Perceptual technologies talks. Program.

FACOLTÀ DI PSICOLOGIA

Laboratory of Action, Perception & COgnition

Tuesday June 1st 2021, h 9:00 – 18:00, room Eraclito, in streaming (https://intranet.unisr.it/live/)

Morning, Perception and attention (in Italian). Speakers:

09:00 **Alessandro Rizzi**, Dipartimento di Informatica – Università degli Studi di Milano
«Del perché il colore non è reale»

11:00 **Elisa Santandrea**, Dipartimento di Neuroscienze, Biomedicina e Movimento – Università degli Studi di Verona
«Distrarsi è bene, non distrarsi è meglio: meccanismi neuro-cognitivi della distrazione e della capacità di difendersi da essa»

Afternoon, Neural control and plasticity of eye movements. Speakers:

14:00 **Yoram Bonneh**, School of Optometry and Vision Science – Bar-Ilan University, Israel
«What can involuntary eye movements tell us about brain processing?»

15:30 **John Semmlow**, Rutgers University – Piscataway, NJ USA
«Vergence eye movements»

17:00 **Tara L. Alvarez**, New Jersey Institute of Technology – Newark, NJ USA
«Neuroplasticity of vergence eye movements»

Alessandro Rizzi.

Del perché il colore non è reale.

La sensazione di colore è una parte integrante della nostra rappresentazione interna del mondo, ci è familiare a tal punto da percepirla come proprietà oggettiva delle cose intorno a noi. In realtà non solo non lo è, ma le caratteristiche di non-oggettività sono funzionali a compensare delle lacune precise del nostro sistema visivo ed ecologicamente sono essenziali alla nostra sopravvivenza. Ho usato il termine *non-oggettività* e non il termine *soggettività* perché il colore non è soggettivo. E' una proprietà del nostro sistema visivo fortemente condivisa tra tutti gli esseri umani. Ci sono pochissime differenze intersoggettive sul come vediamo i colori. Anche se poi l'esperienza può creare delle differenze percettive, la sensazione di colore è sostanzialmente la stessa, anzi vi sono meccanismi visivi ancora poco compresi che stabilizzano la sensazione di colore anche a fronte di differenze molto importanti nella biologia retinale. Tutti questi aspetti sono tra loro collegati ed aumentano la nostra capacità di estrarre informazione visiva dall'ambiente.

Elisa Santandrea.

Distrarsi è bene, non distrarsi è meglio.

Siamo costantemente bombardati da stimoli sensoriali, molti di più di quelli che la nostra mente riesce ad elaborare in un dato momento. Nonostante l'*attenzione selettiva* ci permetta di selezionare le informazioni rilevanti e di ignorare quelle irrilevanti, consentendoci in ultima analisi di mettere in atto comportamenti finalizzati ad uno scopo, possiamo essere vittime della *distrazione*. Stimoli irrilevanti, ma salienti dal punto di vista percettivo oppure motivazionale-emozionale, riescono a prendere il sopravvento, in quanto la distrazione ha un profondo significato neurobiologico. Al contempo, però, la distrazione può peggiorare sensibilmente le capacità cognitive e alterare il senso di realtà; per tale ragione, esistono meccanismi neuro-cognitivi dedicati alla soppressione attiva dei distrattori salienti. Oltre ad individuare alcuni dei correlati nervosi di tale funzione attenzionale di filtraggio, studi recenti ne hanno evidenziato le prerogative funzionali, in particolare la forte tendenza ad essere plasmata dall'esperienza.

Yoram Bonneh.

What can involuntary eye movements tell us about brain processing?

Our eyes are never still, exhibiting a rich repertoire of oculomotor behavior, some of which with well-established functions. Others, such as microsaccades (small saccades at fixation), spontaneous eye-blinks, and ocular drift are largely involuntary and appear stochastic and arbitrary, but have been recently found related to cognitive processes and attention. In this talk, I will present evidence that links these involuntary eye movements to a general "ocular freeze" effect or an "oculomotor inhibition" (OMI) mechanism that presumably turns-off or reduces oculomotor activity while processing previous stimuli. I will show that the time-course of the OMI could be used as a proxy for the time-course of processing sensory events, providing implicit and precise measures for perceptual saliency as well as surprise without explicit behavior. This allowed us to measure sensory saliency (contrast and spatial-frequency of flashed stimuli, pitch difference of brief sounds) in passive viewing by just looking at the onset times of microsaccades and eye-blinks (Bonneh et al, JOV 2015, 2016), or analyzing the slowdown of smooth pursuit, with shorter OMI found for more salient stimuli. In contrast, we find longer OMI for "surprise" in the identity as well as time of items in sequences presented in passive viewing, with the OMI proportional to the "prediction error" as computed in a simple quantitative model. Finally, I will show that the phenomena of oculomotor inhibition could be used to study language processing and ADHD, as well as to obtain implicit cognitive measures from non-communicating individuals, such as non-verbal autistic and patients with disorder of consciousness.

John Semmlow, Tara L. Alvarez.
Vergence eye movements

Eye movements are utilized to enter visual afferent sensory information to the brain. The development of foveal vison requires that the eyes move, in tandem, quickly and accurately to view targets of interest. Eye movements are used in many critical daily skills such as reading, and visual problems can negatively impact a person's professional, academic, or recreational activities.

The evolution of binocular vision provided superior vision, but further required the eyes to move inward and outward quickly with high positional accuracy. The brain faced the difficult task of achieving both speed and accuracy through neural processes burdened with inherent biomechanical and neuronal delays. High positional accuracy could be achieved using visual feedback, but a feedback control system that includes delays will repeatably overshoot the desired target unless eye movements were quite slow. Conversely, the brain could move the eyes quickly using a preprogramed strategy where the eyes are moved using predetermined muscle activations, but such movements would not always be very accurate. In the face of this dilemma, the brain uses both strategies: preprogrammed and feedback control. In version (tandem) movements, this dual-strategy approach is implemented using two different types of eye movements: preprogrammed saccades and feedback controlled smooth pursuit. In the vergence (inward and outward) movements, the two strategies are combined into a single smooth movement where an initial preprogramed movement is "fine-tuned" by a later feedback-controlled response.

Here we present experimental evidence for a "dual-mode" neural strategy to control vergence eye movements. Preprogramed movements will have a fixed relationship between the maximum speed of a movement (i.e., its velocity) and its size (i.e., amplitude). In the saccadic system, this relationship is known as the "main sequence." We show here that an isolated portion of the initial vergence response to a step-like change in target position has such a fixed relationship between the movement amplitude and velocity. As mentioned above, a feedback control system might show small oscillations if high positional accuracy must be maintained. We present experimental evidence of such oscillatory behavior in the late vergence response after the movement has achieved its final position. Isolation and quantitative identification of the two components of vergence eye movements provides new and powerful tools to diagnosis and understand the clinical disorders. Binocular dysfunctions can be severely debilitating in a society that is consistently evolving to become more dependent on small handheld devices such as mobile phones, tablets, and computers.

Tara L. Alvarez, Mitchell Scheiman, Cristian Morales, Suril Gohel, Ayushi Sangoi, Elio M. Santos, Chang Yaramothu and John Vito d'Antonio-Bertagnolli.

Neuroplasticity of vergence eye movements

Neuroplasticity facilitates survival of a species via adaptation through intrinsic and extrinsic stimuli. Eye movements are critical for the brain to receive visual afferent stimuli. Specifically, vergence eye movements (the inward or outward rotation of the eyes used for binocular coordination), enable the perception of objects located at different spatial depths. Binocular coordination is critical for near work such as reading especially for small handheld devices. Convergence insufficiency (CI) is the most common binocular dysfunction affecting between 4% to 20% of the population depending on age and negatively impacts academic, professional, and recreational activities because visual symptoms include blurry or double vision, headaches, eye strain, pulling around the eyes, or the need to reread text. CI responds well to office-based vergence accommodative therapy (OBVAT) composed of twelve one-hour sessions where about 75% of children and young adults experience remediation of visual signs and symptoms that return within normal ranges. Hence, CI is uniquely poised to study neuroplasticity. The convergence insufficiency neuro-mechanism in adult population study (CINAPS) investigated 50 CI patients and 50 aged-matched binocularly normal controls (BNC) longitudinally where assessments included clinical parameters, symptoms, vergence eye movements and functional MRI before and after intervention. Half of the total participants received 12 one-hour sessions of OBVAT administered biweekly and the remaining half received 12 one-hour sessions biweekly of office-based placebo therapy (OBPT) both with home reinforcement. Eye movements were collected using an ISCAN video-based infrared eye movement monitor. Functional imaging utilized a block protocol where one block was composed of 21 seconds stimulating 8 symmetrical vergence step eye movements presented along the midsagittal plane contrasted with a block composed of sustained visual fixation for 19 seconds repeated for five cycles. A correlation analysis was performed between the peak velocity of 4 deg disparity vergence step responses and the beta weights from the blood oxygenation level dependent signal throughout all the voxels of the brain correcting for multiple comparisons. A significant correlation was observed in the change in beta weight and the change in peak velocity within the left thalamus. Linear regression analysis revealed that for the 25 CI and 25 BNC administered OBVAT, the beta weights sampled from the left thalamus using a 5 mm sphere were significantly correlated with disparity vergence peak velocity. Conversely, significant correlations were not observed for participants who were administered OBPT. Data support that the left thalamus is a neural substrate involved in vergence neural plasticity. Results have clinical implications that therapeutic interventions should stimulate the left thalamus to improve oculomotor performance and function. Current pilot studies investigating the effectiveness of virtual reality vision therapy (VRVT) to remediate symptoms and improve vision function for those with CI will be discussed. VRVT has potential because it can be conducted from a home setting where the patients are having fun playing a game while also improving vision function. Studies are ongoing to determine whether VRVT is as effective as OBVAT where VRVT can be more cost effective and easier to administer since the patient can do the therapy from home. Future studies will monitor home compliance.