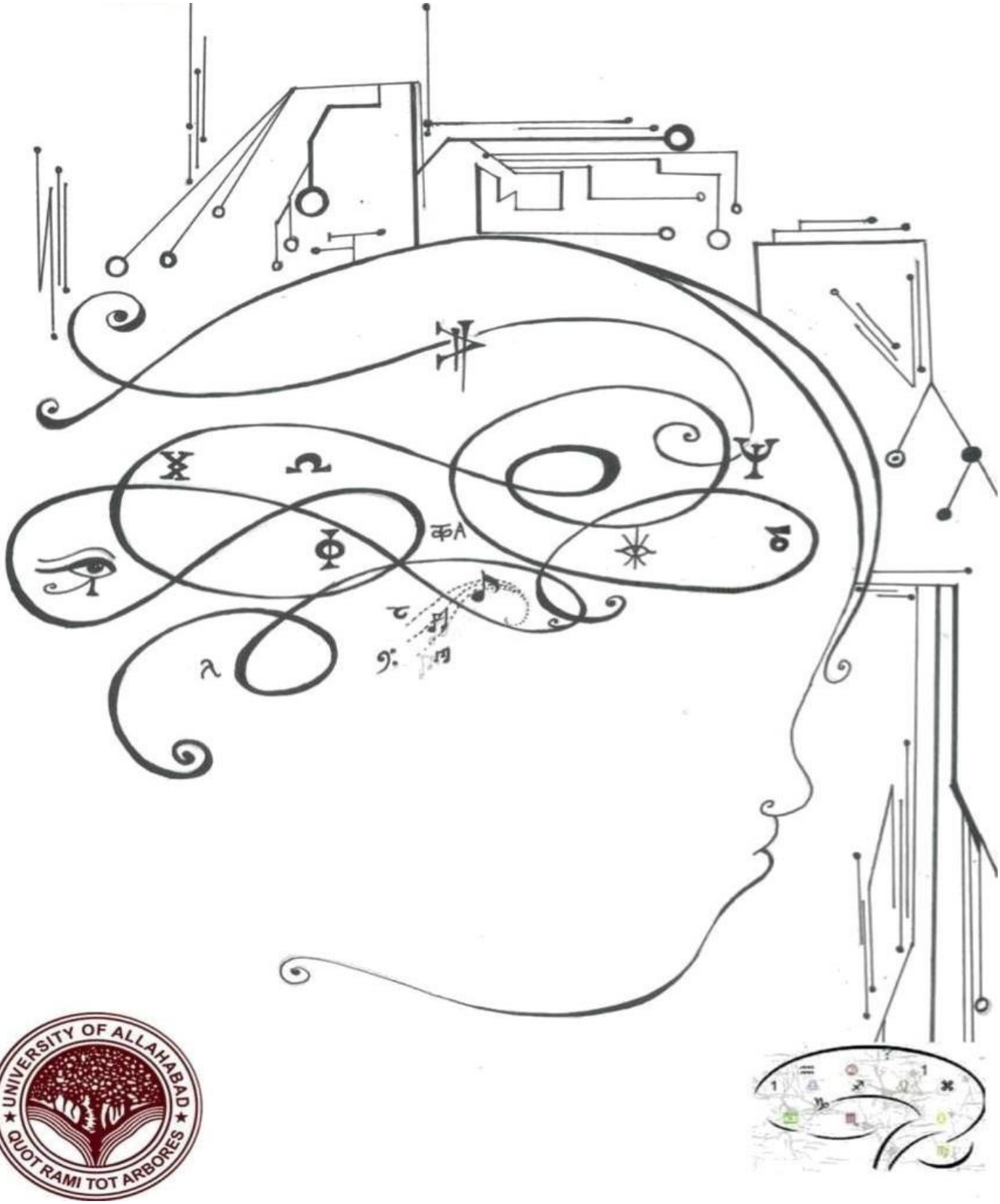
Issue 7: November 2022

CBCS NEWSLETTER



About CBCS

Prof. Bhoomika R. Kar
Head, CBCS

The Centre of Behavioural and Cognitive Sciences as a pioneer institution for cognitive science in India is now moving forward to introduce an integrated MSc-PhD program in Cognitive Science starting in 2023. This program has been designed in compliance with the objectives of the National Education Policy 2020 and to encourage Cognitive Science Research in India. The integrated program will have multiple points of exit with a certificate in one year, MSc degree in 2 years and PhD degree if one continues after the masters. The regular MSc and PhD programs shall continue.

Masters and PhD students at the Centre learn methodologies like EEG/ERP, eye tracking and functional MRI with the lab facilities available at the Centre. Five Masters' students in the current batch have proposed their MSc thesis using functional MRI, three with eye tracking, two using EEG/ERP and psychophysics-based experimentation. The lab rotations in the first semester to familiarize students with the various methodologies/lab equipment available at the Centre, have helped the students to orient, learn and propose research ideas using the appropriate methodologies. The Centre has conducted a series of workshops on methods in cognitive science this year with one on Diffusion Weighted Imaging (June 8-9, 2022), second one on EEG/ERP analysis on Oct 20-21, 2022 and another one on Graph-based network analysis of resting state fMRI data on November 17-18, 2022.

The research areas cover a wide range such as action control, neuroaesthetics, affective computing, social-emotional development, neuroinflammation and cognition, language and cognition, concept learning, time perception, attention, cognitive control, bilingualism, categorization and concept learning, emotion-motivation and decision making. This has been possible also with the appointment of three new faculty members with expertise in varied areas of research: neurobiology of memory;

cognitive neuroscience of time perception, attention, emotion and meditation using fMRI; language, emotion and cognition using eye tracking and EEG/ERP. Given that the University has been in an offline mode completely for the last few months, research has picked up its pace and we are looking forward to some exciting set of findings. Masters students at CBCS have started a bimonthly Journal Club on Saturdays. So far, we have had six sessions during January to April, 2022 and it has resumed on 27th August for the current semester.

We hope that we only learn and grow as disciplined researchers and academicians trying to understand the innerworkings of mind and brain, keep working on strengthening our skills with converging methodologies and have a meaningful and humane approach to studying Cognitive Science. In addition to research, industry related applications in Education, UX design and research, and policy making have also grown in India with better opportunities for cognitive science graduates (including the students of CBCS) in the industry.

Events

Workshop on Diffusion Weighted Imaging, June 8-9, 2022

Centre organized a Two-day Workshop on Diffusion Weighted Imaging (DWI) on June 8-9, 2022. DWI is a promising tool in neuroimaging research and provides useful information for clinical and cognitive neuroscience. DWI is an MR imaging modality, widely used to infer white matter neuroanatomical microstructure and connectivity in-vivo.

Dr. Madhura Ingalhalikar, MRI Scientist, Clario, Texas and Adjunct Faculty, Symbiosis Centre for Medical Image Analysis, Symbiosis International University, Pune was the resource person for the workshop. Her extensive experience and expertise in cognitive neuroimaging and DWI will certainly aid in training and capacity building for fMRI research. Two of her PhD scholars, Archith Rajan and Apoorva Safai with training in diffusion imaging and machine learning assisted her.

The goal of this 2-day workshop was to provide hands-on experience with the acquisition of Diffusion weighted imaging (DWI) sequences, data pre-processing and analysis. Overall, the emphasis of this workshop was on how to use DWI in fMRI as a tool to address research questions in cognitive neuroscience and clinical neuroimaging. Diffusion tensor model and tractography was also discussed. Twenty scholars including Masters/PhD/post-doctoral fellows/young faculty from cognitive science/neuroscience/ biochemistry/medical sciences from various institutions like IIT Kanpur, IIT Gandhinagar, IIT Delhi, IIT Madras, ICSSR, MLN Medical college, Allahabad, Dept of Electronics and Communication, and CBCS, UoA participated in the workshop.

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Workshop on EEG/ERP analysis
October 20-21, 2022

Centre of Behavioural and Cognitive Sciences
University of Allahabad

The Centre organized a Two-day Workshop on EEG/ERP Analysis on October 20-21, 2022. Electroencephalography/Event-related potentials (EEG/ERP) is a noninvasive measurement of electrical activity produced by the brain as recorded from the electrodes placed on the scalp and ERP measures the time course of a cognitive process.

The goal of this 2-day workshop was to provide hands-on training with the acquisition of EEG/ERP data, data pre-processing and analysis. Overall, the emphasis of this workshop was on how to use EEG/ERP as a tool to address research questions in Cognitive Science. In addition, how to measure functional connectivity and compute oscillatory power; and how machine learning and other computational methods can be helpful to understand EEG data was also be discussed.

This workshop was mainly targeted at advanced Masters, PhD and postdoctoral level scholars from Cognitive science/Neuroscience/Psychology/Computer Science, who plan to use EEG/ERP methodology in their current and/or future research. Twenty-five scholars from various institutions like IIT Kanpur, IIT Gandhinagar, IIT Hyderabad, IIT Delhi, IIT Roorkee, IIT Bombay, Norwegian Institute of Science and Technology, BHU, and CBCS, UoA participated in the workshop.

Dr. Marieke van Vugt, Assistant Professor at the Bernoulli Institute of Mathematics, Computer Science, and Artificial Intelligence, University of Groningen, the Netherlands, is the resource person for the workshop. Her extensive experience and expertise in EEG Data Acquisition and Analysis, Computational Modeling, Relevance of Interbrain Synchrony for Social Cognition using EEG and Research work on Mind Wandering will certainly aid in training and capacity building for EEG/ERP research in India.

The workshop started on October 20, 2022 with an introductory talk on EEG by Dr. Marieke van Vugt followed by sessions on designing EEG/ERP experiments by Prof. Bhoomika R. Kar and Dr. Marieke van Vugt, demonstration of EEG recording with a high-density EEG system by Dr. JayPrakash Singh in the lab at the Centre. The hands-on sessions on EEG/ERP analysis with a sample data set were conducted on Day 1 and Day 2 of the workshop covering preprocessing, extraction of ERPs, brain oscillations, connectivity analysis, and machine learning.

We believe that workshops on advanced techniques like EEG/ERP will help in capacity building and upgrade analytical skills for research.

Foundation Day Lecture

The Centre of Behavioral and Cognitive Sciences, University of Allahabad celebrated its 21st Foundation Day on 28th October, 2022. On this occasion the Centre organized a Foundation Day Lecture, "Compositionality in Brains and Machines" by Prof. Bapi Raju S, International Institute of Information Technology, Hyderabad on October 28 at 11:00 am.

The session began with a brief report on the accomplishments of the Centre during the past year by the Head of the Centre, Prof. Bhoomika R. Kar followed by an invocation with a Bharatnatayam performance by Amruthavalli, a second-year masters' student at CBCS. This was followed by an interesting deliberation about compositionality in cognition (vision, language and action) by Prof. Bapi Raju who is a distinguished professor-researcher currently an esteemed faculty member in the Cognitive Science Lab in IIIT Hyderabad. His research interests include neural networks, cognitive modelling and pattern recognition. He has been associated with CBCS since its inception. In his talk he reviewed the strengths and weaknesses of foundational models such as DALL-E-2 and GPT-3, highlighting their limitations in composable generalization. He explained that the combinatorial nature of compositionality poses enormous problems for machines but at the same time, it is intriguing how humans and some animals accomplish this effortlessly. The talk ended with suggestions as to how Cognitive Science can offer insights into deep learning methods. Prof. Janak Pandey, Founder Head, CBCS, congratulated the Centre for its contribution to the field of cognitive science and encouraged the faculty and students, emphasizing upon the multi-faceted growth of this discipline in India. The session ended with vote of Thanks proposed by Dr. Niharika Singh, Faculty, CBCS.

The Centre also organized a session on 29th October, 2022 with two of its alumni, Dr. Ark Verma, Assistant Professor, Dept of Cognitive Science, IIT Kanpur and Dr. Abhilasha, Usability Engineer, Philips, Bangalore. Dr. Verma delivered a talk on "How the 'Self' may guide our social behaviour" and Dr. Abhilasha discussed about cognitive science applications for the industry and interacted with students responding to their concerns/questions about career opportunities for cognitive science graduates in the Industry.

Foundation day Lecture by Prof. Bapi Raju, IIIT Hyderabad on October 28, 2022

Talk by Dr. Ark Verma, Dept of Cognitive Science, IIT Kanpur (right). Dr. Abhilasha, Usability Engineer,Philips, Bangalore (left) on October 29, 2022

Congratulations!

Faculty Appointments

Dr. Shiv Kumar Sharma has joined CBCS as Associate Professor in July 2022. He has been a faculty at the National Brain Research Centre,Manesar for many years. He did his PhD from the Centre of cellular and molecular biology, Hyderabad and received his postdoctoral training at University of California, Irvine, University of Colorado, USA and University of British Columbia, Vancouver. His research focuses onthe neurobiology of learning and memory and Alzheimer's disease.

Dr. Jay Prakash Singh has joined as Assistant Professor at CBCS, University of Allahabad. He did his postdoctoral research on emotion and cognition at IIT Bombay. He has worked on Anticipation and cognitive control in bilinguals during his doctoral work at CBCS. Dr. Jay Prakash is interested in literacy and cognition, language, emotions and decision-making using eye tracking and EEG/ERP.

Dr. Amrendra Pratap Singh: Dr. Amrendra Pratap Singh has joined as Assistant Professor at the Centre of Behavioural and Cognitive Sciences, University of Allahabad. He received a DST-postdoctoral research fellowship from to study the effect of spatial attention of perception of time using functional neuroimaging. He has worked on meditation, perceptual experience and attention during his doctoral work at CBCS. Dr. Singh is interested in time perception, emotions, and meditation usingfMRI.

Congratulations!

Placements: Faculty positions

Dr. Richa Nigam: Dr Richa Nigam has joined as an Assistant Professor in Thapar School of Liberal arts and Sciences, Thapar University, Patiala after completing her PhD at CBCS. She has worked on "Cognitive Ageing and Emotion regulation" during her doctoral work. Cognitive/emotional ageing and dementia are her primary areas of research interest.

Dr. Yagyima Nehabala: Dr. Yagyima Nehabala has joined as an Assistant Professor in Psychology at University Institute of Liberal arts and Humanities, Chandigarh University, Punjab, India after completing her PhD Thesis on "Development of Conflict monitoring and adaptation as a Component of Cognitive and Affective Control".

Admission to PhD and Masters Programme

Aswini Madhira
M.Sc (2017-2019)

Ph.D, Action Control and Cognition lab
University of Hyderabad

Shuborno Chakrabarty
M.Sc (2019-2021)

M.Sc.,School of Public policy,
IITDelhi

Hariharan Purohit
M.Sc (2019-2021)

Ph.D, Department of Cognitive Science
IIT Kanpur

Poulami kar
M.Sc (2019-2021)

Ph.D, Centre of Behavioural
and Cognitive Sciences, UoA

Sumani Pushkarna
M.Sc(2019-2021)

Ph.D, Centre of Behavioural
and Cognitive Sciences, UoA

Shailendra Patel
M.Sc(2019-2021)

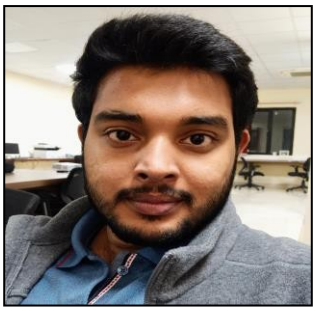
Ph.D, Centre of Behavioural
and Cognitive Sciences, UoA

Industry:

Mr. Sainul Abid
M.Sc(2020-2022)

Associate Data Scientist,
Pristine Infotech India

Kumar Abhijeet
M.Sc(2019-2021)



UX designer &
researcher, Kore.AI,
Hyderabad

Himani Joshi
M.Sc(2019-2021)

UX Researcher
Market Plus, Mumbai

Ritika Kumari
M.Sc(2020-2022)

UX Experience Researcher
WayCool foods

Tanushree
M.Sc(2019-2021)

UX Researcher
Censa

Research Associate:

Muskan Jindal
M.Sc(2019-2021)

Research Associate
IIM Ahmedabad

Pragya Verma
M.Sc(2019-2021)

Research Associate
Centre for Neuroscience.
IISc Bangalore

Shivangi Yadav
M.Sc(2019-2021)

Research AssociateDept of
Neurology,AIIMS New Delhi

Moon Majumdar
M.Sc(2020-2022)

Research Intern, Centre for
Neuroscience

Praveen Kaushik
M.Sc(2019-2021)

Research Associate
IIM Ahmedabad

Research Article

Pragya Pandey
PhD Scholar, CBCS

Influence of the location of the decision-cue on the dynamics of pupillary light response.

We rarely experience either excessive or impoverished brightness while exploring the visual world with varying luminance. The reason might be that the pupils of the eye reflexively constrict in light and dilate in the dark to optimize the retinal illumination. Changes in pupil size with varying luminance levels are known as pupillary light reflex (PLR). The magnitude of pupillary light response (PLR) is a function of corneal flux density (CFD), which is the product of the adaptive field size of the stimulus by luminance. PLR is not completely reflexive, but many non-visual cognitive factors, like attention, decision-making, eye movement preparation, arousal, etc., can also influence the PLR. Various forms of attention can affect the PLR, for example, spatial attention, temporal attention, feature-based selective attention, and pre-saccadic attention shifts. Whether the scope of attention (attentional breadth) also influences PLR remains unclear.

In this study, we investigated whether changing the scope of attention to select the target from alternatives for eye movement influences the pupillary response (PLR). The pupil dynamics were contrasted between the focused and distributed attentional conditions during decision-making, while the global CFD was kept the same between the two conditions. To select the target from four alternatives, participants distributedattention to the peripheral decision cue in one task (Peripheral cueing task) and concentrated at the center inthe other (Central cueing task).

We continuously recorded pupil size and eye position using specialized high-speed (240 times per second) video cameras called infrared eye-trackers. The peripheral and central tasks started with a small white square (fixation spot) at the centre of the monitor, and participants were instructed to look at it. Following the fixation spot, four checker boxes appeared at the periphery, along with a broken circle near the center of the

display (Figure 1). After a few times, the fixation spot and the broken circle disappeared, and all four peripheral checker

boxes were masked by grey squares simultaneously (go-signal). In the central cueing task, participants were asked to select the largest gap of the broken circle and to make an eye movement to one of the squares in the direction of the largest gap (Figure 1A). In the peripheral cueing task, participants were asked to select the checker box with the largest proportion of magenta color and to make an eye movement to the location of the selected target after the fixation spot disappeared (Figure 1D). However, in 40 % of trials (stop trials : Figure 1E), the fixation spot reappeared after a variable delay from its disappearance. The re-appearance fixation spot acted as a stop-signal instructing participant to control the urge to look at the peripheral square.

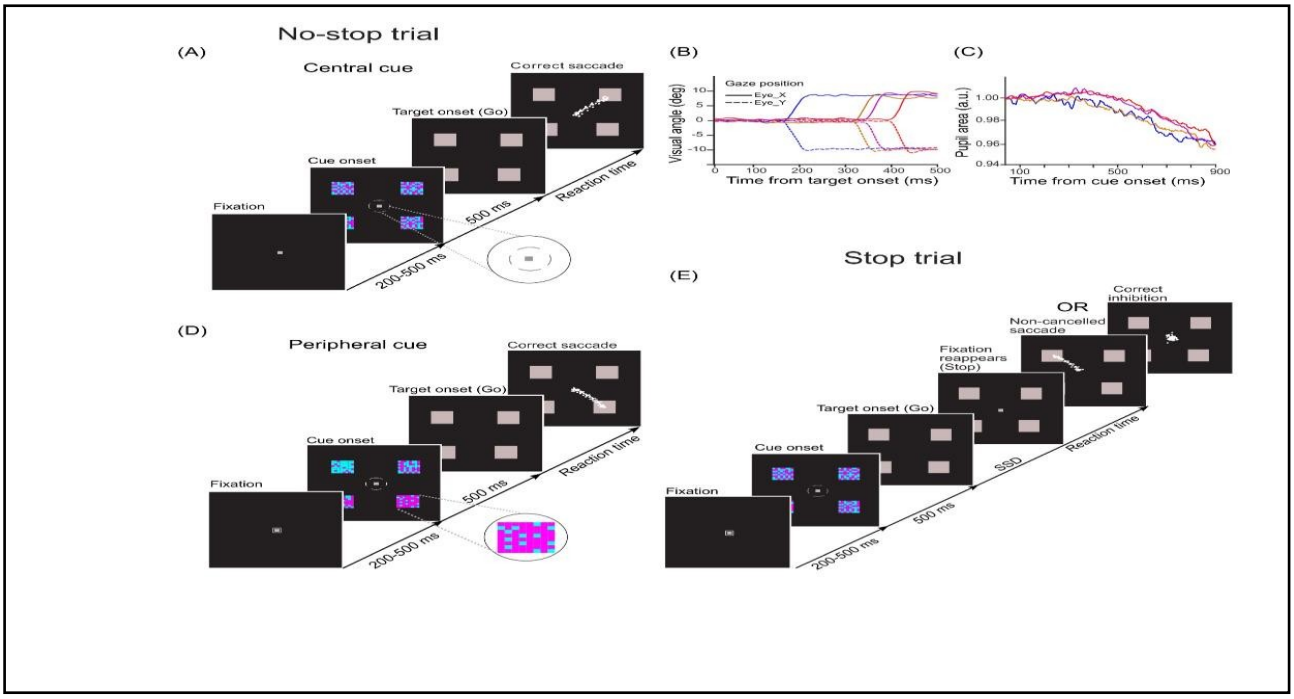
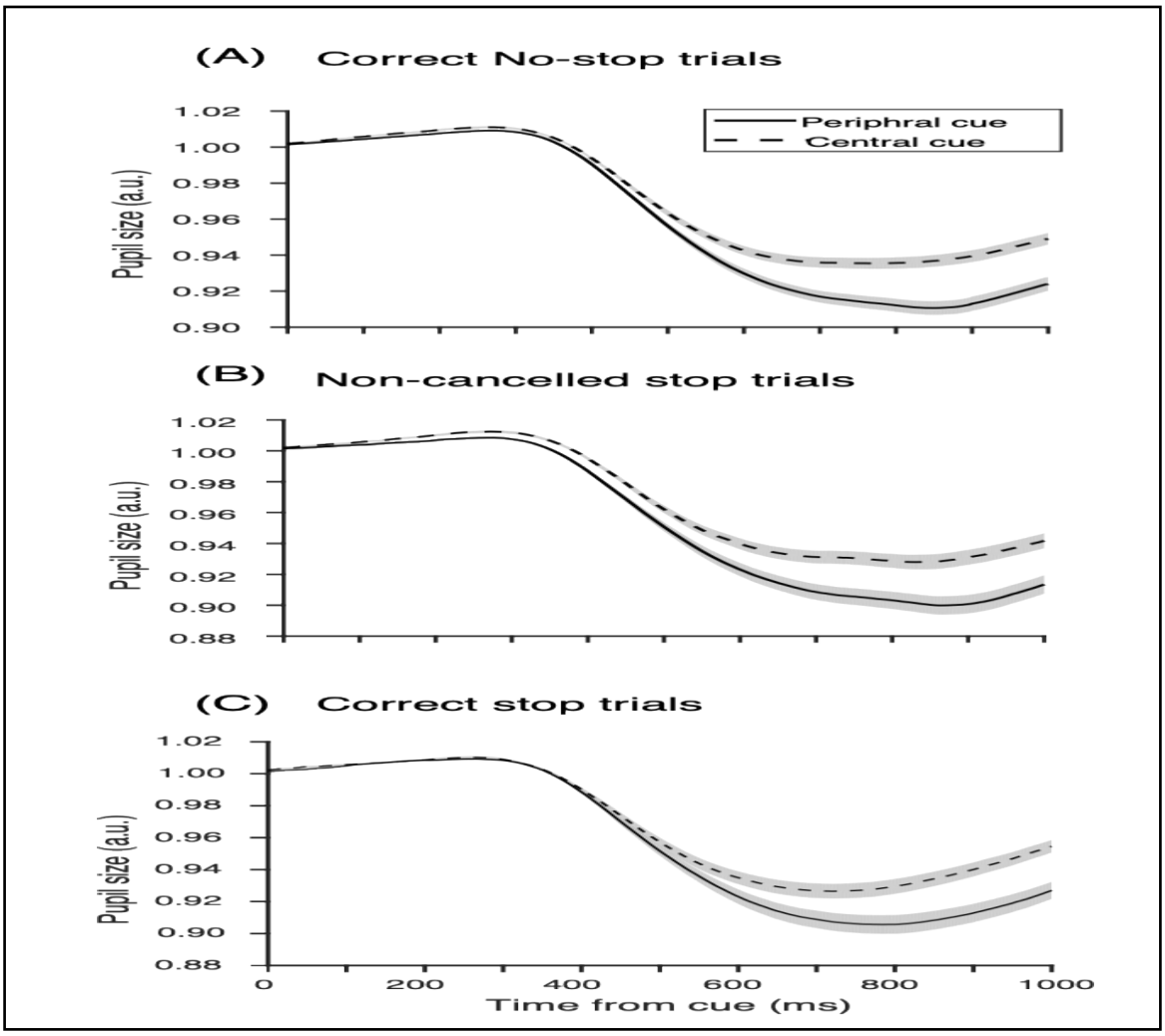


Figure 1. Data shows that pupil size decreased more when a decision cue appeared at the periphery than at the center, despite the same global luminance in both conditions (Figure 2)



Further the biomechanical model of PLR was simulated with different strengths of visual input corresponding to the two attentional conditions. The pupil response of this model successfully mimicked the observed data. It shows the critical contribution of selective attention in PLR modulation. In this study, we demonstrated that the effective CFD (eCFD) determined *via* the luminance multiplied by the size of the stimulus at the location of deployed attention in the visual space is critical for the magnitude of pupillary constriction.

Source article

Pragya Pandey, Supriya Ray (2022). "Influence of the location of the decision-cue on the dynamics of pupillary light response", *Frontiers in Human Neuroscience*. doi: 10.3389/fnhum.2021.755383

Publications

Edited Volume

- Tripathi, R. C., Kar, B. R., & Pande, N. (Editors) (2022). *Towards an Integrative Psychological Science: Issues, Approaches and Applications*. Springer.

Journal Papers

- Hervais-Adelman, A., Kumar, U., Mishra, R., Tripathi, V., Guleria, A., Singh, J. P., & Huettig, F. (In press). How does literacy affect speech processing? Not by enhancing cortical responses to speech, but by promoting connectivity of acoustic-phonetic and graphomotor cortices. *Journal of Neuroscience*.
- Indrajeet, Atkinson-Clement, C., Worbe, Y., Pouget, P. & Ray, S. (2022). Compromised reactive but intact proactive inhibitory motor control in Tourette disorder, *Scientific Reports, 12*, DOI:10.1038/s41598-022-05692-z
- Pandey, P. & Ray, S. (2022). Influence of the location of the decision-cue on the dynamics of pupillary light response, *Frontiers in Human Neuroscience,* 15:755383. doi: 10.3389/fnhum.2021.755383
- Singhal, I., & Srinivasan, N. (2022). A wrinkle in and of time: Contraction of felt duration with a single perceptual switch. *Cognition, 225*, 105151.
- Thomas, S., & Srinivasan, N. (2022). Accurate knowledge about feature diagnostic ties leads to less preference for unidimensional strategy. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.
- Singhal, I., & Srinivasan, N. (2022). Is learning at task-relevant locations always better than task-irrelevant locations? It depends on the distractors. *Attention, Perception, & Psychophysics, 84*, 992–1003.

Book Chapters

- Kar, B. R. & Nigam, R. (2022). Interaction between affect and cognition as a function of ageing: Testing the positivity bias in Indian population. In R. C. Tripathi, B. R. Kar, & N. Pande. (Eds). *Towards an Integrative Psychological Science: Issues, Approaches and Applications*. Springer.

In Conversation

Marieke Van Vugt, PhD
Assistant Professor,
University of Groningen

Your research interests with more details about your current work, which you consider as innovative.

My work centers around two main questions. First of all, I am interested in how, when and why we mind-wander. When is mind-wandering useful? When is it harmful? How do interventions such as mindfulness but also analytical meditation as practiced by Tibetan monks affect mind-wandering? Some of the more interesting findings in this work are that we mind-wander approximately half of the time, even during challenging tasks. When prompted to think about ourselves, we mind-wander more.I am also working on how mind-wandering differs from depressive rumination, and "sticky thoughts" more generally. In my lab, we are currently conducting a clinical trial to examine mind-wandering in patients with depression, and how this may be changed by mindfulness and preventative cognitive therapy.

In a second strand of my work, I examine how inter-brain synchronization measured with EEG is involved in social processes. I have studied this in contexts as exotic as debating Tibetan monks, dancers connecting to each other through movement, but also a more controlled laboratory setting of people attempting to coordinate their decisions.

2. Methodology that you work with and the challenges associated with it.

I used a combination of EEG, behavioral methods and computational modeling to address my questions about mind-wandering and social cognition. I always like to say I am hopelessly multidisciplinary. I just love learning new things! It is not always easy, though, to make sure you understand people from different backgrounds, so I always spend a lot of time trying to understand each other.

One of the methods that I am currently starting to use a lot is machine learning in combination with

EEG data (but also other data such as speech, heart rate and eye tracking). We are using machine learning to try to predict whether someone is mind-wandering. This is a challenging problem, which we can see from the relatively low accuracies we get. This is likely to be caused by imperfection of participants' judgments of their own mental state. So, I am curious how the technology will change to improve our prediction of mental states.

3. Career opportunities, training and prerequisites as a guide for students entering neuroscience/ cognitive science.

I think cognitive and neuroscience are very important fields for this day and age, because students do not just learn about the mind (which plays an increasingly important role in our present-day society), but also learn the tools to analyze complex data, which can be applied in many fields. I strongly recommend that every student in this field learns how to program, since it is such a useful skill, both within science and outside of it. In addition, as I just mentioned, the mind plays a crucial role in present-day society as healthcare for our physical body has improved, we need to take more care of our mind. I think there is a huge potential for the application of cognitive neuroscience techniques to understanding mental afflictions and the mechanisms underlying psychological and psychiatric treatments.

4. Challenges in your field of research, anything that keeps you going, and new technologies related to methodology that you look forward to incorporate (if any).

There are too many challenges to mention! As I mentioned before, I am very interested in the intersection between the fields of cognitive neuroscience and psychiatry. I think the precise tools that have been developed in cognitive neuroscience have lots of potential for tracking the state of our minds, potentially allowing for early intervention in the case of relapse, or for personalizing treatments for psychiatric problems. I am also excited about the potential of using mobile technology to measuring cognitive function outside the lab in our everyday lives.

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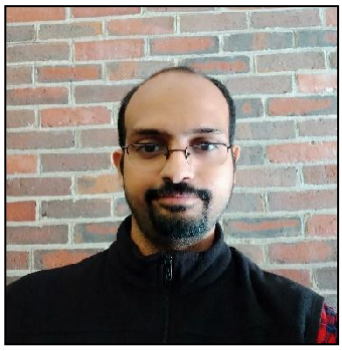
Alumni Corner



Mukesh Makwana
Post-Doctoral Associate
Department of Cognitive, Linguistics and Psychological Sciences, Brown University, USA

My journey in Cognitive Science began in 2010, when I learnt that one of my best friends (now wife) is joining a PhD program in Cognitive Science at CBCS. Before that I had never heard this term, in fact I was already set on a career path of becoming a biotechnologist. I had completed my B.Sc. and M.Sc. in Biotechnology, qualified the competitive UGC-NET and GATE exams in Life Sciences, and was already working as a biotechnologist in a pharma company (Piramal Life Sciences) in Mumbai. However, my career took a massive turn when I started reading more about cognitive processes like attention, perception, memory, and all the philosophical debates about the consciousness, and mind-body problem. I was so *attracted* by the magnetism of Cognitive Science that I immediately decided to quit my biotech job and pursue a PhD in Cognitive Science at CBCS.

At CBCS I had an enriching experience as a doctoral student. In my thesis, I investigated the relationship between intention, time perception, and sense of agency under the supervision of Prof. Narayanan Srinivasan. I also worked on several other interesting projects investigating the role of social context, group identity, and mindfulness meditation on time perception. I was fortunate to receive the competitive CSIR fellowship to support my PhD. At CBCS, I got lot of opportunities to learn and develop research skills, travel around the world to attend conferences and network with great scientists, make friends, and grow both personally and professionally. My days in CBCS were surrounded by a great collection of amazing books in the library, working in very spacious and well-equipped research labs with international standards, and in the company of very helpful and supportive teaching and non-teaching staff members. For me, the most fun and exciting experiences were all the national and international conferences and workshops that the center organized. I mean, 'what more one could ask for?' Time spent at CBCS were the most transformative years of my life.

After PhD, I briefly worked as a visiting researcher at the HBCSE, TIFR, Mumbai with Prof. Sanjay Chandrasekharan and then at the Vision lab at IISc, Bengaluru with Prof SP Arun. At both these places I learnt new research skills and got excellent scientific exposure that advanced my perspectives into different domains of cognition and perception, ranging from studying concept formation and ambidextrous writing in school children to understanding vision in humans, monkeys, and machines. I will highly recommend joining these two labs if you ever get an opportunity.

Since 2019, I am working as a postdoctoral researcher in the PAC Lab (PI. Prof. Song) at Brown University to continue my research in perception and action. Here, I got opportunity to learn continuous motion tracking and computational modelling and apply it to understand the mechanisms underlying selection history. I also got opportunities to interact, learn, and collaborate with many renowned scientists whose research articles I used to read during PhD. I am grateful that each day I get to learn new things. I enjoy my work and hopefully will continue my passion for research and teaching in academia.

Life in academia is fun and exciting, but it comes with own challenges as well. Along with scientific and financial challenges (which everyone is aware of), many a times academician, also has to face personal challenges, in the form of 'two-body problem' (a less talked problem). Having undergone (still undergoing) the roller coaster ride in academia and dealing with two-body problem, if I had to offer one advice to the new incoming students it would be to have an 'unwavering grit' and keep following your dreams and rest will follow.

Thank you!
All the very best.

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Abhilasha Srivastava
Usability Engineer and Design Strategist
Philips, Bengaluru, India

Centre of Behavioural and Cognitive Sciences is much beyond just a 'Centre'. It denotes a 'Culture', of excellence, empowerment, and enrichment. Achievements-applauds, opportunities-thoughts, this is what I gained from CBCS. It gave me a platform that I will cherish always.

I currently lead the product usability program globally in services and solutions delivery of Philips health technology. By working on multiple cutting-edge technologies, I lead and strategize the integration of human centered innovation in design, usability, and user experience research.

My journey at CBCS had been a creative one. As I look back over the years there has been growth, pruning, challenges and most importantly transformation from being a part of the crowd to being apart from the crowd.

I got introduced to the world of cognitive science in 2008 when I started as a 'Research Assistant' at CBCS. Being a psychology graduate I was anyways quite observant and inquisitive about human behavior but CBCS opened up a whole new world of different perspectives. Prof. Narayanan's work on Perception, Attention and Language inspired me the most. I learnt about "how" to think and not "what" to think. And eventually what was supposed to be a short-term involvement converted into a long-term work engagement. I was probably the first student to do her master's thesis in cognitive science while being enrolled in a psychology program. Later, I completed my doctoral work exploring language and brain organization in normative bilingualism.

While doing research I was also intrigued with the fact about how the constantly and ever-changing technological landscape was shaping up human brain-behavior and vice versa. Hence, after completing PhD, I decided to take up something new and challenging in the field of applied

research. I joined Siemens Research and Development in Digitalization and Automation as a 'Human Science Expert', working on multiple cutting-edge technologies like AR/VR/MR/XR, Digital Twins, Knowledge graphs, Drone, AI, Blockchain etc. I employed cognitive science principles to build, scrutinize, test & enhance PoCs, PoVs for technology innovation in IoT – cloud computing led B2B products and services.

The academic program at CBCS prepared me for the corporate world by providing a varied selection of elective courses and project-focused coursework. The ability to take a wide selection of electives has proven useful in networking or professional development settings as I am able to understand or add my input into various dialogues. With most of the coursework focused on project-based deliverables, this directly translated into the professional environment where I must balance multiple projects across a variety of clients or business development operations at once. The skills like EEG, Eyetracking, experimental, behavioral coding, qualitative and quantitative (statistical) techniques learned at the Centre have proven to be very useful in uncovering the intangible and tangible aspects of user experience.

My work which is inherently interdisciplinary allows me to collaborate with experts in technology, computer science, designers, and anthropologists. Regardless of the area or technology, I always focus on the human at the end of the product, so that they have the most seamless and engaging experience. Because in the end, true innovation doesn't only come from cutting edge technology. It comes from connecting that technology to people, and through that connection, empowering and enabling them to achieve things they could never do otherwise.

Over the years, I have also been an industry mentor to multiple students from CBCS and it gives me immense joy, when I see them employ their cognitive science knowledge and excel in their respective fields. My advice to students doing their masters is the same what my mentor Prof. Narayanan Srinivasan advised me – ***'Never cease to question'***. One should commit to expand, care to understand, converse to grow. The moment you dive into your work and soak up every moment of higher learning with the knowledge, your education will serve you for many decades to come. Also, apply for as many internships as possible, it will give you the experience and networking you need along the way to finding your dream job. And it very well may open the opportunity to a career you really enjoy!

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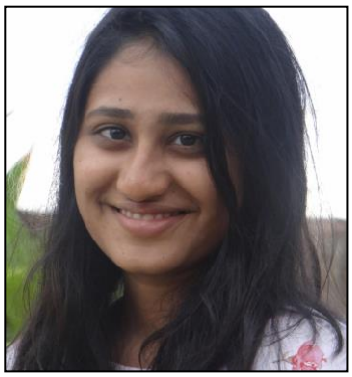
Student Column



Sayali R Pethe
MSc II, CBCS

"Number Cognition in Infancy"

The origin and nature of the knowledge of Numbers is one of the buzzing questions of Cognitive Science. Numerical concepts are intuitive and universal in the human species. Our minds are symbolic, and we make use of Numbers to represent the external world. In fact, Numerical concepts are so widely used that no Human development; from money to measurement, is devoid of them.
And yet, these numerical concepts are abstract-their origin cannot be traced back to human experience. What, then, is the source of Numbers? Is it possible that our species is *evolved* to use Natural Number systems? In this regard, a probe into Infant Minds, marked by their lack of experience, for early signs of Number Cognition would help unravel its innateness in Cognitive and Neural systems.

For decades, infant minds were considered 'Blank Slates'. However, complex and highly efficient human cognitive mechanisms do not simply emerge in adulthood but are shaped from infancy. Infants possess a set of core, early cognitive capacities that enable them to acquire uniquely human and abstract cognitive achievements. Babies, for example, are better learners of the language, which is an outstanding feat of human cognition. Similarly, higher order Numerical Cognition abilities in adults are based on a more foundational capacity of Numerosity or Number Sense. Fascinatingly, it also seems to be evident in babies. This ability, supported by the Approximate Number System, helps us to represent and manipulate numbers non-symbolically, i.e., without applying numerical labels.

In 2009, a noteworthy study investigated whether infants are endowed with abstract numerical representations at birth. In this study, newborns were first presented and familiarized with a continuous auditory stream in which sequences of syllables were repeated for a fixed number. In the next phase of the experiment, characterized as the test phase, infants were presented with visual images containing either the same number of objects as the number of syllables or a different number of objects than the syllables. It was found that infants looked longer when the number of syllables in auditory format and the number of objects in a visual format matched. Since other continuous low-level perceptual factors such as spatial frequency, intensity, and the duration that could have confounded the effect of the independent variable, were controlled, this study provides evidence of the sensitivity of infants towards numerical processing which seems to be independent of modalities.

Another remarkable aspect of Numerosity in infants is its ratio-dependency. Infants' discriminability performance, i.e., their ability to compare numbers non-symbolically, can be predicted by Weber's law. It states that the ratio, and not the absolute difference between quantities determines infants' performance in discriminability tasks. In the earlier study, infants' performance markedly decreased when the ratio of the number of syllables to the number of objects in visual images was 2:1.

However, they could robustly discriminate when the ratio was 3:1, irrespective of the numerical distance between the quantities. This critical ratio ontogenically and phylogenetically decreases with age. In a study conducted in 2000, it was shown that 6-month-old babies could discriminate dot stimuli with a ratio of 2:1, but failed to do so with a ratio of 3:2. In this study, discrimination was regarded as dishabituation to the display containing a novel number of dots.

Moreover, pre-verbal infants are also capable of performing basic arithmetic operations. In an experiment conducted at Yale University, it was demonstrated that 9-month-old infants possess cognitive mechanisms to compute additions and subtractions of numbers large in magnitude. Here, infants were presented with addition (5+5) or subtraction (10-5) conditions. In the addition condition, they were shown movie clips in which 5 objects are covered by an occluder, and subsequently, 5 more objects are added behind the occluder. Similarly, In the Subtraction condition, 5 objects are removed from 10 objects behind the occluder. Afterward, there is a test phase, showing either correct or incorrect solutions in both conditions. It was found that infants looking times are increased for incorrect solutions during addition as well as subtraction.

Furthermore, these abstract numerical representations are linked with spatial representations in babies. In a recent experiment, new-borns were familiarized with auditory sequences (fixed number of syllables) presented with a visual line (short or long). In the test

phase, the auditory sequences changed with respect to the familiarization phase. Along with it, the visual line also changed. This change could either be in the same or opposite direction to the auditory sequences. It was observed that infants looking times were more when the auditory sequences and visual line covaried, i.e., when they changed in the same direction. This ability supports universal discovery and the use of number lines.

The Approximate Number System does not focus on the identities of the individual objects in the set. Instead, it considers the cardinal value of the set. This system is highly imprecise in infancy, but linguistic and cultural developments help to make it more accurate.

It would be interesting to see how numerosity in infancy correlates with mathematical aptitude in adulthood!

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Mind Thinks Music?

"How do both music and vision build things in our minds? Eye motions show us real objects; phrases show us musical objects. We "learn" about a room with bodily motions; large musical sections show us musical "places." Walks and climbs move us from room to room; so do transitions between musical sections. Looking back in vision is like recapitulation in music; both give us time, at certain points, to reconfirm or change our conceptions of the whole." (Minsky, 1981).

Music touches our brain in such a profound way that often-other experiences fail to do so. Plenty of questions are in existence regarding the existence of music. In a paper by Huron (2012), he nicely puts this dilemma by stating that suppose if some aliens were to visit our community, they would probably understand most of our activities like food production, education, governance, and a lot of others except music, a puzzle we have yet to solve. The exploration can be started from the question, what is the point of music in the reality? One approach says music has the ability to strengthen the social and emotional connections in a group hence selected evolutionarily (Cross, 2007). However, people like Steven Pinker approached this question by suggesting that music is just a pleasant side effect of critical things like language and speech as he wrote "Music could vanish from our species and the rest of our lifestyle would be virtually unchanged" (Pinker, 1997; pp. 528-529).

In a theoretic definition, music is a system of discrete frequencies that are arranged according to certain rules. These rules vary from place to place and the involvement of rhythms and timbres further increases its diversity to a larger frame. But in a more subjective way, the music experience is holistic in nature and even silence can be also considered an element of it. For instance, we can see pauses that are labeled by written signs in many of Beethoven's works.

Interestingly, one of the popular American composers, John Cage composed a work called four minutes thirty-three minutes where he placed silences as the only notes, so during the concert performer just sits in front of the piano doing nothing but letting the audience hear the environment around or just experience the silence. It beautifully points to the fact that music doesn't necessarily need some predetermined sounds or sometimes even the sound.

What might be the benefits of delving deep into the behind of musical thinking? An answer from a cognitive science perspective could be, that appreciating and producing music simultaneously can engage many complex perceptual, cognitive, and emotional processes, making music an ideal object for studying the mind (Pearce & Rohrmeier, 2012).

Psychological understanding of music should be approached through its understanding of creation as well as its absorption. A particular song can be liked by some people while others disliked it. This observation might suggest that the way it was composed as well as how people absorb it completes the whole musical experience. So studying some musical theories alone can't help solve the mystery here. Music is a way of conveying an inner dimension the performer has and they welcome the listeners also to enter into the same that might somehow connect their present with the prior knowledge and experiences they are carrying. The music gathers many properties which also might open up the possibility that the experience it provides differs among individuals depending on what element they perceive more.

Cognitive musicology is an interesting branch of cognitive science where they are trying to understand music cognition via computational modeling. It can offer a much clearer idea of how musical elements are represented and accessed to produce that experience which can shed some more light on our comprehension of cognitive mechanisms. Hugh Christopher Longuet-Higgins, who coined the term '*cognitive science*' and was one of the pioneers in the field of cognitive musicology, published some of the early computational models of music cognition. His program has been written to convert a classical music input to corresponding musical notes in order to understand how a listener constructs the internal structure of that experience, emphasizing a rhythm-tonal relationship. Artificial neural networks are also recently adopted into musical research and their main advantage is that they let us explore the internal mechanisms that generate behavior and indirectly show how the model is processing that information (Coutinho & Cangelosi, 2009).

A combined understanding of music and language, a fairly recent approach, came into consideration in the research because of the way both are structured by involving meaningful sounds. It naturally invited speculation on their overlap, however, this similarity is not explicit. Most infants have this distinguishing ability toward language and music, and interestingly these aspects develop without any external instruction (music in terms of its enjoyment), further supporting the approach of their combined studying. Some previous studies have investigated

the relationship between tonal languages (which are more prosodic in nature) and the music system since both have musical elements. They have found that learning a tonal language helps infants to easily discriminate pitches from verbal labels compared to controls who have no experience with a tonal language, suggesting an overlap between linguistic and musical machinery. Music, Language, and the Brain by Aniruddh D. Patel is an interesting book connecting these two domains.

This article vaguely connects some of the dots that represent the motivation and some approaches to understanding music from a cognitive science perspective, still unable to cover a lot of critical things (for example, the neuroscience of music). New ideas are flourishing to reform the research of music using the concepts and advanced tools hoping to give concrete empirical support to the field.

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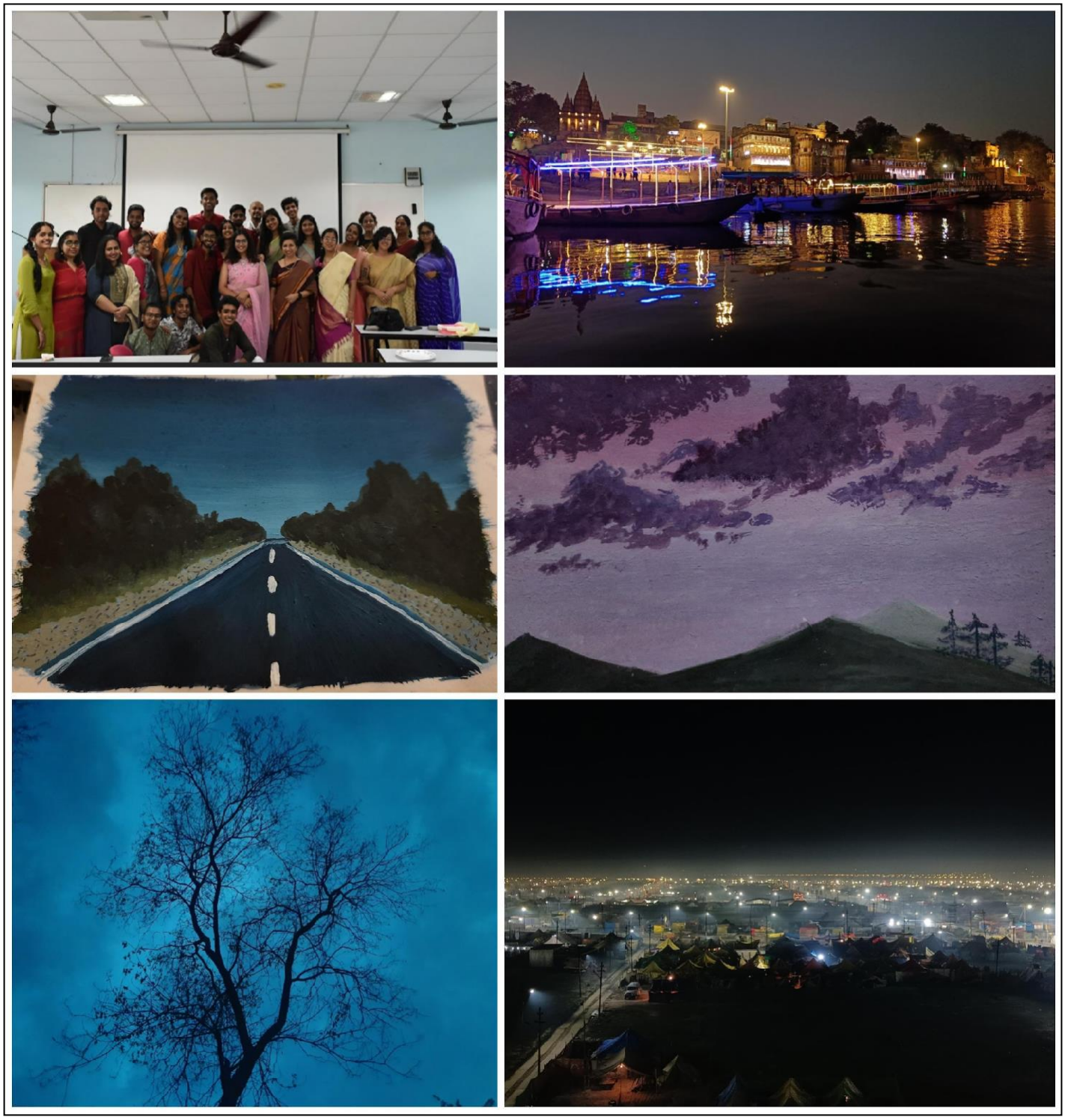

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