The purpose of ECAE’s second International Conference on Educational Neuroscience is to highlight the educational impact of neuroscience research, by presenting cutting-edge developments in neuroscience that have implications for health and learning. A multidisciplinary approach is taken, looking at the most reliable approaches in cognitive neuroscience, brain imaging, brain plasticity, neuropsychology, health and medicine, and technology.

Educational neuroscience aims to bridge learning, cognition and the brain. It aims to learn from the wide-ranging neuroscience research about how the typical (or atypical) brain works in order to generate more scientifically informed educational practices and policies.

The conference was organized over two days in Abu Dhabi, with talks, poster sessions, and workshops.
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Greeting and opening words

Prof. Robert Milne
Acting Vice Chancellor of ECAE.

Your Excellencies, VIPs, international delegates, honored guests, ladies and gentlemen, good morning!

It gives me great pleasure to welcome you to the Second International Conference on Educational Neuroscience hosted by Emirates College for Advanced Education (ECAE), and for those of you who have come from abroad, welcome to Abu Dhabi and the UAE. ECAE is the sole dedicated Educational College in Abu Dhabi and it supports conferences whose topics have an impact on education in this region and internationally.

This conference is truly international with participants from over 20 countries from 5 continents. I’m also delighted to see that many presenters from eight different UAE institutions are taking part.

I confess to no expertise in the area of educational neuroscience but, as an ex-scientist, I want to convey my excitement at being a spectator of this emerging field of human endeavor.

Teaching and educating are very complex activities and involve interdependent systems that govern the interactions between the teacher, the learner and the environment. The impact of teaching practice, policy and environment on learning abilities is widely recognized and documented; however, there is a failure to recognize their impact on the organ by which we learn: the brain. This is what educational neuroscience aims to achieve; specifically to link learning, cognition and the brain. It aims to apply the wide-ranging neuroscience research about how the typical (or atypical) brain works in order to generate more scientifically informed and evidence-based educational practices and policies.

Indeed, the current literature is full of examples where neuroscience evidence has shed light on many issues that are of great importance to education, including;

- why there is a wide variability in learning abilities and disabilities?
- what are the factors that impact upon memory?
- why sleep is important for memory consolidation?
- why affective and emotional factors strongly influence the learning process?
- why brain wandering happens in the classroom?
- how the multilingual brain masters different languages?
- and how the brain processes numbers and words?

All these and many other issues are of paramount importance to education. It is true that the translational effort (from neuroscience research centers to the classroom) is still in its infancy, but I am confident that, ultimately, neuroscience will offer scientific explanations of how we learn and this will open new possibilities to intervene and to design tailored individualized learning strategies.

This conference is designed to promote world-class research and developments in Abu Dhabi, foster international collaborations, and allow students to learn from world-experts who are at the fore-front of their fields. Our outstanding speakers will present some of their most recent and fascinating developments in this field, including why motivation is an important factor, why the brain wanders, how we can enhance cognition, and what are the possibilities for successful intervention in people with learning difficulties particularly through early detection of autism, dementia, and Parkinson.

These endeavors are complex and face skepticism from some educationalists and psychologists. That is why we need to build bridges of trust and mutual understanding between educationalists and neuroscientists. As elegantly put by Prof Willingham: “what is essential for a successful union of neuroscience and education is that both fields have realistic expectations of one another.”

I hope that after the conference you will be convinced that neuroscientists can help educators. I am sure it will be informative, interesting and exciting and a step forward in helping this new scientific field to progress.

I want to extend my thanks to the team at ECAE who have put in many hours organizing this conference.

I am sure you will enjoy the sessions at this conference and will learn more about the developments in this field, meet new friends, establish research collaborations and have a successful couple of days.
I wish you a very successful meeting!
Thank you!
Conference organized by:

Conference sponsored by:

Gala dinner sponsored by:
# Agenda

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Speakers

**Dr. Tracey Tokuhama-Espinosa**
Neuroscience of Learning and Sustained Change, Harvard University Extension School, USA; Education and Neuropsychology, Universidad de las Américas in Quito, Ecuador.

Director, Applied Educational Research Center, Latin American School of Social Sciences (FLACSO).

*The Science in the Art of Teaching: Using Mind, Brain, and Education to Dispel Neuromyths and Improve Education*

---

**Dr. Pankaj Sah**
Queensland Brain Institute, The University of Queensland, Australia.

Director, Science of Learning Research Centre (SLRC), The University of Queensland and the Australian Council for Education Research, Australia.

*The new science of learning*

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**Dr. Sung-il Kim**
Department of Education, Korea University, Korea.

President of the Korean Educational Psychology Association.

*Promoting academic motivation: A perspective from motivational neuroscience*

---

**Dr. Jonathan Smallwood**
Department of Psychology, University of York, UK.

Director, The Mind Wanders, UK.

*Understanding the role of the DMN in learning and memory: a component process account?*
Dr. Milos Ljubisavljevic
College of Medicine and Health Sciences United Arab Emirates University, Al Ain, UAE.
Research member, Institute for Medical Research - Laboratory for Neurophysiology, University of Belgrade, Serbia.
Can non-invasive brain stimulation enhance brain function and health

Dr. Oury Monchi
Department of Clinical Neurosciences, Cumming School of Medicine, University of Calgary, Canada.
Founder and Director of the Parkinson’s Disease, Cognition, Action, & Neuroimaging Laboratory.
Neuroimaging and other markers of cognitive decline in Parkinson’s disease

Dr. Armando Bertone
Department of Educational and Counselling Psychology, McGill University, Canada.
Director, Perceptual Neuroscience Laboratory (PNLab) for Autism and Development.
Defining visuo-cognitive phenotypes in Autism and other neurodevelopmental conditions: implications for assessment and remediation

Dr. Bas Rokers
Department of Psychology, University of Wisconsin – Madison, USA.
Director, The Rokers Vision Laboratory, University of Wisconsin, USA.
Virtual Brains: Using immersive virtual reality to enhance neuroscience instruction.
Dr. Kartik Sreenivasan
Psychology Department, New York University Abu Dhabi, Abu Dhabi, UAE.
Director, Sreenivasan Laboratory, New York University Abu Dhabi, UAE.
Is space special in visual working memory?

Dr. Jocelyn Faubert
École d’optométrie, Université de Montréal, Canada.
Associate Director of Research and Graduate Studies, School of Optometry.
Training the brain: Impact in elite sports, aging and children with learning difficulties
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Scientific Review Panel
Prof Myint Swe Khine: Professor, Emirates College for Advanced Education, UAE | Adjunct Professor, Curtin University of Technology, Australia
Prof Gary C. Sieck: Chair, Physiology and Biomedical Engineering, Minnesota Mayo Clinic, USA
The Science in the Art of Teaching: Using Mind, Brain, and Education to Dispel Neuromyths and Improve Education

Tracey Noel Tokuhama-Espinosa¹,²

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²Harvard University Extension School, Cambridge, MA, USA
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Mind, brain, and education science unifies research from psychology, neuroscience, and pedagogy to enhance human teaching and learning process using transdisciplinary research (Hinton, Fischer & Glennon, 2012; Samuels, 2009). While each of MBE’s subfields has advanced over the last decade in conceptual understandings of learning processes—including experience-based neuroplasticity over the life span (Lillard and Erisir, 2011), schema-dependent encoding’s relation to academic performance (van Kesteren et al., 2014), implicit learning processes (Reber, 2013), the role of affect in cognitive process (Immordino-Yang and Damasio, 2007), and the role of working memory in decision-making (Curtis and Lee, 2010)—a unified vision of teacher education based on these data have yet to emerge (Ansari et al. 2011; Sigman et al. 2014). According to a recent study (Tokuhama-Espinosa, 2017), some of the greatest challenges that exist include debunking myths that allow a lot of commercially driven people to promote fake information among educators. Between 2006 and 2008, the first international Delphi expert panel determined the standards in the emerging field of mind, brain, and education science (Tokuhama-Espinosa, 2008). The research began as a grounded theory development based on a meta-analysis of the literature between 1977 and 2008, which involved reviewing over 4,500 documents in the field, including peer-review journal articles, conference proceedings, textbooks, and popular press material. Based on the review of the literature, a new model of “neuroeducation” and MBE guidelines were developed. The 2006 Delphi panel was asked to classify statements found in the literature and used in teacher training into information that was “well-established,” “probably so,” “intelligent speculation,” and “neuromyths” based on the OECD’s continuum found in Understanding the brain: The birth of a learning science (OECD, 2002). The experts’ opinions were then compared with the criteria of the Best Evidence Encyclopedia and What Works Clearinghouse for “strong evidence of effectiveness” and “positive effects,” respectively. This comparison showed that the experts’ opinions were, indeed, upheld by the neuroscience literature. Based on the experts’ comments, it was found that nearly 80% of the most popular books related to “brain-based learning” were less than 100% accurate in their claims, and in some cases, supported using what the panel labeled as neuromyths as key elements in teacher training. MBE research is relatively new in the sciences. This fact challenges teachers who
have been in education for many years and who need to be brought up to speed about learning and how advances in technology and neuroscience have changed education (Ansari et al. 2017). A new Delphi panel was formed in 2016 as a 10-year follow-up on the original mind, brain, and education science Delphi study. The objectives of the new Delphi were to measure advances in the MBE field, gauge the extent to which information from neuroscience has entered the mainstream teacher education structures of universities, and document specific advances in both domain-specific content areas. New literature published between 2006 and 2016 included 3,041 additional documents and identified 109 current thought-leaders from 21 different countries, all of who were invited to participate in the Delphi, 42 of whom did so. The data from the 2016 Delphi indicate that teacher training and professional development opportunities still do not yet provide enough basic information about the brain and learning. Based on a review of the top 200 U.S. programs in Education, and the top 200 QS World University Ranking of Educational programs, the number of programs in educational neuroscience, cognitive psychology, behavioral neuroscience, and cognitive neuroscience have increased in psychology or neuroscience departments; however, there are few new programs in education departments and even fewer in transdisciplinary studies between departments. Mention of the brain and learning in undergraduate education programs is even less frequent, and often only allude to educational psychology courses in the curriculum with little emphasis on knowledge of the brain. Between 2006 and 2016, there were numerous new peer review journals, conferences, and societies in MBE and related fields. There are now more academic programs than ever that promote the MBE transdisciplinary vision, and more practitioners who work within the field. There have also been significant advances in documenting domain-specific learning, such as how the brain perceives numeric magnitude estimation in math (Dehaene, 2011; De Smedt et al., 2013), learns new words (López-Barroso et al., 2013), or reads (Dehaene et al., 2015). Initial analysis of the 2016 Delphi show that important progress in teacher training has been made by foundations (e.g., The Wellcome Trust, The Annenberg Foundation, The Dana Foundation, among others) and conferences (e.g., Brain and Learning, IMBES, Society For Neuroscience, among others), but these experiences often rely on the initiative of individual teachers rather then on a systematized exposure to quality information within formal teacher education programs. The result is that many of the same challenges that existed a decade ago still remain, including the propensity of neuromyths in teacher education (Dekker et al., 2012) and less than optimal collaboration between the fields of neuroscience, education, and psychology to advance teaching (Pasquinelli et al., 2015). The initial summary findings of the new Delphi panel (2016) (Table 1) indicate consensus on an increased number of principles and tenets in MBE, an expanded understanding of neuromyths and their prevalence in society, and an increased number of research, practice, and policy goals. The standards of their field were refined, and there was agreement on specific advancements in MBE over the past decade, as well as the challenges facing the field in the coming years, including (a) the elimination of neuromyths; (b) policy
changes to include MBE concepts; (c) the need for a greater focus on teaching–learning process rather than just on learning; (d) increased access to schools to engage in research; (e) the establishment of MBE topics in teacher education; and (f) funding for interaction and research between neuroscientists, educators, and psychologists. The results of this study are detailed below.

**Keywords:** cognitive psychology, educational neuroscience, neuroeducation, neuromyths, teacher education, Delphi panel, mind brain and education

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The Science of Learning

Pankaj Sah
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Learning and memory formation occur daily from the day we are born to the day we die. Our interactions with the world, and success in this, are tightly regulated by the memories we store and our response to the environment. For humans, much of our learning takes place in an organised and regulated environment of the classroom. In this environment, a teacher typically engages with participants, the students, and passes on knowledge. In the western world, interest in methods of teaching date back to Socrates, and modern scientific approaches emerged from the establishment of departments of education in universities, where teachers are taught the methods of teaching. This structure has resulted with a theory and practice of education—pedagogy. In a parallel stream, experimental neuroscience and psychology have also studied learning and memory formation, and these studies have also resulted in an understanding of learning and memory formation at the biological level. The new science of learning attempts to use the results from psychology and neuroscience to drive pedagogy. This approach is leading to an experimental approach to education and establishing an evidence base to educational approaches. While there are potential problems with this approach, it provides novel solutions to problems in educational outcomes. In this talk, I will discuss the experience of the Australian Science of Learning Research Centre (SLRC) and our approach to integrating experimental neuroscience and psychology educational practice. I will present the results from several projects that are now being evaluated in the classroom.

Keywords: learning, neuroscience, plasticity, classroom, synapse

Acknowledgement

This work was funded by a grant from the Australian Research Council.
Promoting Academic Motivation: A Perspective from Motivational Neuroscience

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One of the fundamental questions regarding the neuroscience of motivation is what neural mechanisms underlie the selection, energization, maintenance, and modification of an action. By integrating neuroscientific findings on reward, learning, value, decision-making, and cognitive control, I propose a tentative model on motivational processes, which consists of three distinct but continuous sub-processes (Kim, 2013). In the motivational process model, motivation is defined as a series of dynamic value-based decision-making processes including generation, maintenance, and regulation of motivation of which primary functions are approached toward pleasure, learning through reward-prediction error, and goal-directed control. These sub-processes interact with each other by transferring neural currency through dopaminergic pathway from the striatum to the ACC, OFC, and DLPFC. The motivation-related brain regions can be categorized into three distinct neural networks: reward-driven approaches, value-based decision making, and goal-directed control (Kim et al., 2017). Reward directly drives our initial approach or seeking behavior toward incentives. The reward circuit is a process in which an approach behavior is triggered dependent on incentive salience. It is also implicated in the learning of stimulus-action-reward associations. This system is pertained to the ventral and dorsal striatum. Value guides our actions by highlighting those options that maximize utility. The valuation pathway involves value-based decision-making process that represents value, evaluates various outcomes of actions, and constantly calculates and updates existing values. The OFC play crucial roles in the process of maintaining motivation. Goals can guide our behavior toward an anticipated future reward. The goal-directed control network is engaged in the regulation of motivation through cognitive control. This system is associated with executive functions such as goal maintenance, performance monitoring (updating), and strategy selection (shifting). The ACC and DLPFC are the main neural circuits related to regulation of motivation. The neuroeducational model of academic motivation suggests several educational implications with regard to the generation, maintenance, and regulation of motivation to learn in a real-world learning environment.

Keywords: motivation, goals, neuroscience, reward, self-regulation, neuroeducation, value, value-based decision making
REFERENCES


Training the Brain: Impact in Elite Sports, Aging, and Children with Learning Difficulties

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In the last decade, we have seen a dramatic increase of commercially available computerised brain training methods for enhancing perceptual and cognitive capacities of individuals. One assumption underlying this approach is that some perceptual–cognitive systems are fundamental for human performance and that training on these approaches will transfer to other tasks that were not trained but require similar cognitive systems (near transfer) and to real life abilities (far transfer). However, although there is growing evidence that enhancing cognitive functions with generic approaches does demonstrate near and far transfer capacities, the established commercial solutions have been criticised because studies tend to only provide evidence of transfer to abilities structurally similar to the training task. Another potential criticism is that many solutions use a shotgun approach with a large number of exercises that seemingly address specific aspects of brain function, with the underlying assumption that the brain will be able to use them dynamically and simultaneously, as is often required in real life situations. This approach typically leads to very long training protocols, often between 30 and 40 hours, and leaves the users and professionals wondering whether this is the most efficient form of brain training. Other potential bottlenecks for the scalability of this intervention technique are the lack of simplicity and whether it can generalise to a variety of populations. We have proposed a method called 3D-MOT in the scientific literature that is now commercially available under the name of NeuroTracker (Faubert and Sidebottom, 2012; Faubert, 2013). Our approach has been to propose an easy to understand exercise, along with features that would enhance transfer potential that avoids some of the limitations above. Also to inherently force the brain to simultaneously solicit different cognitive mechanisms such as dynamic attention, sustained attention, working memory, and executive functions during the task. The result of this introduction has been a rapid adoption of the technique by independent users, professionals, and researchers (around 400,000 total). Figure 1 is a world map showing the spread of the distribution of the NeuroTracker system used in professional and university settings as of June 2016. Given its rapid adoption, it is relevant to summarize the research findings from the scientific community and determine where NeuroTracker stands relative to the original goals. The research to date demonstrates that: (1) it is possible to measure individual differences on this ability (Faubert and Sidebottom, 2012; Faubert, 2013;
Legault et al., 2013); (2) the level of performance corresponds with the learning rate on this task (Faubert and Sidebottom, 2012; Faubert, 2013); (3) the initial measures are predictive of real-life decision-making performance metrics and socially relevant abilities (Legault and Faubert, 2012; Mangine et al., 2014; Harenberg et al., 2016); (4) the brain is plastic to this process and training on this system shows transfer on real-life performance measures (Romeas et al., 2016); (5) training on this task improves relevant brain function as measured by cognitive metrics and brain imaging (Parsons et al., 2014); (6) benefits are demonstrable in a large population base varying from children with neuro-developmental conditions all the way to sports professionals (Faubert and Sidebottom, 2012; Legault and Faubert, 2012; Faubert, 2013; Legault et al., 2013; Parsons et al., 2014; Romeas et al., 2016; Tullo et al., 2016a,b); and (7) all these benefits have been demonstrated with only a few hours of total investment (3–5 h of distributed training). The NeuroTracker method relies on particular features suggested to be fundamental (Faubert and Sidebottom, 2012) including (1) distributing attention among a number of moving targets among distractors, known in the literature as Multiple Object Tracking (Pylyshyn and Storm, 1988; Cavanagh and Alvarez, 2005); (2) a large visual field; (3) speed thresholds; (4) binocular 3-dimensional cues (3D) (i.e., stereoscopic vision) (Faubert and Sidebottom, 2012; Faubert and Allard, 2013); and (5) an adaptive learning system that maintains the level of difficulty at the appropriate level for each user. In this talk, I will explain the principles, review the relevant studies with the NeuroTracker approach, and discuss ongoing and potential

FIGURE 1: a world map (up to June 2016) of the spread of the NeuroTracker system use in professional and university settings.
future avenues for research including how to enhance the approach with dual tasking and with direct neurofeedback/biofeedback paradigms for generating closed-loop systems.

**Keywords:** aging, cognition, sports, autism, ADHD, performance, brain training, plasticity training, 3D-MOT, NeuroTracker

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Towards a Neurocognitive Account of the Wandering Mind

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The capacity think in an intelligent and original fashion is the desired end point of a successful educational system. Studies have highlighted that spontaneous experiences, exemplified by states such as mind-wandering and the associated neural processes linked to the default mode network, have a paradoxical relationship to educational outcomes. Evidence indicates that the tendency to mind-wander is linked to poor encoding and comprehension, as well as improved capacity for original thought. This talk describes a series of studies that use the tools of neuroimaging to understand the component processes that underlie the mind-wandering state and that are aimed at understanding why these experiences are linked to both costs and benefits in educational performance.

Keywords: imagination, neurosciences, default mode network, mind wandering, component process
Defining Visuo-Cognitive Phenotypes in Autism and Other Neurodevelopmental Conditions: Implications for Assessment and Remediation

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Perceptual profiles in autism are characterized by a superior ability to process non-social (or elementary), detailed visuospatial information, with concurrent and difficulties perceiving more complex information, particularly when laden with social content (i.e., faces, gestures, and voices). When assessed with Wechsler-based tests of intelligence, cognitive profiles in autism are often defined by deceased performance on subtests that necessitate verbal communication and social understanding (i.e., Comprehension subtest), whereas performance on non-verbal subtest are either equal to typically developing children, or superior (i.e., Block Design subtest). In addition to this visuo-cognitive phenotype, children and adolescents with autism and other neurodevelopmental conditions (Attention Deficit Hyperactivity Disorder, Language Disorders, Intellectual Disability, etc.) present a profile that includes academic difficulties that are often characterized by both intellectual and attentional challenges. One approach to address attentional difficulties in these populations has been to use computerized attention training methods. However, most of the approaches currently available do not take into account the strengths and challenges defining their respective visuo-cognitive phenotypes. In essence, the efficacy of current attention training methods is often not optimally accessible or adaptable to students of varying levels of cognitive and social ability. We conducted a pilot study that examined the efficacy and feasibility of training attention using a three-dimensional multiple object-tracking (3D-MOT) paradigm, or NeuroTracker (NT), in students diagnosed with a neurodevelopmental condition with concurrent attentional difficulties. We assessed performance over 15 training sessions over the course of a 5-week period using the NT in a school-setting for 129 students, who were equally and randomly assigned to one of three groups: a treatment group (NeuroTracker); an active control group (visual math-based game); and a treatment as usual (TAU) group. We expected to see an effect of near-transfer (exclusive to the treatment group), defined by an increased post-training performance on another validated test of attention. Results demonstrated that post-training attention measures were significantly improved from baseline for the treatment group only, suggesting that training with the NeuroTracker effectively increased attentional abilities in students with a neurodevelopmental condition. These findings suggest that training attention with NeuroTracker—a non-verbal, visually
based approach—is both accessible and adaptable to students with a neurodevelopmental condition and concurrent attentional difficulties within a school setting. I will discuss how a flexible attention training approach such as NeuroTracker is advantageous when tailoring cognitive remediation programs from both a strength- and needs-based perspectives.

**Keywords:** ADHD, neurodevelopmental disorders, autism spectrum disorders (ASD), school-based interventions, attention training
Virtual Brains: Using Immersive Virtual Reality to Enhance Neuroscience Research and Instruction

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**Introduction:** Virtual Reality (VR) provides novel and exciting opportunities for research and education. It can immerse people in the 3D environments that are otherwise inaccessible, such as the faraway galaxies, the human brain, or a single molecule. Navigating through such virtual environments can provide natural, compelling ways to educate students about the inner working of these complex systems. There are, however, multiple barriers to adopting VR for educational purposes. First, novice users can report poor, uncompelling experiences due to perceived lack of immersion. Second, users often have difficulty in navigating and remaining oriented in virtual environments. Here, we offer solutions that will facilitate the development of virtual reality-based instructional methods. Solving the lack of immersion. The first part of the talk explores the hypothesis that novice users experience a lack of immersion due to poor recruitment of sensory signals in VR. In our natural environment, many signals inform us about the position of objects relative to the self, such as binocular disparity and motion parallax. Unfortunately, our understanding of the contribution of these signals to visual perception is limited; because, typical psychophysical experiments eliminate these cues by presenting stimuli on flat computer displays and fixing head position. Understanding how these cues contribute to perception in VR, where users are free to move around, will help to make their experience more immersive. To test our hypothesis, we used the Oculus Rift, a VR head-mounted display with head-tracking functionality. This VR display allows us to present visual stimuli under naturalistic viewing conditions, while maintaining tight experimental control. We designed “3D Pong,” a video game-inspired perceptual experiment. We asked users to adjust the position of a paddle, so that it would intercept a ball moving in a random direction in 3D space. In one condition, participants were provided with binocular disparity, but not motion parallax cues; in a second condition, both cues were available. To prevent users from simply adjusting paddle position at the last moment, we removed the ball from view well before it reached the paddle. We found that many novice users did not take full advantage of all available signals. They showed poor perceptual performance, suggesting poor sensitivity to binocular disparity and motion parallax (Figure 1). Moreover, repeated exposure did little to improve performance (Figure 1A). In a separate group of novice VR users, we encouraged recruitment of binocular disparity and motion parallax by incorporating
explicit task feedback. After users adjusted paddle position, we provided visual and auditory feedback indicating whether their adjustment resulted in a “hit” or a “miss.” With explicit feedback, users learned to incorporate the available cues. Appropriate recruitment of binocular disparity signals was evident in a reduction of adjustment errors compared to the no-feedback group. And, recruitment of motion parallax signals was evident in an increase of ball intercepts when motion parallax signals were available compared to when they were not (Figure 1B). These results show that novice users do not appropriately incorporate the available sensory signals in VR environments at first. However, they can learn which sensory cues are informative through explicit feedback. Interestingly, signal recruitment appears to be implicit. Users frequently reported being unaware that they moved their heads during the experiment, even though the resulting motion parallax improved their performance. These results suggest novice users should be introduced to VR by way of dynamic interaction rather than passive viewing.

Improving navigation in virtual reality. The second part of the talk discusses our efforts to develop VR methods for immersive neuroscience education. A major problem in the traditional anatomy education is how to convey the 3D volumetric structures and the multidirectional pathways that connect them (Preece et al., 2013; Drapkin et al., 2015). Anatomy instruction typically uses 2D drawings and 3D cadaver dissections. However, 2D drawings are limited by their inability to be viewed from different perspectives, and cadaver dissections are limited by their high cost, low accessibility, and low reusability (Preece et al., 2013). Immersive VR solves these limitations by allowing students to manipulate 3D volumetric forms in enriched stereoscopic viewing conditions (Luursema, et al., 2008) and by supporting interactivity (e.g., displaying functional implications after lesioning a brain region). Our approach is motivated by the simple notion that humans have difficulty in learning lists of facts and definitions, but they are incredibly adept at learning their way around new environments (e.g., buildings, campuses, and cities). By enabling students to explore the brain in a virtual environment, we can shift learning demands from rote memorization to systems involved in navigation and mental map formation. While VR-based instruction affords clear benefits, novice users often find it difficult to navigate and remain oriented in virtual environments. To address this challenge, we are investigating the use of color cues to create virtual environments that are easy to navigate without getting lost (Figure 2). We draw from a rich literature on color data visualization. Previous research has mostly focused on 2D graphs and maps (Lin et al., 2013; Gramazio et al., 2014; Schloss et al., 2015), and we are translating these principles to the interpretation of direction in space within 3D environments. By understanding intuitions for the directional cues colors provide in 3D environments, we can make immersive environments easier to navigate. We are testing navigation in a virtual game we have developed, called “BrainWalk.” Participants are asked to navigate through the brain by visiting a sequence of waypoints (orbs) indicated on a separate 2D map. We are currently evaluating how coloration of brain elements (see Figure 2) influences the time it takes participants to successfully visit all waypoints.
**Future directions:** Although VR is currently expensive and requires dedicated hardware, we ultimately aim to scale the resulting educational tools to more accessible and affordable VR technologies (e.g., cell phone-based solutions such as Google Daydream and Samsung Gear VR). Our results will facilitate VR-based education well beyond neuroscience, extending broadly from astronomy to microbiology.

**FIGURE 1:** Task feedback enhances recruitment of sensory cues in VR. (A) Percentage of trials in which participants intercepted a ball moving along a 3D trajectory as a function of trial number. VR exposure did not improve the performance when task feedback was not provided (left, \( n = 38 \)). When task feedback was provided, participants (\( n = 24 \)) performance improved rapidly and significantly (right). (B) Percentage of trials in which participants intercepted the ball's trajectory when the display contained binocular disparity, but not motion parallax signals (red bars), and when the display contained both signals (green bars). Motion parallax signals were due to scene updates with participants' head movements. When task feedback was not provided, the percentage of trials in which the target was intercepted was low and did not depend on the available motion-in-depth signals (left). When feedback was provided, the percentage of trials in which the target was intercepted improved significantly and depended on both the availability of binocular disparity and motion parallax signals (right).
Keywords: feedback, motion perception, neuroanatomy, perceptual learning, virtual reality, 3D vision

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Can Non-Invasive Brain Stimulation Ameliorate Age-Related Deterioration of Motor Functions?

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Last decade has witnessed growing research suggesting that different forms of non-invasive brain stimulation (NIBS) techniques, like transcranial direct current stimulation (tDCS) and repetitive transcranial magnetic stimulation (rTMS) can improve a wide range of brain functions, in the normal, healthy, and diseased brain. Healthy aging is associated with gradual functional decline, affecting various cognitive and behavioral domains, including memory, language, executive, and motor functions. Despite the initial promising effect of NIBS on behavioral outcomes, especially in healthy subjects, the results in healthy older individuals appear less consistent. This inconsistency may be related to universal problems pertinent to NIBS application and type of stimulation, such as “offline” or “online” stimulation, single vs. multiple stimulation sessions, the effect of stimulation intensity and polarity (anodal vs. cathodal), as well as stimulation location. In several successive studies, we examined the effects of various tDCS protocols on the motor and cognitive tasks of different complexity and novelty in the same population of healthy older subjects and compared them with healthy young subjects. tDCS was applied concomitantly with motor task (online design), before, and after motor task (offline design), as single or multiple stimulation session, at 1.5 or 2 mA, either as anodal or cathodal stimulation, over primary motor cortex (M1) or over dorsolateral prefrontal cortex (DLPFC—right or left side). The tests included grooved pegboard test, simple and serial reaction time, simple and complex visual-motor coordination task, trail making test, and spatial working memory test. Overall, the results suggest that tDCS effects appear to depend on intrinsic brain capacity to respond to stimulation (responders vs. non-responders) in both young and older healthy individuals. In subjects who responded, the results suggest a stronger favorable effect of tDCS in normal aging than in young subjects, with “offline” and multiple sessions of stimulation being more effective than “online” and single-session stimulation, respectively. Finally, in older subjects, the stimulation with 2 mA and stimulation of M1 was more effective than stimulation with 1.5 mA and DLPFC. Despite the positive trend, the overall effects seem to be at the borderline level of functional significance in this population. To further advance the application of tDCS in the older population, a better understanding of the origins of diverse responses to tDCS related to anatomical, and functional specificity and their interaction with main technical features of tDCS will be essential.
Keywords: motor cortex, motor skills, tDCS, old age, brain plasticity and aging, prefrontal cortex (PFC)

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Investigating the Heterogeneity of Cognitive Profiles and Evolution in Parkinson’s Disease with Neuroimaging and Other Biomarkers

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Parkinson’s disease (PD) is the second most frequent chronic neurodegenerative disorder, affecting up to 2 percent among persons older than 65 years of age and nearly 10% of people over 80. The cardinal symptoms of PD include tremor, rigidity, and bradykinesia that originate from the loss of dopaminergic neurons in the striatum (Bernheimer et al., 1973). It has recently been shown that the non-motor symptoms in PD such as cognitive and behavioural impairment are highly prevalent and have a severe and direct negative effect on health-related and perceived quality of life (Santos-García and de la Fuente-Fernández, 2013). It is now well established that 25–40% of persons with PD will develop cognitive deficits early in the disease. Moreover, the risk of developing dementia is almost six times higher in PD patients than in age-matched controls (Aarsland et al., 1996). Persons who meet criteria for mild cognitive impairment (MCI) exhibit measurable cognitive deficits, but those deficits neither severe enough to interfere significantly with daily life nor reach criteria for dementia. A task force has recently been commissioned by the Movement Disorders Society to establish formal clinical criteria for PD-MCI (Litvan et al., 2012). While longitudinal studies have made it clear that the presence of MCI in PD increases significantly the probability of developing dementia (Broeders et al., 2013), its manifestation is heterogeneous. Current studies report patients with single domain MCI including amnestic, executive, and visuospatial single domain MCI and others with multi-domain MCI. These studies suggest that PD-MCI might consist of distinct subtypes with different pathophysiologies and prognoses. It has been proposed by Barker and Williams–Gray (Sauerbier et al., 2016) that two different cognitive profiles are observed in PD patients with early cognitive dysfunction, which likely originate from different aetiologies. One profile termed the ‘Frontal executive impairments’ likely originates from fronto-striatal malfunctioning and dopaminergic deficits both in the frontal lobes and the striatum. The other is linked to posterior cortical impairments likely originating from cortical Lewy bodies and non-dopaminergic deficits. They propose that it is the latter pathological profile (posterior cortical impairments) that might be the most predictive of dementia (Sauerbier et al., 2016). However, it is not clear at this stage whether this profile reflects a single pathological entity. In this talk, we will review different clinical characteristics linked to neuropsychological and neuropsychiatric function as well as sleep that can
affect cognition in PD. We will also discuss genetic and other blood biomarkers as well as neuropathological ones that are associated with cognitive decline and dementia in PD. A particular focus will be given to different neuroimaging methods that attempt to characterize better the various cognitive profiles and patterns of evolution observed with PD. These include task-based functional magnetic resonance imaging (fMRI), resting-state functional connectivity, cortical thickness and volumetry, white matter measures based on diffusion weighted imaging, as well as ligand positron emission tomography. We will argue that the data coming from most of these methodologies indicate multiple pathological processes at the origins of cognitive decline in PD, resulting in great disparity of clinical cognitive manifestations and evolution among patients. Indeed, Sauerbier et al. (2016) have proposed the existence of 6–7 subtypes of patients with Parkinson’s disease based on non-motor deficits. This suggests that large multidisciplinary and multimodal longitudinal studies taking into account multiple biomarkers are warranted to distinguish early cognitive impairment in Parkinson’s disease and to identify patients with different phenotypes with respect to evolution of cognitive deficits. Comparisons with MCI-patients without Parkinsonism such as those at the prodromal stages of dementia of the Alzheimer’s type will also be useful (Monchi et al., 2016).

**Keywords:** dementia, neuropsychology, Parkinson, biomarkers, mild cognitive impairment (MCI), neuroimaging (anatomic and functional)

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Is Space Special in Visual Working Memory?

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Working memory (WM) is critical for reasoning, communication, and abstract thought, and is closely tied to scholastic outcomes. An important goal of basic and translational neuroscience is therefore to understand the nature of WM representations as well as their limitations. In the current study, we sought to understand how individual features of an object are bundled together in visual WM. Specifically, we evaluated the hypothesis that spatial location is a critical feature, without which other features cannot be bound into a coherent WM representation. To test this, we examined the degree to which participants’ reports about an object’s color and orientation depend on their ability to correctly report the object’s spatial location. Across three experiments, we had participants perform a task requiring them to hold five objects (colored triangles) in WM. Each triangle had a different color, orientation, and location, and each of these three features varied in a 360° circular space. Participants saw these five objects for 1,200 ms, followed by a 900-ms blank retention interval. Next, they saw a probe, which was either the color or location of one of the objects (experiments 1a and 1b) or the orientation or location of one of the objects (experiment 2). The task was to report the other two features of that object in the corresponding 360° spaces. For example, if given a color probe, participants indicated the orientation and location of the object with the probed color. We analyzed the report errors (the circular difference between the feature report and the true feature value) for each feature. Of interest was the degree to which performance for one feature influenced performance on the other feature. To assess this, we fit each participant’s error data with a mixture model that assumes that errors are a combination of a uniform distribution and a circular normal (von Mises) distribution, yielding estimates of the guess and target response rates and the memory precision for each feature. In order to establish the dependency of memory for one feature on another, we measured the decrease in target response rate for one feature (e.g., color) when the other to-be-remembered feature of that object (e.g., location) was reported inaccurately. Specifically, we utilized the mixture model to identify likely guess trials (trials with a report greater than three SDs from the true value) and then examined the error distributions for one feature of an object, contingent on the other feature being a guess. If features are bound together, one would expect guesses on one feature to also be guesses on the other feature, since when information about one feature is lost in memory, information about the object’s other feature must also be lost. Conversely, if the two features are not bound, we would
expect that guess trials for one feature will not necessarily be guess trials for the other feature. To quantify the amount of dependence between features, we calculated the percentage importance (PI), where the PI for feature A is the percentage decrease for target responses for feature B when looking at all reports versus only guess trials for feature A. Large values of PI for a feature therefore indicate that information for one feature is highly dependent on another feature. In all three experiments, there was a dramatic effect of spatial location. PI for spatial location was significantly higher than the PI for the other feature, demonstrating that when participants misreported an object’s location, they were unable to correctly report the other feature of that object. Moreover, and most strikingly, PI for location was ~90% across the three experiments, indicating that nearly all information about orientation (experiments 1a and 1b) and color (experiment 2) disappears in the absence of location information. In contrast, misreporting color or orientation had little impact on the ability to report other features of the object. These results highlight that not all features are equal in visual WM; losing information about spatial location results in a near complete absence of information about other features, suggesting that spatial location is a critical feature for coherent object representations in WM. More broadly, identifying how information is lost from WM is an important step in understanding how we can avoid failures in WM.

**Keywords:** feature binding, spatial working memory, visual working memory, mixture model, visual short-term memory (VSTM)
Educational Neuroscience: It Is Time to Embrace Negative Results

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Educational neuroscience aims to use neuroscience evidence to (i) understand why there is wide variability in learning abilities and disabilities and (ii) evaluate the effectiveness of different teaching/learning methods. A large proportion of that neuroscience evidence comes from neuroimaging studies that have investigated brain structure and function in both healthy and clinical populations in many tasks and topics, including memory, language, attention, emotion, decision-making, multisensory processing, sleep, and rest. Although this literature is huge, it is not free from biases that may hamper its usefulness and generalisability (Ioannidis, 2005; Kriegeskorte et al., 2009; Jones and Cercignani, 2010; Button et al., 2013; Ioannidis et al., 2014; Eklund et al., 2016). Ignoring such biases and limitations may lead to the development of unrealistic mechanistic explanations of brain function (Stelzer et al., 2014). In this context therefore, it is important that these biases are weighed and taken into account, when looking for potential applications to education and learning. This is because educational neuroscience, as it is the case for clinical neuroscience, must rely on reliable, reproducible, and robust effects before making informed decisions about learning styles or tools, or when building models with credible explanatory power that can generate accurate individualised predictions about learning abilities. One known bias in the neuroimaging literature is the overpublication of positive effects, though this bias is present in almost all fields of science (Fanelli, 2010). The impact of this problem on reproducibility is well known, but its most damaging effect is the perpetuation of (false) positive effects until they become accepted as fact (Nissen et al., 2016), which are likely to be misrepresented or misunderstood by the media or general public (Gonon et al., 2011). This is why a shift must be undertaken to limit the damaging impact of such publication bias by encouraging the publication of null or negative results. Indeed, any translational effort to the classroom must take into account what can and/or cannot be done and when things work or do not work in brain research. Negative findings are becoming the missing pieces in the neuroscience literature, and this is why some initiatives have emerged to give voice to negative results (Pfeffer and Olsen, 2002; Schooler, 2011). Many journals, for instance, are now open to the publication of negative findings (such as PLoS ONE, eNeuro, Journal of Negative Results in Biomedicine, and F1000Research). The following hypothetical example
illustrates the importance of this issue. A teacher wants to design an efficient teaching strategy to improve the way students retrieve facts during mathematical processing. The teacher came across a highly cited neuroimaging study about some behavioural factors that might modulate brain activation in the angular gyrus for fact retrieval during number processing. The teacher also found many other neuroimaging studies that claimed observing similar effects in other independent samples. However, it was not clear to the teacher that those neuroimaging studies employed “alternative” statistical manipulations (Nieuwenhuis et al., 2011; Woo et al., 2014) that were mainly motivated by the findings of the previous highly cited study. Reading those papers did not give a full picture of all these methodological and statistical issues (Carp, 2012); however, it gave the impression that those positive effects have been validated and reproduced by different studies using different independent samples. When the teacher designed a teaching method based on those behavioural factors, no advantage of the new method was observed. This could be related to many factors, but one of them might be that the observed effects in the angular gyrus were not genuine true effects. It is in this context that negative results are important so that the reader can appreciate whether a given effect of interest has been consistently observed, at what effect size, and which specific contexts yielded null effects.

**Conclusion:** There are many calls to bridge the gap between neuroscience and education, in particular when it comes to implementing optimal teaching approaches that go hand in hand with how the brain processes information (Sousa, 2010). This endeavour must follow the most unbiased of scientific practices, by opening publication space to negative/null results. Specialised journals like “Brain Mind and Education,” “npj Science of Learning,” and “Trends in Neuroscience and Education” could lead the way by encouraging the publication of sound and relevant negative findings. Without it, the literature in educational neuroscience will be skewed, which will make difficult the correction for false positives. It will also mean that much time and resources will be wasted in developing ineffective teaching methods that happen to be based on skewed or false brain research findings.

**Keywords:** neuroimaging, publication bias, cognitive neuroscience, educational neuroscience, translational research, negative effects

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Bridging the Gap between Neuroscience and Classroom Teaching New Pathways in the Application of Social and Emotional Neuroscience

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Background and goal of the research: Teaching changes the structure of the brain in far more complex ways than any brain surgeon's scalpel (Olson, 2014). Education is an art built upon the social relationship between teacher and student that harnesses the neural mechanisms of learning (Siegel, 2013). The brain being inherently social learns within relationships—through emotional communication that supports a sense of safety and security, and through logical communication that conveys meaning and relevance (Cozolino, 2013). Understanding the science behind these fundamental relationships in our lives is essential, since these close relationships actually stimulate the brain to absorb experience, shape neural connections, and learn (Cozolino, 2014). Teachers are being influencing the development of students since the creation of formal classrooms. We have discovered methods for teaching (e.g., lectures, Socratic questioning, and project-based learning), which are tools the visible classroom uses to transmit knowledge. Besides these methods, many educators, myself included, perceive other forces at work in their classrooms, which Olson (2014) named invisible classroom, and intuitively use them to support and improve their teaching; others have ignored these forces and suffered the consequences (e.g., experiencing feelings of pedagogical incompetence, and in the absence of adequate support, dropping out the profession) (OECD, 2016). In this paper, we combine our academic study of leading researchers (e.g., Siegel, 2001, 2012; Doidge 2007; Cozolino, 2013, 2014) in the field of interpersonal neurobiology (the study of how our relationships continually shape our brains) and social neuroscience since 2000, with the IntersTICES-Type Activity, a set of strategies aiming at empowering teacher trainers to develop their e-learning culture. Viens and Renaud (2001) defined e-learning culture as the teachers’ representations regarding ICT-potential, their attitudes, their skills, and resources that reflect in their habitual teaching practice. This allows us to equip teacher trainers with practical information and strategies to facilitate environments that forge new pathways in the application of social and emotional neuroscience and interpersonal neurobiology to classroom teaching to get learners of any age into a state of mind open to learning.

Method: We implemented a multidisciplinary approach drawing from research in the fields of interpersonal neurobiology, social and affective neuroscience, social
psychology, and e-learning. The IntersTICES-Type Activity takes into account several dimensions, including psychosocial aspects and the real context of the classroom setting.

**Results:** To effectively bridge the gap between neuroscience and classroom teaching, teacher trainers and their students—future teachers—need to understand and use neuroscience’s basic processes, and neuroplasticity, which *via* the IntersTICES-Type Activity (Villa, et al., 2015) give us tools to create the kinds of experiences having the potential to change habits of thought, feeling, and behaviour that generated obstacles to student learning (Schwartz and Begley, 2003; Olson, 2014). However, it seems that educators in initial teacher-training programs lack the knowledge and strategies that prepare them to design learning environments that collaborate with the brain’s natural learning process. To help teacher trainers integrate this knowledge and strategies into their practice and effect change in the way they think and work, we propose the IntersTICES-Type Activity. Two general and overarching principles have to be considered when implementing it. These principles, supported by a pedagogical engineering approach, which promotes reflection in the habitual practice, encompass (1) undertaking a systemic–systematic procedure that supports conducting more specific needs and context analyses and (2) taking into account the teacher’s e-learning culture.

**Conclusion:** Teachers are people whose job is to engage, attach, and teach other people in the real world (Cozolino, 2014). There is a need to change the way we understand how emotions influence thinking and learning. Knowing about human attachment and love can make for more effective teachers and make the days in the classroom go more easily (Olson, 2014). The neurobiological mechanisms for reflexive imitation mirror neurons (Pellegrino et al., 1992); provide us with the most powerful implication of these neurobiological findings for education: we evolve to learn from important others as we observed their activities (Cozolino, 2014). Thus, building relationships and modelling effective teaching appear to be important roles played by teacher educators (Marlow and Nass-Fukai, 2000). Moreover, pre-service teachers have to trust their educators to develop confidence in their own teaching and gain valuable feedback and encouragement about their development as a teacher.

**Keywords:** social neuroscience, interpersonal neurobiology, pedagogical strategies, E-learning culture, application, the IntersTICES-type activity

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Neuroergonomics and Instructional Design: Designing Environments for Lifelong Learning

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Background and goal of the research: Access to knowledge is proportional to the attention multiplied by time devoted to a task (Aberkane, 2014). It means that the more time and attention spent to achieve a task, the more knowledge to which we have access is important. This explains the growing interest for creating motivating learning environments (Daniels, 2010). In this area, new and emerging technologies can offer increased opportunities for training and pedagogical interventions (Brown, 2010). However, access to knowledge not necessarily involves understanding and learning (Rose and Meyer, 2002), especially for people with cognitive impairments (e.g., memory and attention). Resources can play a key role in the human empowerment process (Arab, 2016). In our experience while designing services or technological devices for people with intellectual disabilities, we found that accessibility of resources is the major obstacle towards acceptance, usability, and learning to adapt to a new situation. How living environments (e.g., school, neighborhood, workplace, and public spaces) must be designed to improve people’s learning and information processing capacities while facilitating the appropriation of resources and construction of personal practices? To address such issues, we developed R-HDM, a Resources-centered Human Development Model, to explain how to design and promote resourceful environments that empower people in developing their capacities for adaptation (Arab, 2015, 2016). We defined a resourceful environment as an environment that provides essential conditions for an individual to perceive, activate, and coordinate relevant resources for the achievement of his/her personal goals. In this paper, we address opportunities and challenges of merging research in ergonomics and instructional design with neuroscience for designing and implementing resourceful learning and teaching environments helping individuals become lifelong learners.

Method: We adopted a multidisciplinary approach drawing on knowledge from psychology, ergonomics, special education, handicap, economics as well as neuroscience. In particular, R-HDM encompasses four theoretical frameworks: the human activity model (Leplat, 1997); the capabilities approach (Sen, 1999); the capable individual approach (Rabardel, 2005); and the “Human Development Model and Disability creation process” (MDH-PPH2) (Fougeyrollas, 2010).
Results: To be effective, people use a set of skills (e.g., communication, collaboration, creativity, critical thinking, and self-regulation). The empowerment process lies in their ability to mobilize and coordinate relevant resources to enhance these skills. However, our research shows that the presence of useful resources does not necessarily mean they will be used (Arab, 2015). The development and use of resources depends directly on the presence of adequate conversion factors (i.e., contextual factors—individual, social, and environmental). It is only through acting on these factors that we can strengthen people’s capacities and powers to act (Figure 1). Adequate conversion factors allow people to convert resources into opportunities for action (i.e., capabilities). Inadequate conversion factors can limit or prevent human development. To address intellectual disabilities that may emerge over time, we investigate learning and teaching activities as mediated and mediating activities using resources (e.g., cognitive, conative, informational, emotional, human, and materials).

FIGURE 1: Operationalizing R-HDM for designing lifelong learning environments (Arab, 2015)
R-HDM explains how social and environmental characteristics, in interaction with people’s health status (e.g., incapacities and deficiencies), may enable them so that they can function, effectively and efficiently, in other ways to think and act through alternative resources or coping mechanisms.

**Conclusion:** Drivers and challenges of the twenty-first century education should be to provide all people, especially “neuro-atypical” people (e.g., people with dyslexia, dyscalculia, dyspraxia, intellectual disabilities, attention deficit disorder, or autism spectrum disorder), the best conditions that will promote access to knowledge (i.e., reading, understanding, and learning). In this area, cognitive neuroscience can help design innovative education practices taking into account the brain functioning and its interaction with learning processes. Designing lifelong learning environments requires building accessibility by making connections between resources to foster creativity, innovation, even serendipity (e.g., reminiscences like Proust’s madeleine). Innovative learning environments should mobilize latent reserves of capacities to act (often unconscious) that people can develop when adequate conversion factors (e.g., cognitive accessibility, teacher’s motivation, engaging and inspiring interactions) enable them to convert resources (e.g., adaptive technologies) into opportunities for action (Arab, 2015). In this context, R-HDM provides a conceptual and methodological framework for implementing resourceful environments, which meet learner’s actual capacities and needs while promoting the acquisition and development of relevant skills. It should open new avenues for people’s empowerment enhancing access to new apprenticeships.

**Keywords:** brain plasticity, instructional design, special education, neuroergonomics, cognitive accessibility, lifelong learning environments, R-HDM

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Neuroscience and Basic Education in Brazil: A Challenging, Promising Way Ahead

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This presentation highlights Brazil’s evolving landscape of challenges and opportunities to improve quality in basic education and the increasing potential of emerging neuroscience-based policies and practices. Improving basic education in Brazil with 48.8 million enrollments in 2015 (aged 5 to 18, MEC 2015/INEP 2016) and overly insufficient quality, is one of the most fascinating and urgent agendas in the country’s path towards Goal number 4 in the 2030 sustainable development goals (United Nations Sustainable Development Goals, 2015). The world’s 7th largest economy (GDP-US$3.1 trillion PPP, World Bank, 2016) features great regional imbalances of income and educational attendance and quality that present huge challenges and opportunities for improvement. According to the most recent Programme for International Student Assessment (PISA-OECD, 2015), among 70 nations, Brazil scored very poorly in all three areas: science (ranked 63rd position), reading (59th position), and mathematics (66th position). This worrying fact reinforces an enduring, undesirable, reality since the first PISA test in year 2000. In these three main areas, the Brazilian students performed below basic proficiency level required by PISA 2015 (science 56.6%, reading 50.99%, and mathematics 70.25%). In summary, the three most important and urgent challenges are reduce dropout and truancy rates; improve teachers’ and education officers’ training and performance; and enhance learning outcomes. In January 2001, as demanded by the Constitution, the Federal Government approved the decennial National Education Plan 2001–2010 (Law 10.172/2001) intended to increase “school attendance, years of study and quality at all levels and reduce social and regional imbalances preventing the success to quality education.” Focused on public education and characterized by a penchant for corporatism of interest groups, general results showed an important increase in school attendance; however, quality remained low. Building from a 4-year backlog since the previous plan, in June 2014, the Federal Government...
approved Law 13.005/2014—National Education Plan 2014–2024. Composed of 20 overarching goals, it intends to continue perfecting the previous objectives while including up to 2024: eradication of illiteracy; 100% school attendance for basic education; adequate funds as a percentage of GDP; education for work and citizenship anchored on moral and ethical values; and, scientific, cultural, technological, and humanistic education respecting diversity and socioenvironmental sustainability. While indispensable by legal and societal demands, both plans were too ambitious and optimistic. In a continental nation of diverse political, educational, economic, and sociocultural realities, they lacked clear road maps with feasible milestones towards implementation, including how to secure required funds and the indispensable institutional capacity: two old-fashioned paradigms in Brazil’s growing democratic path. In recent years, profiting from the expanding potential of neurosciences to improve education results and tired of insufficient, slow, piecemeal advancements, laudable, academic and private initiatives have been set in motion in Brazil. Such initiatives summon civic awareness “beyond government responsibilities” and aim at the cross cutting transcendence for quality education, in particular to children and adolescents, as pivotal prerequisite for the country’s future. In this regard, Brazil already has a highly qualified expanding community influencing education policies at federal, state, and municipal levels and shaping practices. Stand out in this globally connected network: The Brain Institute at Federal University of Rio Grande do Norte (UFRN, Natal/RN); The Santos Dumont Institute [Non-Governmental Organization (NGO)/Macaíba/RN]; Brazilian Network of Science for Education (CpE—a decentralized consortium of academic researchers, NGOs, and businesses); and the National Network on Education and Science (UFSM-UNIPAMPA/RS). The UFRN Brain Institute web page, for instance, exemplifies research and activities, including graduate and undergraduate programs. Worth mentioning the contributions of Brazilian neuroscientists such as Suzana Herculano-Houzelb, a former faculty member at the Federal University of Rio de Janeiro recently moved to the US, Sidarta Ribeiro, director of the Brain Institute at the UFRN, and Miguel Nicolelis, cofounder and scientific director of the International Institute for Neurosciences of Natal-Edmond and Lily Safra (IINN-ELS). This excellent constellation of institutional and human capital is poised, committed to demand, and assist public authorities to translate timely, state of the art, neuroscientific knowledge into better design and implementation of effective basic education policies, tools, and practices.

Keywords: neurosciences, basic education, national education plan, Brazil, Brazilian neuroscientist.

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Examining the Effect of Practicing with Different Modeling Conditions on the Memorization of Young Piano Students

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Playing securely from memory is an essential facet of Western classical piano performance; it has been a standard practice in competitive, professional, and educational settings, for many decades (Nellons, 1974; Bastien, 1995). The complex phenomenon of memorization has been extensively explored and therefore been conceptualized from different angles (Ginsborg, 2004), including piano pedagogy, music psychology, cognitive psychology, and neuroscience. In neuroscience, playing the piano is considered a serial motor skill because the discrete movement of striking the piano keys must be done in a definite sequential order (Schmidt and Lee, 2005; Hay, 2006). Therefore, exploring neuroscience's perspective about how the brain works and coordinates movements is essential. For example, several neuroimaging studies have described the tight and automatic coupling between auditory, visual, and motor networks in the brain of musicians (Haslinger et al., 2005) and even of beginners who had just 20 min of piano training (Bangert and Altenmüller, 2003). Also, research in neuroscience showed that brain regions responsible for the planning of movement and movement itself are activated when observing actions, a function of the so-called mirror neurons. Hence, the role of imitation in the learning of musical instruments denotes the stronger involvement of this mirror system when subjects observe an action they know they will have to imitate (Buccino et al., 2004). The ability to learn precise, difficult motions through observation seems an effective method for learning; it seems that musicians learn much from watching someone else perform a piece that they are working on (Schlosser, 2011). This brings to the forefront the importance of using a teaching tool that doesn't count primarily on verbal instruction when learning a new task for strong memory retention, but rather on combining auditory, visual, and motor networks. This tool is known as modeling, which is defined as the presentation, live or recorded, of anything that may be later imitated by an observer (Madsen et al., 1975). The work of cognitive psychologist Bandura (1977, 1986, 1997) on how we learn from modeling became the predominant theoretical foundation for most research concerning the demonstration of motor skills (Edwards, 2010). To test if modeling can be effective in memorizing piano music especially for young students, this study examined the effect of practicing with different modeling conditions on memorizing a piano piece. These modeling conditions were: aural modeling and video modeling.
with cues. The study conducted a quasi-experiment with 24 young piano students at the grade 3 level of Royal Conservatory of Music (RCM) in Canada or equivalent. Participants practiced with one modeling condition in order to measure which condition will produce best retention results. Based on statistical analysis using ANOVA, results showed that video modeling with cues seemed to be most effective practice tool which supports neuroscience research that states that the use of visual, aural, and motor technique produce the best memory recall. This provides great potential for using video modeling with cues as a practice tool for piano students for better memorization.

**Keywords:** aural modeling, memorization of music, video modeling with cues, motor learning in music, learning through modeling

**REFERENCES**


Brain Training Games Improve Memory and Speed Processing in Healthy Subjects

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Objectives: Does brain training games (BTG) work in healthy subjects? The beneficial effects of BTG are expected to improve cognitive functions. It was hypothesised that training would result in improved memory functioning and speed processing when compared with baseline visit.

Methods: Fifty-one volunteers enrolled for using a brain training game (Lumosity) for about 15 min per day, at least 7 days per week, for 3 weeks. They performed Cambridge neuropsychological Test automated battery (CANTAB) test before and after 3 weeks training for various cognitive functions. Measures of the cognitive functions fell into categories (flexibility, memory, attention, speed, and problem solving). Blood group was taken to study the brain-derived growth factor (BDNF), apolipoprotein (Apo) E (APOE) for blood marker.

Results: A statistically significant difference was found after the training in terms of attention switching task (AST) latency ($P = 0.000$), AST (congruent) ($P = 0.000$), AST (incongruent) condition ($P = 0.000$), and motor speed ($P = 0.000$). There was a positive correlation between pattern recognition memory (PRM) and ApoE.

Conclusion: This is the first report to study BTG in KSA that warrants further research to determine the role and its possible link to cognitive function. Our results do not indicate that everyone should play brain training games. However, the commercial brain training game might be a simple and convenient means to improve some cognitive functions.

Keywords: memory, cognitive functions, flexibility, brain training, attention task

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Cognitive Achievement and Peer Victimization in the United Arab Emirates: Exploring the Rural–Urban Divide

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Background: Closing the rural–urban cognitive achievement divide, resulting primarily from grave inequities in educational provisions and opportunities, is an inevitable prerequisite for ensuring quality education for all. The alarmingly high rural–urban disparities in educational achievement and attainment may jeopardize children’s healthy physical, social, emotional, and intellectual functioning. Hence, the purpose of this study was threefold: first, to examine the rural–urban gap in cognitive achievement among early adolescents in the United Arab Emirates (UAE); second, to investigate the rural–urban divide in the frequency of peer victimization among early adolescents in the UAE; and third, to explore the links between cognitive differences in academic achievement and peer victimization among rural and urban early adolescents in the UAE.

Methods: Data for the study were drawn from the UAE’ Grade 8 sample of the 2011 Trends in International Mathematics and Science Study (TIMSS). The Emirates of Abu Dhabi (N = 4,373, female = 2,140, male = 2,233; Mage = 13.80, SD = 0.80) and Dubai (N = 5,571, female = 2,698, male = 2,873; Mage = 13.93, SD = 0.86) took part in the TIMSS 2011 surveys and cognitive assessments as benchmarking participants. The rest of the Emirates in the UAE (N = 14,089, female = 7,035, male = 7,054; Mage = 13.86, SD = 0.84) participated as non-benchmarking entities. The TIMSS 2011 mathematics achievement scale (ranging from 0 to 1,000) as well as the index of students bullied at school (ranging from 1 = almost never to 3 = about weekly) were employed to measure cognitive achievement and the frequency of peer victimization, respectively. The TIMSS 2011 school location variable was used to classify the location of schools across the UAE as follows: urban, suburban, medium-sized city, small town, and remote rural.

Results: In the Emirate of Abu Dhabi, early adolescents living in the urban as well as suburban areas, medium-sized cities, and small towns scored significantly higher on the TIMSS mathematics assessment than did their peers living in remote rural areas (Mdiff = 68.00, SE = 12.40, p = 0.000; Mdiff = 59.00, SE = 12.20, p = 0.000; Mdiff = 49.00, SE = 11.80, p = 0.000; Mdiff = 37.00, SE = 11.90, p = 0.007, respectively). Urban adolescents also scored significantly higher on the TIMSS mathematics assessment than
did their small town counterparts (Mdiff = 37.00, SE = 13.70, p = 0.02). In the Emirate
of Dubai, early adolescents belonging to urban, suburban, and medium-sized cities
scored significantly higher on the TIMSS mathematics assessment than did their small
town peers (Mdiff = 59.00, SE = 7.60, p = 0.000; Mdiff = 56.00, SE = 8.60, p = 0.000;
Mdiff = 35.00, SE = 9.10, p = 0.000). Urban and suburban adolescents in the Emirate of
Dubai also performed significantly better than did their peers living in medium-sized
cities (Mdiff = 24.00, SE = 6.40, p = 0.000; Mdiff = 20.00, SE = 5.10, p = 0.006). Urban
early adolescents in the rest of the UAE scored significantly higher on the TIMSS
mathematics assessment than did their peers in medium-sized cities (Mdiff = 12.00,
SE = 5.90, p = 0.04), small towns (Mdiff = 45.00, SE = 6.40, p = 0.000), and remote
rural areas (Mdiff = 63.00, SE = 8.10, p = 0.000). Early adolescents in suburban areas
and medium-sized cities also scored significantly higher on the TIMSS mathematics
assessment than did their peers in small towns (Mdiff = 40.00, SE = 7.60, p = 0.000;
Mdiff = 33.00, SE = 6.80, p = 0.000) and remote rural areas (Mdiff = 58.00, SE = 8.10,
p = 0.000; Mdiff = 51.00, SE = 8.40, p = 0.000). Further, early adolescents in small
towns as well scored significantly higher on the TIMSS mathematics assessment than
did their counterparts in remote rural areas (Mdiff = 18.00, SE = 8.80, p = 0.04). The
five groups of adolescents in the Emirate of Abu Dhabi did not differ significantly
from one another in terms of the frequency of peer victimization. In the Emirate of
Dubai, early adolescents living in medium-sized cities were significantly more often
subjected to peer victimization than did their urban as well as suburban counterparts
(Mdiff = 14.00, SE = 0.03, p = 0.000; Mdiff = 13.00, SE = 0.03, p = 0.003). Early ado-
lescents hailing from suburban areas, medium-sized cities, small towns, and remote
rural areas in the rest of the UAE were significantly more frequently peer victimized
at schools than did their urban counterparts (Mdiff = 03.00, SE = 0.02, p = 0.015;
Mdiff = 06.00, SE = 0.02, p = 0.004; Mdiff = 13.00, SE = 0.03, p = 0.000; Mdiff = 11.00,
SE = 0.03, p = 0.002). Early adolescents belonging to urban and suburban areas as well
as small towns in the Emirate of Abu Dhabi who were subjected peer victimization on
a weekly basis scored significantly higher on the TIMSS mathematics assessment than
did their remote rural counterparts who were victimized by peers on a weekly basis
at schools (Mdiff = 74.00, SE = 12.80, p = 0.000; Mdiff = 67.00, SE = 15.08, p = 0.000;
Mdiff = 65.00, SE = 13.60, p = 0.000). Urban early adolescents in the Emirate of Dubai
who were victimized by peers on a weekly basis scored significantly higher on the
TIMSS mathematics assessment than did their medium-sized city counterparts who
were also peer victimized about weekly (Mdiff = 28.00, SE = 12.20, p = 0.02). Early
adolescents, hailing from small towns and remote rural areas in the rest of the UAE,
who were subjected to peer victimization more frequently scored significantly lower on
the TIMSS mathematics assessment than did their urban, suburban, and medium-sized
city counterparts who were peer victimized at schools on a weekly basis as well.
**Conclusion:** These findings suggest some glaring disparities that exist between rural and urban early adolescents in the UAE in regards to their cognitive achievement. They also demonstrate, to a certain extent, how peer victimization further exacerbates such disparities.

**Keywords:** United Arab Emirates, peer victimization, TIMSS, cognitive achievement, rural–urban divide
Attention-Deficit-Hyperactivity-Disorder (ADHD) and Mind-Body Alternatives: Protocol for a Meta-analysis and Preliminary Data

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Background: Attention deficit hyperactivity disorder (ADHD) is a very common childhood disorder with potentially severe impact on affected youngsters and their families. Students with ADHD often do not actively engage in academic instruction because they have difficulty in attending to task demands resulting in deteriorated academic outcomes. Although pharmacotheraphy is often the treatment of choice, it has typically short-term effects and is associated with various side effects and poor adherence. Therefore, there is a need for other interventions for youngsters with ADHD. Mind–body training is emerging as a potentially effective intervention for the ADHD treatment. Typically, these trainings are conducted in small groups where participants learn to focus and enhance their attention, awareness, and self-control, as well as learn to be fully present in here and now in a non-judgmental way. The present meta-analysis provides an overview of the literature regarding mind–body-based interventions for the treatment of ADHD.

Method: We limit the meta-analysis to peer-reviewed empirical studies that examined effects of meditation or mindfulness on symptoms of ADHD. We searched in PsycINFO, PubMed, and SCOPUS databases. Additionally, we plan to thoroughly examine reference lists of previous meta-analyses. The search terms « ADHD AND meditation OR mindfulness » and their derivatives terms (e.g., impulsivity, inattention, hyperactivity, samatha, yoga, etc.) are considered for inclusion. Impact of mind–body treatment in ADHD is extended to cognition and relative domains such as executive function and brain structures alterations. Eligible control conditions are placebo, wait-list, no treatment, and usual care. Along with Krisanaprakornkit et al. (2010) and Cochrane’s guidelines, we consider relevant randomized trials (RCT), comparative studies, clinical trials, prospecitive or follow-up studies, and single- or double-blind studies for inclusion. The search was performed from the first available date up to December 2016. The literature search produced 157 studies: PsycINFO (n = 68), PubMed (n = 67), and SCOPUS (n = 22). Upon first evaluation by two
FIGURE 1: Analysis of inattention and hyperactivity (adapted from Cairncross and Miller, 2016).

independent reviewers, 53 duplicates (+2 conferences, 1 erratum) were eliminated. After reviewing the abstracts of the 101 remaining studies, 68 studies were eliminated. From the remaining 33 studies, 10 corresponds to the Cairncross and Miller (2016) meta-analysis.

Results: Preliminary results from Cairncross and Miller (2016) meta-analysis. The data were synthesized to compare difference between pre- and post-intervention scores divided by the population SD (Cohen's \(d\)). The analyses focused on the overall effects of meditation or mindfulness on ADHD symptoms. Effects based on more than one informant were combined to obtain a single effect-size estimate. The variance
for the composite effect size was computed taking into account both the individual informant variance and the correlation between informant reports (fixed at 0.7). The composite Cohen’s $d$ and its associated variance were computed for each individual study and each outcome of interest: inattention and hyperactivity symptoms. (1) For inattention, the random effect model and Cohen’s $d$ indicate an effect size of 0.680, SE = 0.150. The Cochran’s $Q$ indicates that the effect size varies according to studies \[Q (dl = 9) = 30.137; p < 0.05\] so there is heterogeneity (Higgins and Thompson’s $I^2 = 76.67\%$). (2) For hyperactivity, the random effect model and Cohen’s $d$ indicate an effect size of 0.523, SE = 0.105. The Cochran’s $Q$ also indicates that the effect size varies according to studies \[Q (dl = 8) = 17.154; p < 0.05\] so there is heterogeneity.
Conclusion and future studies: Along with the meta-analysis of Cairncross and Miller (2016), we found a positive effect of mind–body treatment alternatives on ADHD symptoms. However, we also found moderate to high heterogeneity between studies, mostly for the inattention symptoms. Meta regression analyses rule out the possibility of an effect of age, gender, duration of treatment, and medication on that heterogeneity. In future studies, we will need to address more closely this issue. In the next months,
we plan to increase our pool of studies in order to extend the present preliminary data and update Cairncross's findings.

Keywords: adult, attention deficit disorder with hyperactivity, mind–body therapies, young adult, meta analysis, child

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Stimulus Overselectivity in Autism and Its Correlation with Attention and Cognitive Flexibility

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Introduction: Stimulus overselectivity describes a phenomenon where an individual responds only to a subset of the stimuli present in the environment, and, thus, may restrict learning regarding the range, breadth, or number of features, of a stimulus (Kelly et al., 2015; Farber et al., 2017; Reed, 2017). Instances of overselective responding are found in many clinical populations that experience some assault to their levels of cognitive function, including individuals with intellectual disabilities, learning disabilities, acquired brain injury, and schizophrenia as well as typically developing individuals experiencing situations involving increased cognitive demands (Reed et al., 2012; Reynolds et al., 2012; Kelly et al., 2016). Stimulus overselectivity is very often noted in individuals with autism (Leader et al., 2009; Reed et al., 2009; Kelly et al., 2015), and this failure to respond to all necessary or important cues in the environment may be a factor contributing to many of the problems seen in autism, including deficits during observational learning, learning with prompts, or learning during matching-to-sample tasks (see reviews by Kelly, 2012 and Ploog, 2010). One well-researched theoretical perspective regarding stimulus overselectivity is the “attention deficit” view, which posits that overselective responding is a product of an attentional deficit in sampling all of the component elements of a stimulus (Dube, 2009). The first aim of the current study was to explore the relationship between attention and overselective responding in children with autism. Overselective stimulus control can be related to a number of aspects of cognitive function, such as levels of intellectual functioning (Kelly et al., 2015) and levels of executive function, especially as indexed by cognitive flexibility (Gard et al., 2014). The second aim of the current study was to analyse the association between stimulus overselectivity and cognitive flexibility in children with autism.

Method: Twenty-four children, 12 diagnosed with autism (experimental group) and 12 mental age-matched typically developing children (control group), participated in the current study. Levels of stimulus overselectivity were measured using a discrete trial discrimination paradigm, as utilised by Kelly et al. (2015, 2016). Selective attention, sustained attention, and attentional switching were measured using the Test of Everyday Attention for Children (TEA-Ch; Manly et al., 1999). Cognitive flexibility was measured using the computer-based intra/extra dimensional set shift (IED; Cambridge Cognition, 2011), which is one of the 22 neuropsychological tests in the Cambridge
Neuropsychological Test Automated Battery (CANTAB) eclipse. The two dependent variables utilised in the current study were number of stages completed and number of adjusted errors. A correlation analysis was conducted to analyse the relationship between overselectivity and attention, as well as overselectivity and cognitive flexibility.

**Results:** A significant degree of stimulus overselectivity was found in the experimental group using the visual discrimination task. The correlation analysis revealed that overselectivity neither significantly correlated with either of the TEA-Ch subtests that measured selective attention (subtests 1 and 5) nor attentional switching (subtests 3 and 8). Although there were no significant correlations between stimulus overselectivity and the sustained attention subtests 2, 4, 6, and 9, there was a significant correlation with subtest 7. This finding suggests the possibility that an individual's ability to self-maintain an actively attentive stance to a given task is correlated with their level of overselective responding. The fact that only one of nine attention subtests was significantly associated with stimulus overselectivity may indicate that the attentional processes under investigation in the current study are not reliable correlates of overselectivity. In terms of cognitive flexibility, the correlation analysis revealed that neither of the IED-dependent variables was significantly associated with levels of overselectivity in both the control and experimental groups. This result indicates that overselective responding is not related to the level of executive function, a finding that supports the findings of Kelly et al. (2016).

**Conclusion:** This study offered further evidence of the overselectivity phenomenon by replicating the effect in the current sample of individuals with autism. The novel findings to emerge from this research were that the results from the TEA-Ch and the IED offer experimental evidence contradicting the hypothesis that overselectivity is associated with attention and cognitive flexibility. Replication of the current findings is essential for two reasons. First, the sample was too limited in size. Second, the standardised measures were possibly unsuitable measures for this clinical population as the lower functioning participants had difficulty passing the practice trials and completing the tasks assigned. Further analysis of stimulus overselectivity and its correlates is warranted given its importance when designing behavioral interventions for individuals with autism.

**Keywords:** attention, autism, cognitive flexibility, stimulus control, stimulus overselectivity

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Declarative Memory Improvement by Transcranial Random Noise Stimulation (tRNS) of the Frontal Cortex

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Human beings devote a considerable part of their lives to learning. Before being stored in declarative (long-term) memory, knowledge is temporarily processed by working-memory. In this experiment, the cortical areas supporting working-memory function were investigated by using non-invasive tRNS, to discover which one is involved in declarative memory formation. In other words, we investigated which area, frontal or parietal, is casually linked to knowledge acquisition. Participants studied a paragraph and then their memory was tested; they were required to write down anything they could remember from the paragraph. This memory task was performed 5 min and 7 days after studying the paragraph. Participants received tRNS on either the frontal or the parietal cortices; a placebo group was included too. We found that frontal stimulation, but neither parietal nor placebo, significantly improved declarative memory performance. This was found after 5 min and 7 days. In other words, participants who were stimulated on the frontal cortex remembered more information both immediately and in the long term. These results suggest that the frontal cortex is significantly involved in declarative memory formation. Additionally, these findings can have important practical applications, such as improving learning in healthy and pathological populations.

Keywords: frontal cortex, working memory, parietal cortex, declarative memory, transcranial random noise stimulation
The Effect of Working Memory on Stroop Performance

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Working memory and response inhibition are two distinct, yet intertwined executive processes (Luna et al., 2001; McNab and Klingberg, 2008) critical for goal-directed behaviors (Miller and Cohen, 2001; DeLuca et al., 2003). Broadly speaking, response inhibition involves suppressing automatic, reactive responses (Luna, 2009), whereas working memory involves the ability to maintain and manipulate information, as well as control and direct attention (Kane et al., 2001; Cowan et al., 2005). The development of these processes relies strongly on the prefrontal cortex, which continues to develop into early adulthood (Casey et al., 2000; Luna et al., 2001; Paulsen et al., 2015). Generally, working memory is shown to mature in late adolescence (DeLuca et al., 2003; Luciana et al., 2005; Huizinga et al., 2006), whereas inhibitory control continues to mature into early adulthood (Luna et al., 2001; Davidson et al., 2006; Velanova et al., 2009). Since most executive functions, such as response inhibition and working memory, play distinct roles and develop along separate trajectories, the development and function of these processes have often been studied in isolation. However, there is evidence that response inhibition and working memory are concomitant processes, and that working memory is essential to successful response inhibition (Luna et al., 2001; Diamond, 2013). One task particularly well-suited for studying the relationship between response inhibition and working memory is the Stroop task (Long and Prat, 2002). In the Stroop task (MacLeod, 1991), participants are asked to quickly and accurately indicate the color in which a word is displayed while ignoring the word’s semantic meaning. The present study aimed at describing the developmental trajectories of accuracy and response time on the Stroop, determining how working memory facilitates Stroop performance, and examining whether the effect of working memory on Stroop performance differs across age groups. To address these aims, a sample from a large-scale investigation of more than 5,000 individuals between the ages of 10 and 30 (M = 17.05 years; SD = 5.91) from 11 countries was used. All individuals completed a computerized adaptation of the Stroop task (Banich et al., 2007) and a working memory task. The Stroop task employed in this study includes incongruent and neutral trials that are presented in two block types: one in which the presentation of both trial types is equal, and one in which the presentation of incongruent trials is rare. Comparing
performance between blocks types allows inferences to be made about goal neglect and is ideal for examining working memory differences in Stroop performance. Results indicate that Stroop performance does indeed differ across development and between working memory groups, and that the observed age differences depend upon working memory capacity. Within the high-working memory group, response time becomes faster between 10 and 17 years, and then begins to slow between 18 and 30 years. Within the low-working memory group, response time becomes faster between 10 and 21 years, and begins to slow between 22 and 30 years. Furthermore, whereas adult levels of accuracy are achieved relatively early among participants with high-working memory (by 14–15 years), accuracy does not reach adult-like levels until 16–17 years among participants with low-working memory.

**Keywords:** development, executive functions, working memory, response inhibition, Stroop performance

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Cascading ‘Contextual Problems’ or Strengths in Autism? Implications for Education

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Background: The processing style of children diagnosed with autism spectrum disorders (ASC) is uniquely characterized by a predisposition to focus on local information at the expense of meaning or gist. This impairment is the basis of the weak central coherence (WCC) account (Frith, 1989). According to the WCC, children on the spectrum have difficulties in forming coherence over a range of stimulus or in other words they show an inability to integrate information in context in contrast to their typically developing peers. The WCC is linked to aberrant brain connectivity in the disorder (Belmonte et al., 2004). The autistic brain model is defined by greater local or short-range connections in various parts of the brain. Individuals with autism are explained to have retained these connections, which their peers would have lost as part of the pruning process during brain development (Happé, 1999). The WCC was first examined for visual perception and then for various other domains including language. Thus, WCC interferes with adaptive living. The classic autistic symptomatology, which includes problems with social communication and detection of emotions, has also been attributed to WCC.

Aim: Here, we demonstrate that the WCC is most discernable for functioning that is multimodal in nature or requires integration of information across various domains at least for children with high functioning autism (HFA) (or those who score above 80 on non-verbal reasoning measure). This exercise is instrumental in order to obtain precise profiles of communication strengths and weaknesses for children on the spectrum.

Method: We reviewed all the recent studies (2014–2016) on autism, language, and contextual processes.

Main findings: We describe a major study for the sake of brevity. Janke and Perovic (2016) examined the performance of a group of HFA children, aged 11–16 years on sentences similar to (1) and (2) and obtained evidence for intact contextual processing. (1) Peter persuaded John to drink milk and (2) reading the magazine slowly made the group sleepy. Interpreting (1) requires the knowledge of syntax. The referent (John)
could be found within the main clause of the sentence. The hearer does not need to go beyond the level of the sentence or consult the boarder discourse context in order to arrive at the correct interpretation, whereas for (2), there could be multiple answers to the question, who read the magazine? It could be the group or someone else not mentioned in the sentence. And hence arriving at the correct interpretation requires one to engage in contextual processing. The authors reasoned that the HFAs did well as they did not have to go beyond the given truth conditions for the purpose of interpretation. This sort of less complex processing is different from theory of mind (ToM) reasoning where an individual needs to go beyond the given truth conditions in order to succeed on false belief tasks. Thus, they concluded that they exploited simpler pragmatic (discourse) stages and found them to be intact in HFA.

**Conclusion:** Research in neuroscience and cognitive science has shown that HFAs have distinct neural signatures and behavioral peculiarities. It is time to turn these results into beneficial teaching programs. For instance, children have been shown to acquire new words by utilizing social contexts from an early age, e.g., eye gaze of the speaker who utters the words and pointing (Baldwin, 1993; Woodward, 2003). Children on the spectrum are deficient at exploiting these social cues for learning new vocabulary, which in turn interferes with their communicative ability (Baron-Cohen et al., 1997). We propose the “linguistic pragmatic bootstrapping” idea here that is built on two notable strengths of these children, namely, the presence of local neuronal connections, which in turn apparently supports the ability to take the local discourse context into account. The main tenet of the proposed idea is to expose children to categories of objects that share a common albeit local feature, e.g., a vegetable and marzipan and promote learning based on it. For instance, children familiar with the category of vegetables could be encouraged to learn a new label (marzipan) by associating the label with the picture of the object. Children are likely to succeed as they are able to discount the well-known category of “vegetable” and associate/pair the new label with the image.

**Keywords:** language, autism spectrum disorders, pragmatic language, pruning, social functioning, adaptive living

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Age and Task Difficulty in Perceptual Decision-Making

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Background: Numerous aspects of perceptual and cognitive function change with age. In younger adults, perceptual information can influence decision-making even when parts of the content are not needed for a given task. The interaction between perceptual content and decision-making shifts as a function of difficulty and little is known of how age affects this interaction. The aim of this study is to evaluate age-related change when manipulating decision difficulty along two dimensions: stimulus similarity and information complexity, using both behavioral (psychophysical) measures and fMRI. The factors involved in determining difficulty can vary from person to person, so here, difficulty level is equated individually for each participant along the dimensions of interest.

Methods: Participants: 20 right-handed healthy adults, with 12 younger participants (6 female, 6 male, aged 28.4 ± 3 years, range: 24–32) and 8 older participants (4 females, 4 males, aged 68.4 ± 7 years, range: 62–82). Stimuli consisted of two Gabor patches (windowed sinusoidal grating) appearing side-by-side; they remained on-screen until participant response. Participants were asked to specify which of the two patterns contained the higher spatial frequency (finer lines). To manipulate similarity, line width (spatial frequency) of the patterns ranged from highly different (easier) to highly similar (more difficult). To manipulate complexity, carrier gratings were shown in the same orientation (simpler information) or in different orthogonal orientations (more complex information). Behavioral session: the method of constant stimuli with a 2-alternative forced-choice was used to measure spatial frequency discrimination thresholds (75% correct responses), expressed as Weber fractions for differences in spatial frequency. Scanning session: in a mixed-design, complexity (orientation) conditions were grouped, and Gabor pair events were shown at four different levels of similarity (i.e., difficulty); these were individually equated based on the behavioral session.
Results: Findings indicate an overall effect of difficulty arising from stimulus similarity, with slower responses at more similar levels (ANOVA: \( F = 163.6, p < 0.001 \)), along with slower responses in older participants (\( F = 64.6, p = 0.004 \)). There was a significant interaction between age and similarity (\( F = 11.5, p = 0.04 \)), driven by slower response times in older participants when perceptual decisions were made at discrimination threshold level. Overall, patterns of brain activity were similar across age groups: brain activation increased with task difficulty for both stimulus orientations in bilateral occipital, parietal, and frontal regions, whereas brain responses in bilateral inferior parietal lobule decreased with task difficulty. However, the subgenual anterior cingulate cortex showed an interaction between age and orientation.

Conclusion: Overall, difficulty in perceptual decision-making, when evaluated as a function of stimulus similarity and complexity, displays comparable patterns of behavioral responses and brain activity across age, except in one anterior brain region. This suggests that perceptual decision-making is overall comparable across age, but that difficulty arising from stimulus similarity may be treated differently with advanced age.

Keywords: aging, decision-making, perception, complexity, task difficulty, difficulty level
Assessment of Vigilance Using EEG Source Localization

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Introduction: Vigilance is a term that is mostly used as sustained attention. Researchers have found that people who participated in sustained attention type tasks suffered a noticeable decrease in their ability to detect critical stimuli over time. This phenomenon is known as vigilance decrement. The mindlessness, also known as underload, theory of vigilance decrement suggests that the monitor loses focus of attention due to the long intervals separating infrequent critical signals, where they start treating their vigilance assignment in a spontaneous automatic manner (Helton and Russell, 2010). Vigilance is important for jobs where sustained attention for prolonged times is required. These jobs include air traffic control, luggage inspection, surveillance jobs, and driving. Vigilance decrement can cause catastrophic consequences. Therefore, vigilance level assessment is a widely researched topic. Several methods have been used to assess vigilance level such as eye tracking, heart rate variability, and physiological data such as electrocardiogram (ECG) and electroencephalogram (EEG). EEG is a non-invasive neuroimaging technique that measures scalp potentials due to firing of neurons in response to different stimuli. EEG data has been tightly correlated to vigilance. EEG has high-temporal resolution of about a few milliseconds which makes it appropriate for real-time monitoring of brain activity (Cao et al., 2006). The most studied characteristic of EEG signals in accordance with alertness level is power spectral density (PSD) of different brain waves: delta, theta, alpha, and beta. Event-related potential (ERP) is a useful EEG characteristics, which involves averaging the EEG activity time-locked to the presentation of a stimulus. Analysis of ERPs can aid in studying brain activity with respect to certain evoked stimuli. Functional descriptions of the ERPs components can identify the cognitive processes. The P300 is an ERP component which arises where a target stimulus is presented infrequently among more common non-target stimuli. The subject must pay attention and respond for a P300 to be elicited (Key et al., 2005). One factor that affects the P300 amplitude is attention, making it attractive to studies of populations with attention deficits.

Objectives and goals: Vigilance decrement can cause fatalities in several critical tasks. Early detection of this decrement can allow reducing appalling costs. Therefore, the objective of this work is the construction of a vigilance assessment model using a
novel method: EEG source localization. Additionally, the conventional PSD approach is used to compare with existing findings. The main challenge in this ongoing effort is developing an accurate vigilance measuring system that can detect vigilance decrement in critical conditions by monitoring neural source dynamics in real time while ensuring high temporal and spatial resolutions.

Methodology and outline: In this study, Advanced Source Analysis (ASA-lab) software is used to collect and analyze EEG data as well as reaction times from 30 subjects while performing a 20-min task that induces vigilance decrement under controlled conditions. The task involves the subject reacting to target events among other non-target events. The recorded raw EEG data are preprocessed to remove unwanted signals to get a clean EEG signal showing only the subject's brain activity. Furthermore, the signal is filtered to keep only frequency components of interest which are typically 0.1–30 Hz. Using ASA-lab two methods are used to study the brain behavior for low and high vigilance states. In the first method, the PSD of the EEG data is investigated and compared between low and high vigilance states. Second, sLORETA source localization algorithm is used to localize the P300 component to examine the changing aspects of the neural sources from low and high vigilance states.

**FIGURE 1:** Average reaction time
**Results and conclusion:** The EEG signals are analyzed by comparing the first and last 5 min of the data which are regarded as awake and drowsy states, respectively. The reaction time of subjects' response to target stimuli is shown to increase as the task progresses as seen in Figure 1. In PSD approach, the spectral behavior of brainwaves is compared between awake and drowsy states across different regions of the brain. The results summarized in Table 1 show the trend among subjects in transition from awake to drowsy states. An increase in delta δ and alpha α waves is observed which could be due to their dominance in relaxed states. The increased theta θ and decreased beta β activity in the right and left temporal lobes were anticipated due to the association of beta waves with alertness and theta with drowsiness. The frontal theta power decrease agrees with (Bodala et al., 2016). In the second method, the P300 component was localized for awake and drowsy states using sLORETA algorithm. The source density distribution across the head is compared for both states to construct a preliminary vigilance assessment model. The most decrease was found to be in the parietal lobe. In Peers et al. (2005), patients with parietal lesions as a group showed a significant impairment in processing speed which could explain the results obtained. Further studies on source dynamics of the brain with vigilance can promise a high precision vigilance measurement model in real-time applications.

**Keywords:** event-related potentials, P300, EEG source localization, electroencephalogram, power spectral density, brainwaves

**TABLE 1:** Brain waves PSD changes from awake to drowsy states.

<table>
<thead>
<tr>
<th>Brain waves</th>
<th>Brain region</th>
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<tbody>
<tr>
<td></td>
<td>Parietal lobe</td>
</tr>
<tr>
<td>Delta δ</td>
<td>Increase</td>
</tr>
<tr>
<td>Theta θ</td>
<td>Decrease</td>
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<tr>
<td>Alpha α</td>
<td>Increase</td>
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<td>Beta β</td>
<td>Increase</td>
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How Well Do Acculturation Strategies Predict Cognitive Achievement among Immigrant Adolescents?

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The migration of people dramatically shapes and changes the demography of immigrant-receiving societies around the world. As people migrate, travelling with them are the ideals, values, and beliefs of their heritage culture that may to a greater or lesser extent overlap with the culture of the receiving nations, and as such will present a level of pressure and challenge to adapt to life in the new environments. Correspondingly, pressure and challenge are also felt by the host nations and are of particular concern for governments to facilitate adjustment by ensuring immigrants, especially immigrant children and youth, acculturate, adapt, and therefore succeed, and contribute positively to the wealth of the host nations. This study examined first- and second-generation immigrant adolescents for the presence of links between acculturation orientations, heritage culture-oriented strategies versus host culture-oriented strategies, and cognitive achievement in mathematics, reading, and science. Additionally, the association of perceived cultural distance and heritage and host language use at home with cognitive achievement was also examined. Regression analyses, after accounting for student demographic characteristics, revealed that both first- and second-generation immigrant adolescents’ heritage culture-oriented strategies were significantly negatively linked to cognitive achievement in mathematics, reading, and science; whereas their host culture-oriented strategies were significantly positively related to cognitive achievement. Further, amongst first-generation immigrant adolescents, perceived cultural distance was significantly negatively related to their cognitive achievement. However, no significant relationship was found between the use of the host language at home and cognitive achievement levels.

Keywords: acculturation, immigrant adolescents, cognitive achievement, host culture-oriented strategies, heritage culture-oriented strategies
Category-Selective Attention for Animals: Beyond Visual Features

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Previous studies have demonstrated that humans have an attentional priority for detecting animals compared to inanimate objects. While these findings are consistent with the claim regarding the evolutionary significance of animals in human history, it is unclear whether the attentional advantage for animals depends on visual or semantic differences between the categories. Indeed, animals and inanimate objects vary greatly in shapes, and the visual and semantic features are often confounded. To distinguish visual and semantic influences on the attentional priority for animals, we conducted two visual search experiments (both N = 28). Participants searched for the presence of either an animal or a man-made object on a six-item display, with a non-target category item (e.g., man-made object when searching for an animal) appearing as a distractor in half of the trials. The rest of the distractors were fruits/vegetables. Experiment 1 used images that differ in visual characteristics across the three categories, and revealed faster and better search for animals, compared to man-made objects, replicating previous findings. Also, search performance for either category was comparably reduced with the presence, compared to the absence, of a non-target category item. Experiment 2 used instead images that were equated in image statistics and shapes (either round or elongated) across the three categories. Two aspects of the results are critical: (1) the overall advantage for animal search, compared to object search, was minimized, but (2) an interaction in response times revealed that the presence of an animal as a non-target category distractor slowed down the search performance for object search, whereas the presence of an object distractor did not slow down animal search. These results suggest that while differences in visual features between animate and inanimate categories indeed contribute greatly to the attentional advantage for animals, part of the advantage may also be driven by semantic influences.

Keywords: visual attention, visual search, semantic, animacy, category selectivity
The Use of Matrix Training to Promote the Generalization of Responding to Greetings with a Child with Autism

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Background and goals: Individuals with autism spectrum disorder often have difficulty generalizing skills across different stimuli, situations, and environments (Froehlich et al., 2012). For example, a child with autism might learn to greet a familiar adult in one setting, and then fail to display that skill in a novel setting. Stokes and Baer (1977) outlined a number of strategies for promoting generalization of skills. Many of these strategies require explicitly training a substantial number of variations of the skill before generalization is seen. A more recent development (Axe and Sainato, 2010) is the use of matrix training to promote generalization. Matrix training is an instructional technique that allows an educator to program for generalization in a particularly efficient manner. In matrix training, the teacher constructs a table consisting of a combination of items and actions (e.g., three items and three actions, which yields nine combinations of item–action), trains the child on a small number of the combinations, and then probes for the emergence of the other possible combinations without training. This emergence of skills that were not directly trained is referred to as recombinative generalization. Responding to greetings is a socially important skill for individuals with autism to learn and generalize. This skill lends itself nicely to an instructional matrix-training approach. The purpose of the present study was to investigate an instructional matrix-training approach to promote the generalization of responding to a greeting across multiple contexts with a 6-year-old girl with autism.

Method: A pretest–posttest design was used to assess a 3 × 3 matrix, consisting of three different greetings by a familiar adult (“hi,” “hello,” “hey there”) and three locations (cubby, classroom, cafeteria). More specifically, it consisted of a total of nine combinations: three combinations were directly trained and six combinations evaluated for recombinative generalization. Three of the nine possible combinations were trained until a mastery criterion was met. The additional six contexts were assessed for recombinative generalization.

Results: Following training, recombinative generalization occurred with all six untrained combinations, and mastery criterion was achieved without additional training in three of the six untrained contexts. Figure 1 provides data for performance
(percentage correct) across baseline (dark and diagonal hash bars), trained context mastery post-tests (solid bar), and recombinative generalization probes (light hash bar).

**Conclusion:** These findings replicate and extend prior research and demonstrate that an instructional matrix-training approach is effective and efficient for establishing recombinative generalization of responding to a greeting across multiple contexts in a child with autism.

**Keywords:** autism spectrum disorders, generalization, applied research, matrix training, recombinative

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Strategies to Promote Appropriate Use of Mobile Devices in the UAE Classroom

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Mobile devices such as smartphones are popular among students of all ages. It is acknowledged that these devices can support teaching and learning practices, both inside and outside the classroom. However, student personal devices can also lead to classroom disruptions if not used appropriately (Batista and Barcelos, 2014). As a result, many schools have banned or restricted students’ mobile devices in the classroom to prevent inappropriate use. It seems, however, difficult to impose policies that ban or restrict the use of mobile technology in the schools, as these devices are part of students’ daily lives, which they use for both personal and academic activities. In addition, some students may want to use their devices for emergency circumstances, while others may not comply with the ban (Keengwe et al., 2014). It is worth noting that, recently, many schools have raised the ban, allowing students to bring their devices to schools (Thomas and Munoz, 2016). Regarding the United Arab Emirates (UAE), including the Abu Dhabi Emirate, the use of mobile devices in schools is widely banned; if students use these devices, it can lead to disciplinary action (ADEC, 2016). Aiming at supporting mobile technologies in the higher education classroom, researchers have investigated strategies to promote appropriate practices (Thomas and McGee, 2012; Ben-Av and Ben-Av, 2016); however, limited studies have been conducted in schools (Thomas and Munoz, 2016), and, in particular, in the UAE classroom K–12 context. Much research is needed in the region in this field of inquiry to inform practice and the integration of the devices in schools to enhance learning outcomes. Such research can also develop awareness among stakeholders that effective strategies can help maximize the potential of mobile technology in the UAE classroom. Research by Santos and Bocheko (2016), for instance, made a contribution towards such need by investigating strategies to manage in-class use of mobiles devices from student and instructor perspectives in the UAE. The study, that adopted mix methods of data collection, found that participants favored a strategy that does not turn-off or ban the devices in class. Some of the main patterns discussed in the study, and also reported in other contexts (Jackson, 2013), included the integration of the devices in teaching to help minimize disruptions, involve students and instructors in training to develop awareness of appropriate practices and integration, and consider students in the development of strategies for mobile devices usage in class. Further, a key finding discussed by Santos and Bocheko that may be relevant to the UAE context was the
need to consider students’ opinions when creating strategies to manage the devices in class as their expectations may vary depending on the culture and context. Although this study focused on the higher education classroom, it works as a springboard to further the discussions on how to manage mobile technology in the classroom, especially in the UAE context, as well as inform future studies in the region at school level. For example, future studies could explore strategies for appropriate practices as perceived by teachers and students involved in cycles 1—3 and other stakeholders such as principals. Future studies could also expand the methodology adopted by Santos and Bocehco by using other data collection tools and diverse groups.

**Keywords:** integration, classroom, mobile technology, smartphones, appropriate strategies

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Holistic Processing of Faces Is Modulated by Facial Expressions

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Faces are thought to be processed holistically: all facial features appear to be processed as a whole, instead of as individual features. At a glance, observers can easily extract the identity and emotional expressions of a face. To what extent is identity and expression processing integrated? Previous findings often used only neutral faces to study holistic processing of facial identity, thus, it remains unclear to what extent facial expressions may influence identification judgments. Moreover, observers appear to emphasize different facial features in recognizing various facial expressions, such as processing both the top and bottom face halves for happy faces, and focusing on the top halves for angry faces. Here, we asked whether holistic processing of facial identity is modulated by happy or angry facial expressions. In a composite paradigm, participants (N = 24) performed identity matching on either the top or bottom halves of each pair of sequentially presented composites and were asked to ignore the task-irrelevant halves. The face halves were either aligned or misaligned. The pairing of identities between the face halves were either congruent or incongruent. The composites showed happy or angry expressions; the expressions on the top and bottom halves of the composites were always congruent; and the expression conditions were randomized. We found significant holistic processing in all expression conditions. More importantly, the holistic effects were modulated by expressions, as indicated by a significant 3-way interaction of expression, alignment, and congruency. Critically, holistic processing was stronger for happy than angry faces. The results suggest that identity judgement is influenced by the different processing strategies for different expressions, even when emotional information is task-irrelevant. This provides evidence that holistic processing integrates the identity and emotional information of faces and is dynamic across trials.

Keywords: emotions, face processing, expressions, composite effect, face identity
Using an Instructional Matrix to Promote Generalization of Responding to Greetings

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**Background and goals:** Individuals with autism spectrum disorders (ASDs) display marked deficits in social communication as a hallmark of the disorder (American Psychiatry Association, DSM-V). These deficits in social communication skills are not related to cognitive functioning and do not improve with age, suggesting that social skills should be targeted in early intervention plans for children with ASD (Cervantes et al., 2013). An additional area with which many individuals with ASD show difficulties is generalizing learned skills (Radley et al., 2014). Matrix training is a strategy which can promote the generalization of trained skills. Skills are trained in multiple contexts, each of which includes a unique combination of components, and are tested for generalization in untrained contexts as trained contexts are mastered (Goldstein, 1983). Recombinative generalization is said to occur when an individual performs the skills of an untrained combination. Similar to the matrix training strategy, the current study trains diversely using an instructional matrix in which the goal is to promote stimulus generalization among common stimuli that will likely be present in situations where the behavior of responding to greetings is important. These stimuli include different settings, ongoing activities, and greetings from others, creating a \(3 \times 3 \times 3\) training matrix. The purpose of the current study was to examine the effects of training diversely using an instructional matrix on the generalization of responding to greetings across contexts in three children diagnosed with ASD.

**Method:** Participants were three children diagnosed with ASD: two boys (ages six and seven) and one girl (age eight). The \(3 \times 3 \times 3\) matrix incorporated three settings (Classroom, Library, and Cafeteria), three activities (No Item, Item, and Item with Screen), and three greetings (Hi, Hello, and Hey There) to create twenty-seven unique contexts. A multiple baseline across participants design was used. Following baseline assessment, each participant was trained to respond to greeting in three contexts. A probe was conducted after training to assess responding to greeting in all contexts. One participant met criteria to conduct training in three additional contexts. A probe was conducted following the second training session with this participant.
FIGURE 1: Percentage of trials correct during baseline and post-training probes of untrained contexts (generalization probes). Each data point shows a single session of 5 trials in one of the 27 different contexts. Training sessions and maintenance probes are not shown.

Results: Following training, participants increased the number of untrained contexts in which they responded to greeting from 5 to 20 (Figure 1, Panel 1), 12 to 20 (Figure 1, Panel 2), and from 0 to 17 (Figure 1, Panel 3).

Conclusion: These results suggest that training with multiple exemplars as defined by an instructional matrix may be a useful strategy for promoting generalization of skills for individuals with autism.
**Keywords:** social skills, instructional matrix, matrix training, recombinative generalization, responding to greeting

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Mapping Levels of Neurotransmitters in Different Brain Regions after Seizures under Heat Stress

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**Background:** Hyperthermia elicited by heat stress is a common occurrence in hot environments, to which children are particularly vulnerable. In humans, heat stress can impair brain function, including working memory (Walter and Carraretto, 2016) and cognitive function (Hancock and Vasmatzidis, 2003), and can induce seizures (Hocking et al., 2001). Neurotransmitters are crucial to sound brain function, and their balance is affected globally by heat stress-induced seizures (McMorris et al., 2006). However, what is less known is how heat stress-induced seizures impact specific brain tissue involved in memory function. The hippocampus is a brain structure that plays an important role in spatial learning and memory (Sharma and Hoopes, 2003), but its neurotransmitter levels in hyperthermia-induced seizures are not well known. This study examines the effect of heat stress on three neurotransmitters in vivo in mouse hippocampus. Two of these are important to cognitive function: gamma-aminobutyric acid (GABA) and 5-hydroxytryptamine (5HT), and the third is involved in arousal, norepinephrine (NE).

**Method:** Forty male mice divided into 4 groups were exposed to heat stress, and seizures were then induced using electric shock (ES; electrically induced) and pentyleneetetrazol (PTZ; pharmacologically induced), separately. Specific brain regions were then examined for neurotransmitter levels, including the striatum, nucleus accumbens, hippocampus, frontal cortex, hypothalamus, and the amygdala. GABA, 5HT, and NE levels were determined via HPLC with electrochemical detection. In addition, levels in 10 control mice were also examined.

**Results:** Following hyperthermia, GABA levels were significantly reduced (an average decrease of 32%) following PTZ exposure in multiple brain regions; however, no significant change in GABA levels was observed after ES exposure. On the other hand, 5HT and NE levels were significantly increased (an average increase of 61 and 54%, respectively) following ES exposure; however, no significant change in 5HT and NE levels was observed after PTZ exposure. It was interesting to observe that further treatment with ES increased 5HT and NE levels to 97 and 82%, respectively.
Conclusion: Change in GABA levels (by PTZ) confirms the exacerbating risk of seizures by hyperthermia. Also, monoamines (such as 5HT and NE) are involved in heat stress-induced convulsion, which suggests that electrically induced seizures are more susceptible to heat stress. Future studies will be conducted to further explore the effect of heat stress on neurotransmitters, and how they relate to learning and cognitive function.

Keywords: hippocampus, seizures, GABA, neurotransmitters, 5HT, hyperthermia, mouse model, brain regions, NE

REFERENCES


Prefrontal Cortex Modulation with Transcranial Direct Current Stimulation (tDCS) for Nicotine Craving Reduction: A Double-Blind, Sham-Controlled Study

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Objective: Health authorities say that six million smokers in the Kingdom of Saudi Arabia (KSA) spend a whopping SR11 billion annually to satisfy their urge for nicotine. The aim of this study was to test whether nicotine intake behaviors are modulated by transcranial direct current stimulation (tDCS) over the dorsolateral prefrontal cortex (DLPFC) for 3 days in tobacco smokers who wished to quit smoking.

Methods: Subjects (n = 22) received 3-day tDCS regimens (active or sham) at a 1.5 mA during 20 min. Nicotine cravings, cigarette consumption, and neurocognitive and mood assessment were assessed before and after each session.

Results: Comparing between 3 days before and after stimulation (6 days in total) has shown a significance for both active (p-value = 0.007) and sham groups (p-value = 0.07), respectively. But when 17 days data were analyzed (7 before and 10 after the first session), the active group (p-value = 0.004) was more statistically significant than sham group (p-value = 0.005).

Conclusion: Overall, these findings suggest that tDCS over the DLPFC may be beneficial for smoking reduction, and the approach makes use of potential pathways to modulate brain function.

Keywords: cognitive therapy, nicotine, addiction, brain stimulation, tDCS

Acknowledgement

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Phenotypic and Genetic Heterogeneity Linked to the Magnesium Transport Mediator CNNM2

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Metal cation transport mediator (CNNM) gene family comprises 4 isoforms (CNNM1–4) that are expressed in all human tissues except for CNNM1, which is mainly expressed in the brain. Structurally, CNNMs are complex proteins that contain an extracellular N-terminal domain preceding a DUF21 transmembrane domain, a ‘Bateman module’ and a C-terminal cNMP-binding domain (de Baaij et al., 2012). Recent studies suggest CNNM2 (cyclin M2) to be part of the long sought basolateral Mg2+ extruder at the renal distal convoluted tubule or its regulator. The Bateman module of CNNM2, consisting of two consecutive CBS (cystathionine β-synthase) domains, associates itself in disc-like dimers commonly referred to as “CBS modules.” Interestingly, nucleotide binding triggers a conformational change in the CBS module from a twisted towards a flat disc-like structure that mostly affects the structural elements connecting the Bateman module with the transmembrane region (Corral-Rodríguez et al., 2014). Mutations in CNNM2 cause familial dominant hypomagnesaemia (Stuiver et al., 2011), a human disorder characterized by renal Mg2+ wasting that may lead to symptoms of Mg2+ depletion such as tetany, seizures, and cardiac arrhythmias. On the other hand, mutations in CNNM4, the closest homologue of CNNM2, have clinical consequences that are limited to retinal function and biomineralization and are considered the cause of autosomal-recessive cone-rod dystrophy with amelogenesis imperfecta (Parry et al., 2009; Polok et al., 2009). Recently, growing evidence highlights the role of CNNM2 in neurodevelopment. Mutations in CNNM2 have been implicated in the development of a range of neurodevelopmental phenotypes, including epilepsy, intellectual disability, schizophrenia, and others (Arjona et al., 2014; Ohi, 2015). In the present study, we aim to elucidate the function of CNNM2 in the developing brain.
Thus, we present the genetic origin of symptoms in two family cohorts. In the first family, three siblings of a highly consanguineous Palestinian family in which parents are first cousins, and consanguineous marriages ran over the past four generations, presented varying degree of intellectual disability, visual impairment due to cone-rod dystrophy, and autism spectrum disorder. Whole exome sequencing and subsequent segregation analysis revealed the presence of homozygous pathogenic mutation in the CNNM2 gene, the parents were heterozygous carriers for that gene mutation. Magnesium blood levels were normal in the three children and their parents in several measurements. They had no symptoms of hypomagnesemia. The CNNM2 mutation in this family was found to locate in the CBS1 domain of the CNNM2 protein. The crystal structure of the mutated CNNM2 protein was not significantly different from the wild-type protein, and the binding of AMP or MgATP was not dramatically affected. This suggests that the CBS1 domain could be involved in pure neurodevelopmental functions independent of its magnesium-handling role, and this mutation could have affected a protein partner binding or other functions in this protein. In the second family, another autosomal dominant CNNM2 mutation was found to run in a large family with multiple affected individuals over three generations. All affected family members had hypomagnesemia and hypermagnesuria. Oral supplementation of magnesium did not increase the levels of magnesium in serum significantly. Some affected members in this family have defects in fine motor skills such as dyslexia and dyslalia. The detected mutation is located in the N-terminal part, which contains a signal peptide that is thought to be involved in sorting and routing of the protein. In this project, we describe heterogenous clinical phenotypes related to CNNM2 gene mutations and protein functions. In the first family, we report for the first time the involvement of CNNM2 in retinal photoreceptor development and function. CNNM4 is already described to be involved in retinal development. We also report for the first time the presence of a neurophenotype independent of magnesium status related to the CNNM2 protein mutation. Taking into account the different modes of inheritance and the different positions of the mutations within CNNM2 and its different structural and functional domains, it is likely that CNNM2 might be involved in a wide spectrum of psychiatric and neurological comorbidities with considerable varying phenotypes.

**Keywords:** inheritance patterns, neurodevelopment, cone-rod dystrophy, CBS1 domain, magnesium transport mediator

**REFERENCES**


Influence of Neuro-developmental Therapy with Repetitive Magnetic Stimulation on Gait Functions in Female Adults with Multiple Sclerosis

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Background: Multiple sclerosis (MS) is a chronic progressive disorder representing the major non-traumatic disability in adults. Magnetic stimulation has been studied in patient with MS, especially as diagnostic and prognostic method. Transcranial magnetic stimulation (TMS) on the cortex has been proved to be the most effective among the evoked potentials in MS patient. On the other hand, magnetic stimulation on peripheral body part in actual rehabilitation setting has been rarely investigated. Activity of gluteus medius directly influences gait in MS but has been poorly understood.

Objective: The present study aimed to investigate the efficacy of neuro-developmental therapy (NDT) with repetitive magnetic stimulation (RMS) targeting gluteus medius on gait in the female patients who had multiple sclerosis (MS).

Methods: Five female adults with multiple sclerosis were recruited for the study. They were functionally able to walk more than 10 m independently or under supervision. Intervention consisted of repetitive peripheral magnetic stimulation (RPMS) on gluteus medius (intensity: 110–120% of resting motor threshold; frequency: 20–30 Hz; duration: 5–10 min) and NDT (postural setting for standing and gait training). Patients attended 10 times of intervention. Evaluations were done twice: pre- and post-intervention. Spacio-temporal gait parameters, postural stability, and limits of stability were measured for the evaluation.

Results: In pre- and post-evaluations, significant differences were found in medial lateral index in postural stability test ($p = 0.02$) and direction control to left and
to backward/right in limits of stability test \( (p = 0.02) \). The important differences in pre- and post-evaluations were shown in cadence \( (p = 0.03) \), stride length \( (0.02) \), and gait cycle duration \( (p = 0.01) \).

**Conclusion:** According to our study, it was determined that NDT with RMS approaches were effective to improve the gait in female adults with MS. We conclude that the combination of NDT with RMS is effective in MS rehabilitation.

**Keywords:** gait, multiple sclerosis, physical therapy, postural stability, limits of stability, repetitive magnetic stimulation, neuro-developmental therapy

**REFERENCES**


Objectives: Diabetes Mellitus is associated with a higher incidence of neurobehavioral symptoms, fatigue, and cognitive impairment, in the form of longer reaction times and impaired spatial planning [1-4]. However, to see the independent effect of diabetes on cognitive impairment by controlling the confounding effect of fatigue and mini mental state needs further studies. Therefore, we hypothesized that there are some missing links and controversies in the relation between cognitive impairment in T2DM and its relationship with body composition indices and adipokine visfatin.

Methods: This pilot observational case–control study was conducted at the Department of Physiology, College of Medicine and King Khalid University Hospital (KKUH), Riyadh, Saudi Arabia. We used a validated standardized mini–mental state examination (MMSE), Fatigue Severity Scale (FSS), and a Visual Analogue Fatigue Scale (VAFS) as screening tests before neurocognitive assessments. All subjects were matched for MMSE, FSS, and VAFS scores. We excluded the diabetics with high FSS and VAFS scores and lower MMSE scores, to match them with the control subjects. After screening of 103 subjects, the final selection included 65 participants (31 patients with T2DM and 34 healthy controls). Clinical and demographic characteristics were measured for each participant. Cognitive functions were evaluated by Cambridge Neuropsychological Automated Battery (CANTAB) to assess executive functions and memory. The test paradigms used were stop signal task (SST) and intra–extra dimensional set shift (IED). Blood samples were collected to measure visfatin, fasting blood glucose (FBG), and HbA1c levels. Body composition was analysed by bioelectrical impedance analysis (BIA) using Body Composition Analyzer (Type BC-418 MA, TANITA Corporation, Japan). The bioimpedance analyzer uses eight points of tactile electrodes (contact at the hands and feet). The technique uses multiple frequencies to measure total body water, fats, and fat free mass in total and its segmental distribution in trunk and limbs.

Results: Patients with T2DM showed higher visfatin levels and significantly impaired cognitive functions compared to healthy control individuals in stop signal reaction time (SSRT) last half, SST median correct reaction time on GO trials, stop signal
delay (SST SSD) 50% last half, and SST direction errors on stop and go trials in SST task (Figure 1). It was observed that stop signal task stop signal reaction time (SST SSRT) last half ($p=0.03$), stop signal task median correct reaction time on GO trials ($p=0.0012$), stop signal task stop signal delay (SST SSD) 50% last half, and ($p=0.02$), stop signal task direction errors on STOP and GO trials ($p=0.04$) were significantly delayed in diabetic patients compared to the controls, while the difference for stop signal task proportion of successful stops in the last half ($p=0.24$) was not significant between the two groups. The SSP length was significantly lower in diabetics compared to control subjects indicating impaired working memory capacity ($p=0.02$). The correlation between visfatin levels and cognitive functions was not statistically significant. However, visceral adiposity correlated inversely with IED task for total errors, SST median, and SST SSD last half.

**FIGURE 1:** Comparison of cognitive assessment tests of CANTAB between control and diabetic subjects. (A) Stop signal task stop signal reaction time (SST SSRT) last half. (B) Stop signal task median correct reaction time on GO trials. (C) Stop signal task stop signal delay (SST SSD) 50% last half. (D) Stop signal task (SST) direction errors on STOP and GO trials. (E) Stop signal task proportion of successful stops. (F) Special span (SSP) length. Note: milliseconds (ms), number of errors (noe), and number of items (Items).
**Conclusion:** Patients with T2DM have cognitive impairments, in the form of longer reaction times in flexibility of attention and impulse control along with impaired working memory, compared to matched control subjects. Moreover, visceral adiposity may be related to pathophysiology of cognitive impairments in these patients.

**Significant outcomes:** Compared to healthy subjects, patients with T2DM had significant delay in response time to SST and decrease in SSP length time paradigm. IED, SST, and SSP paradigms assess the flexibility of attention, impulse control, and working memory capacity, respectively. Visceral adiposity correlated significantly with impairment in cognitive functions including IED and SST tasks, while no relationship was observed with SSP. Serum adipokine visfatin levels did not correlate significantly with any neurocognitive tests.

**Limitations:** The limitations of our study were that we had relatively small sample size and its cross-sectional design. Moreover, only three cognitive paradigms were assessed although CANTAB battery contains about 25 tasks.

**Keywords:** fatigue, working memory, cognitive function, type 2 diabetes mellitus, waist/hip ratio

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**REFERENCES**


Prevalent MLC1 Founder Mutation Causing Autosomal Recessive Megalencephalic Leukoencephalopathy in Consanguineous Palestinian Families

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Megalencephalic leukoencephalopathy with subcortical cysts (MLC) is a rare hereditary disease that manifests as early-onset macrocephaly, accompanied by mild but progressive gross motor developmental delay, and seizures that may be provoked by trauma. Later in the disease course, significant spasticity and ataxia develop, which may be accompanied by mild intellectual deterioration. Brain MRI shows characteristic abnormalities, including diffuse supratentorial white matter swelling and the presence of subcortical cysts in the anterior temporal region and frontoparietal region. The severity of the disease is variable according to the phenotype. In the classical phenotype, patients present with early-onset clinical picture. Macrocephaly is present at birth or in the first year of life and is associated with mild delay in gross motor development and progressive evolution of pyramidal symptoms and sign. Cerebellar ataxia may develop later in life. Most children become wheelchair-dependent as teenagers. Intellectuality is normal or mildly affected later in the disease course. Mutations in MLC1 gene are responsible for most patients with the classical phenotype and are inherited in an autosomal recessive manner. An atypical improving phenotype has a similar initial presentation with improvement in the clinical picture later in life. This phenotype is caused by heterozygous mutations in the HEPACAM gene. In this study, we sequenced the entire coding region of MLC1 gene in six Palestinian patients coming from four different parents with consanguineous marriages. All studied patients originate from several Palestinian villages located in south and south east Nablus. We identified an MLC1 splice mutation in all of the studied patients. This highlights strong founder effect in this area, where marriage counseling and screening should be provided.

Keywords: macrocephaly, founder effect, leukoencephalopathy, autosomal recessive, splice site mutation, consanguinity, MLC disease

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Behavioral Deficit and Hippocampal Neurodegeneration Following Short-Term Adrenalectomy

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The development of animal models to study cell death in the brain is a delicate task. One of the models that have been discovered is the induction of neurodegeneration through glucocorticoid withdrawal by adrenalectomy. This is one of the few non-invasive models to study neurodegeneration. In the current study, we aimed to investigate the impact of the loss of adrenal hormones on different hippocampal neuronal populations of Wistar rats. Moreover, the cognitive function of these rats was evaluated using the passive avoidance task (PA) after 3, 7, and 14 days of adrenalectomy. Our results showed cell death in the dentate gyrus (DG) and CA4 on the third day in the hippocampus of adrenalectomized rats compared to the sham operated. Seven days later, in addition to the progression of the cell death in the DG and CA4, we observed few degenerative CA3 pyramidal cells in adrenalectomized rats compared to the sham. Moreover, 2 weeks postoperatively, our results showed a considerable cell death all over the DG and pyramidal cells of the CA4 and CA3 of the hippocampus of adrenalectomized rats compared to sham operated. In order to investigate the effect of adrenalectomy on the behavior of the animals, we used a passive avoidance test at 3, 7, and 14 days after adrenalectomy. Our results showed a significant reduction in the latency time in the adrenalectomized rats compared to the sham operated rats 3, 7, and 14 days after adrenalectomy. In conclusion, our results showed that the neuronal death in the current model is not selective where both granule and pyramidal cells undergo substantial neurodegeneration. In addition, the neural death was accompanied by a behavioral deficit in the ADX animals.

Keywords: adrenalectomy, neurodegeneration, hippocampus (Hip), granule cells, passive avoidance
Acknowledgement

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