from matched controls during a task in which APs are anecdotally similar to controls: the task of emotional judgment. Functional MRI and Diffusion Tensor Imaging (DTI) were acquired from 15 APs and 15 controls (matched in age, sex, ethnicity, and musical training). In the fMRI portion of the study, subjects listened to musical sound clips and rated the arousal level of each clip on the scale of 1 (low-arousal) to 4 (high-arousal), relative to a silent rest condition. Behavioral results showed no significant difference between APs and controls. However, a second-level contrast between music and rest conditions showed that APs recruited additional neural activity in left Heschl's gyrus (primary auditory cortex). Functional connectivity analysis using graph theory showed increased connectivity in APs, especially in the left superior temporal gyrus (secondary auditory cortex). DTI showed that APs had larger connections between the left posterior superior temporal gyrus and the left posterior middle temporal gyrus, regions thought to be involved in sound perception and categorization respectively. Despite a behavioral task designed to minimize differences between APs and controls, we observed significant between-group differences in brain activity and connectivity. Results show that AP possessors have increased structural and functional connectivity in perisylvian regions, and recruit these regions as extra neural resources for perceiving and categorizing musical sounds. These results suggest that AP may be a case of hyperconnectivity, providing a link between AP and other populations that are reported to have increased incidence of absolute pitch, such as autism spectrum disorders, synesthesia, and cases of exceptional ability.

Metric strength directs a patterned allocation of attention across time

Ahren Fitzroy
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Abstract: Selectively attending to portions of an incoming sensory stream based on certain distinguishing aspects can help us make sense of what would otherwise be overwhelming amounts of information. Previous research on selective attention has largely focused on the use of spatial selection, but recent evidence demonstrates that people also use time of stimulus presentation as an attentional selection criterion. Event-related brain potential (ERP) research has shown that temporally selective attention affects early perceptual processing as indexed by the amplitude of the first negative peak 100 ms after sound onset (N1) in a manner similar to that observed for spatially selective attention. Further, physically identical stimuli elicit larger amplitude N1s when presented at times of metric strength in both stimulus-inherent and listener-imposed metric hierarchies, suggesting that metric structure guides the allocation of attention across time. These findings are consistent with the predictions of Dynamic Attending Theory (DAT). Multiple oscillator variants of DAT predict that hierarchically organized exogenous rhythms will induce a hierarchical distribution of attention across time; the present studies employ subject-initiated hierarchical rhythmic structures to test this hypothesis. Larger amplitude N1s were elicited by tones on the first beat of subjective measures, suggesting a global attentional preference for downbeats. Differences in N1 amplitude among non-downbeats indicate that attention is not equally distributed among weaker beats, and suggest attention may be allocated in a hierarchical manner during quaternary meter perception. These results indicate that metric structure guides the allocation of attention across time in a patterned manner as predicted by DAT.

Error correction in event and emergently timed tasks: further insights into the linear two two-process model

Breanna E. Studenka
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Abstract: Sensori-motor synchronization requires both maintaining proper period, and proper phase with respect to temporal events (e.g., tone onsets). Both period and phase maintenance are thought to require an internal representation of time. When the period of a rhythm changes, both phase and period correction processes serve to guide behavior to re-synchrony. Research supports that smoothly produced movements (e.g., circle drawing) are difficult to synchronize with a rhythm due to diminished information regarding cycle endpoints. Tactile feedback events inserted at one point on the circle trajectory improved error correction induced by a phase shift suggesting that perceptual information aids clock-like timing in smoothly produced tasks. In the presented study, we induced a period shift during rhythmic circle drawing, and examined how re-synchronization was established. Additionally, tactile feedback events were added to test whether perceptual events might aid period and phase correction. Subjects better re-established proper phase with the new metronome when tactile feedback was available. Furthermore, for circle drawing, our data were better modeled by phase correction that decreased after the first adjustment for positive perturbations and increased after the first adjustment for negative perturbations (reflecting the influence of inertial properties of continuous circle drawing). This finding adds to the understanding of the two-process error correction model for tasks other than tapping, and argues for the importance of accounting for differences in perceptual detection and kinematic characteristics of movement (e.g., inertia) in timing models.