

Accepted Abstracts 2012

ERPs and gamma oscillations modulated by visual awareness and task-relevance

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A primary challenge in identifying neural correlates of visual awareness is to isolate neural activity associated with awareness from activity associated with preconscious and post-perceptual processing. Here, we adapted an inattentional blindness paradigm to allow concurrent recording of the EEG. Event-related potentials (ERPs) and gamma oscillations were compared across three conditions: Stimuli were task-irrelevant and not-perceived, task-irrelevant but perceived, or task-relevant and perceived. A negative amplitude shift in ERPs from ~200-300ms was uniquely associated with awareness. An earlier ERP negativity was present in all conditions, including inattentional blindness, thus indexing a preconscious stage of visual processing. P3-like components, as well as induced gamma oscillations, were only evident when stimuli were relevant to the task, therefore suggesting that these patterns of activity reflect post-perceptual stages of processing as opposed to awareness per se. Results will be discussed in the context of the search for neural signatures of conscious perception.

Why is it hard to read Arabic?

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Previous research has shown that reading in Arabic is slower than reading in other languages, even among skilled native Arabic speakers. In addition, the process of reading acquisition by beginning readers is slower than in other languages. We present three possible sources of these phenomena from both a psycholinguistic and a neuropsychological perspective. We examine the effects of diglossia (the fact that children learn to read a language in which they are not fluent), and the visual characteristics of Arabic orthography on reading acquisition, and suggest that the particular combination of grapheme-phoneme relations and visual characteristics of Arabic orthography result in a specific reading strategy among skilled readers that involves the cerebral hemispheres differently in Arabic than in Hebrew or English.

Within- versus cross-dimensional capture in fixed-feature visual search

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Recent ERP findings indicate that colour singletons fail to capture attention when observers search for a less salient shape that remains fixed across trials. This is consistent with the dimensional weighting account, according to which signals on the relevant (shape) and irrelevant (colour) dimensions are enhanced and suppressed, respectively. The goal of the present experiments was to examine the influence of prior knowledge of a target for over-riding a more salient distractor in a compound search task, when the target and distractor exist within the same visual dimension (colour versus colour; Experiment 1) and across different visual dimensions (shape versus colour; Experiment 2). More interference was found in the within-dimensional condition than the cross-dimension condition (18 msec vs. 7 msec). Both the within- and cross-dimensional targets elicited an N2pc component (indexing selection) and the distractor elicited a PD component (indexing suppression). In the within-dimensional experiment, the amplitude of the N2pc varied as a function of the proximity of the distractor to the target. These results indicate that when dimensional weighting is not a viable selection strategy, the visual system suppresses the location of the distractor while selectively processing the target.

Applying internet-based research methods to digitize R. E. MacLaury's Mesoamerican Color Survey

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One of the most widely cited datasets in Psychology is the "World Color Survey" (or WCS). The WCS stems from the classic 1969 theory of cross-cultural color categorization published by Berlin and Kay (Basic Color Terms: Their Universality and Evolution.) It contains color categorization and naming data from 110 linguistic societies across the globe. The raw WCS data were painstakingly hand-transcribed and digitized over years by just a few researchers, and has since been referenced across a range of psychological, linguistic, and cognitive science pursuits. Recently an equally valuable MesoAmerican Color Survey (or MCS) has become available which includes 116 surveyed societies from Mesoamerica. The MCS substantially extends the scope and wealth of information provided for by the WCS. A project to transcribe the MCS data into an open-access digital database for general use by students and research scientists is discussed. The project employs internet-based research methods to address the challenges inherent in the labor-intensive transcription and coding of the MCS data.

Saliency guides selection of relevant visual stimuli

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According to the automatic-capture hypothesis of visual attention the most salient item in a display will always attract attention first, even if observers know that the item is a task-irrelevant distractor. However, recent ERP results from studies investigating the N2pc, a neuro-electric index of attentional selection, have demonstrated that observers can prevent selective processing of salient-but-irrelevant distractors when target and distractor features are fixed over trials. Here, we investigated whether observers would deploy attention initially to the most salient item if the task required evaluation of both a salient color singleton (previously used as an irrelevant distractor) and a less-salient form singleton. In other words, we asked whether stimulus saliency would determine the order in which observers would evaluate the two task-relevant singletons. In our main experiment, we presented a color singleton (red circle) and a form singleton (green diamond) among four identical nontargets (green circles) on every trial. Each of the six items contained a horizontal or vertical line, and participants were asked to indicate whether the orientations of the lines contained in the two singletons were the same or different. Although there was no requirement to attend to either singleton first, we found that the salient color singleton elicited an earlier and larger N2pc than did the less salient form singleton. These results indicate that when salient items are relevant to the task at hand, observers reliably attend to those items before attending to less salient items.

Saving Free Will From Science

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The classic experiment by Libet showed that the readiness potential (RP) preceded the moments of intention (W) and action (M). These findings deny conscious intention and free will as the cause of action. But is this claim truly valid? We approached this question by testing the authenticity of M and W. In Exp1, participants pressed a button that elicited a delayed tone. Here M and W shifted systematically with the time of the tone rather than remaining constant. In Exp2, the tone was used to falsely inform the participants of their speeded performance. M shifted in accordance with the false feedback. In Exp3, M and W varied when using different timing instruments or parameters. In Exp4, M varied across subpopulations. Our results suggest that the moments of intention and action are retrospectively inferred and cannot be bound to the RP. Thus, Libet's findings cannot invalidate the existence of free will.

Understanding variation in working memory capacity: A translational approach

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Everyday functioning requires the coordination of both working memory (WM) and attentional selection. Understanding this relationship can be facilitated through translation research on people with schizophrenia (PSZ), a population that shows reliable reductions in WM capacity. Here we measure event-related potentials in both PSZ and matched controls during a lateralized change detection task that assessed WM capacity. We focused on contralateral delay activity (CDA), which correlates with WM capacity in healthy individuals, and found the expected pattern of results in controls. However, the typical relationship between CDA and WM was not present in PSZ. Moreover, PSZ had a greater CDA amplitude than controls at memory load 1. In PSZ, this tendency to be more selective of the to-be-remembered object in the face of one contralateral distractor correlated with decrease in WM capacity when memory load increased from 3 to 5 objects. These results are consistent with findings from other paradigms suggesting that schizophrenia may be associated with overselection. We propose that failure to distribute attention broadly may underlie WM impairment in schizophrenia. More generally, these findings speak to the important link between WM and attentional processes.

A Neurocomputational Theory of Attentional Selection in Multielement Displays

Philip L. Smith* & David K. Sewell The University of Melbourne (*Presenting author)

We generalize the integrated system model of Smith and Ratcliff (Psychological Review, 2009) to obtain a new theory of attentional selection in multielement visual displays. The theory proposes that attentional selection occurs via competitive interactions among detectors that signal the presence of task-relevant features at particular display locations. The outcome of the competition, together with attention, determines which stimuli are selected into visual short-term memory (VSTM). Decisions about the contents of VSTM are made by a diffusion-process decision stage. The selection process is modeled by coupled systems of shunting equations, which perform gated where-on-what pathway VSTM selection. The theory provides a neurocomputational account of key findings from attention tasks with near-threshold stimuli. These are: (1) the success of the MAX model of visual search and spatial cuing; (2) the double-target detection deficit; (3) redundancy costs in the post-stimulus probe task; (4) the joint item and information capacity limits of VSTM, and (5) the object-based nature of attentional selection. We argue that these phenomena are all manifestations of an underlying competitive VSTM selection process, which arise as a natural consequence of our theory.

Müller-Lyer Illusion Reconsidered

Karen B. Schloss & Bill Prinzmetal*, University of California, Berkeley (*Presenting author)

The Müller-Lyer illusion is one of the most familiar and dramatic of the classical visual illusions. The most popular theories of the Müller-Lyer illusion involve the assumption that in, some sense, the wings-in (arrowhead) portion are processed as closer to the observer than the wings-out version (arrow tail). There are several different forms of this theory (e.g., Gregory, Gillam), but they all assume that the wing-in forms a convex shape in the world while the wings-out form a concave shape.

In three experiments we challenge the assumption that the perception of convexity (for wings-in) and concavity (for wings-out) are necessary for the Müller-Lyer illusion. In Experiment 1, we demonstrated that the wings-out portion of the illusion yields as large an illusion when it is part of a convex object as when it is shown alone. In Experiment 2, a wings-in configuration located at a concavity in a natural scene still makes a line appear shorter, relative to a control line directly below it on the same surface. In Experiment 3, we demonstrated both wings-out and wings-in portions of the illusions when the wings-in are part of a concave surface and the wings-out are part of a convex surface. These results are counter to the most popular explanations of the Müller-Lyer illusion. It is unnecessary to associate a wings-in stimulus with a convexity and wings-out with a concavity to obtain a Müller-Lyer illusion.

Impact of a test-enhanced-learning experience on subsequent encoding-retrieval strategies in verbal, mathematical, and visuospatial memory

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After initial study of new material, taking a practice test produces better performance on a final or criterion test than does studying again, despite an overwhelming preference for studying again among students. The lion's share of research on this "test-enhanced learning" effect has been with verbal materials such as word lists and passages of text. However, test-enhanced learning has been demonstrated in other cognitive domains, including acquisition of resuscitation skills by medical students, memorizing the spatial layout of a 3D virtual-reality environment or a 2-D map, and as we reported last year, learning to solve a novel type of math problem called "modular arithmetic". These demonstrations are interesting, but to be theoretically and practically useful, they need to be systematized into a coherent framework for understanding similarities and differences across domains. One of the most important features of test-enhanced learning is that it induces transfer: Facilitation extends beyond the particular contents of the initial learning episode that were explicitly queried or overtly produced during the practice test. People remember more of the contents that were

not explicitly queried or produced as well as more of those that were. We wondered what other types of transfer might occur. Perhaps preferences for test-preparation techniques might shift away from restudying and toward practice testing. This meaning of “transfer” is common in organizational psychology: whether people taught a new technique in a training environment actually use it out in the world. The investigation we report here aims at yet a third type of transfer, asking whether a test-enhanced learning experience might alter acquisition strategies and processes per se. Would a single cycle of encoding and retrieval of new learning be more successful even in the absence of any kind of test-preparation activity at all intervening between the encoding processes of initial study and the retrieval processes of the final criterion test? We have been seeking such “altered-processing transfer” in each of three domains: verbal (reading and remembering a brief text), mathematical (learning to do modular arithmetic), and visuo-spatial (studying and drawing from memory a spatial array of four complex visual shapes). In this talk, we will describe the experimental design for isolating altered-processing transfer and report the nature of the observed transfer effects. At the time of writing this abstract, we have seen facilitation of subsequent processing in free recall accuracy but not processing time when remembering text, and in solution time but not accuracy in solving modular arithmetic problems. Data are now being collected for remembering visuo-spatial arrays and will be included in the talk.

Beta-band oscillatory activity in the human brain related to perception, attention, memory, and action: Is beta the new gamma?

Pierre Jolicoeur, Stephan Grimault, Ulysse Fortier-Gauthier, Christine Lefebvre, Canada Shannon O'Malley U of Montreal, Roberto Dell'Acqua U of Padova, Italy

Oscillatory activity in the neighbourhood of 23 Hz, in the so-called beta-band, has been found to reflect various perceptual, cognitive, and response functions. In this talk we review recent results from our laboratory suggesting that a greater decrease in beta-band amplitude tends to be associated with a greater engagement of processing capacity. Our findings suggest some general principles that could enable the field to interpret changes in beta-band activity across a variety of paradigms and tasks and relate them to underlying cognitive function including perception, attention, memory, and action.

Stability of visual working memory representations across changes in eye position

Brittany J. Dungan & Edward K. Vogel, University of Oregon

One theory of how we perceive a stable visual world despite changes in eye position is that we use visual working memory (VWM) to integrate object information from across fixations. However, given the contralateral organization of VWM in the brain, it's unclear how eye position changes that cause remembered objects to shift across visual fields would affect which hemisphere will continue to maintain the object representation. Either the objects in VWM would initially be represented in the contralateral hemisphere, but would then shift to the opposite hemisphere following the change in eye position, or continue to be represented in the initial contralateral hemisphere despite the change in eye position. To test this, we recorded event related potentials while subjects performed a change detection task. Subjects fixated a central cross prior to the memory array onset and either maintained central fixation throughout the trial or were cued to refixate a new position to the left or right of central fixation during the retention period, thus bringing the objects into a new visual field. The results showed a sustained contralateral delay activity (CDA) that persisted in the original contralateral hemisphere even after the subjects had refixated.

Transfer of categorical visual information

Shlomo Bentin, The Hebrew University of Jerusalem

Stimuli presented in one visual hemifield are usually transferred from the contralateral to the ipsilateral hemisphere. However, it is not evident that such transfer always occurs and, if it does, what is the kind of information that is transferred. Presenting faces and chairs randomly in the right or in the left visual hemifield while healthy participants monitored the screen for occasionally appearing flowers elicited a robust bilateral N170-effect (N170 elicited by faces was larger than that elicited by watches), regardless where the stimuli were presented. The latency of the N170 was faster by about 10 ms in the hemisphere contralateral to the stimulus location. When the N170 elicited by two faces presented simultaneously one in the left and one in the right visual field were compared with two simultaneously presented chairs, the bilateral N170 effect occurred at the same latency in each hemisphere. However, when a face and a chair were simultaneously presented one in the left and the other in the right visual field, comparing such pairs with stimuli composed of two chairs yielded an N170-effect only in the hemisphere contralateral to the location of the face. In the hemisphere contralateral to the chair, an N1 emerged, which did not distinguish the chair-face pair from the chair-chair pair. This pattern suggests that when each hemisphere receives different information and the task requires only a shallow categorization, there is no transfer of categorical information from one hemisphere to another. By contrast, when the task required individual face recognition and identification, bilateral face-chair stimuli elicited bilateral N170-effects. It is assumed that when the task involves deeper levels of analysis (such as person identification) the hemispheres should

cooperate and categorical information would be transferred even with bilateral stimulation.

Attenuation of the predictable sensory consequences of actions: Does the action effect have to be self-generated to become attenuated?

John A. Dewey & Thomas H. Carr, Michigan State University

Sensory attenuation refers to the phenomenon that self-generated stimuli are often perceived as less intense than identical but externally generated stimuli. Such effects are usually explained in terms of predictive forward models that attenuate the predictable sensory consequences of actions (action-effects). An unsettled question is whether merely observing another agent performing a familiar action may also trigger a forward model with attendant sensory attenuation, or alternatively, if a motor signal is necessary. We conducted three experiments to investigate the hypothesis that sensory attenuation does not depend on a motor signal per se, but only on the predictability of the action-effect. In Experiment 1, perceived speed of self-triggered visual action-effects was attenuated (slower) compared to action-effects triggered by another human or the computer. In Experiment 2, we found that differences in perceived speed of self, other, and computer triggered action-effects remained even when each condition was preceded by a Go signal to make the onset of the action-effects equally predictable for all conditions. In Experiment 3 (under way), I will investigate the related hypothesis that unexpectedly incongruent action-effects are perceived to be extra intense compared to a context with equal proportions of congruent and incongruent action-effects. This would suggest a continuum where the more predictable the action-effect is, the more it becomes attenuated.

Extracting Visuo-spatial Working Memory Processes from Rats' Target Object Recognition Performance in a Foraging Task

Jerome Cohen, Varakini Parameswaran, Mariam Arain, and Corrine Keshen, University of Windsor

We describe three studies from our laboratory that examine rats' object recognition performance within a foraging context that reveal their underlying visuo-spatial working memory processes. In all three studies, rats must first sample three of four experimenter-selected objects before being allowed to find the fourth, target object within the array (patch). By manipulating the location of the test array and objects within the array and of the relevance of objects' non-spatial attributes in probe trials, we were able to determine how rats process and represent a target object's various features in their working memory. Our findings more clearly demonstrate the limited capacity aspect of rats' visuo-working memory and how rats retrieve different information of a missing object. We discuss how this more naturalistic, free-ranging foraging preparation may allow for more reliable and valid comparisons of visuo-spatial working memory processes between different animal species.

Ten Minute Talks

Zombies, Predators, and Pleasantness! Can Survival Processing Effects be Attributed to Arousal?

Lucy J. Troup, Nicholas C. Soderstrom, Colorado State University, Maia Nguyen, Dickinson College, Jerimiah Lujan, Colorado State University

Recall is improved when items are processed in terms of their survival utility, known as the survival processing effect (Nairne & Pandeirada; 2010). This has been linked to evolutionary theory, Weinstein, Bugg, and Roediger, (2008). Soderstrom and McCabe (2011) showed that problems never faced by our ancestors (i.e., evading zombies) showed better recall compared to the standard ancestral scenario. A replication of Soderstrom and McCabe (2011) using a within-subjects design, was conducted with measures to determine if general survival processing effect is mediated by arousal. Results supported the general survival processing effect, both zombie condition and standard survival scenario increased recall compared to rating words for pleasantness. This further challenges the specificity of the ancestral priorities framework, suggesting that the evolutionary basis for memory may not provide an accurate account of elevated recall effects. Explanations of the zombie effect include "bizarreness". This characteristic of studied materials is known to boost memory performance, particularly when using within-subjects designs (McDaniel & Einstein, 1986). Trends found in biophysical data point to arousal in the survival processing effect.

Neural mechanisms underlying perceptual integration in object perception

Anastasia V Flevaris, UCSD, Antígona Martínez, UCSD & Nathan Kline Institute, & Steven Hillyard, UCSD

Object perception depends not only on physical stimulus properties but also on internal factors including the observer's perceptual state. We compared neural activity elicited by varying perceptions of the same physical image – a bistable moving image in which perception spontaneously alternates between dissociated fragments and a single, unified object. A time-frequency analysis of EEG changes associated with the perceptual switch from object to fragment and vice versa revealed greater alpha reduction accompanying the switch to object-percept than to fragment-percept. Recordings of event-related potentials elicited by irrelevant probes superimposed on the image revealed enhanced sensory processing of these probes when they appeared to be contained within the perceived unitary object. These data support the hypothesis that objects attract attention and enhance the representation of elements within their boundaries. Importantly, the perceptual "object" in this case emerged as a function of the perceptual state of the viewer.

Free will and car crashes

Thomas J. Ayres

It is generally assumed that emergency avoidance maneuvers (such as swerving or braking to avoid an impending automotive collision) follows from a sequential process such as hazard detection --> hazard identification --> decision making --> response programming. Such a logical model implies a crucial role for conscious perception/cognition. Consideration of findings from actual emergencies, however, belies this simple scheme. In particular, in many cases drivers involved in collisions often report that they never saw the obstacle until the moment of impact (and therefore were unable to commence any avoidance response), despite physical evidence that braking or swerving began at or even before the impact ñ indicating that information processing must have begun on the order of 1 second or more prior to impact. Findings and implications will be discussed in terms of perception/action dissociation and the role of conscious (willful) cognition in speeded vs. reasoned responses.