YEARBOOK

2021

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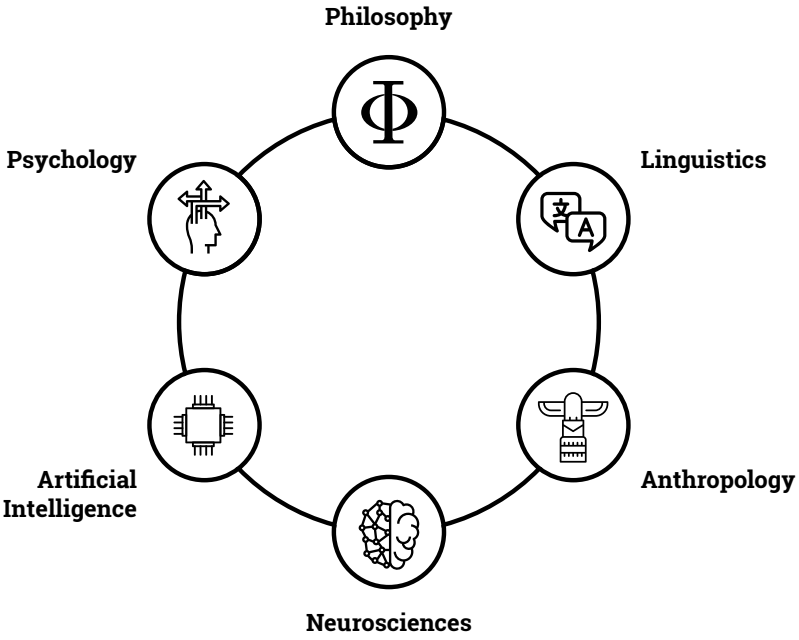
2021



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The unique entry point for the socio-economic world in the field of cognition

Created in 2016 and awarded the Carnot label in 2020, the Cognition Institute is unique in Europe, designed to develop and promote research partnerships and technology transfer among its 22 laboratories and the socio-economic world in the field of cognitive sciences.

To illustrate this major challenge, we are pleased to offer you the second edition of our Yearbook or « Highlights » of the year 2021, in which you will find a non-exhaustive list of the progress made by our laboratories this year in the field of cognitive sciences and which can be a source of inspiration for competitive innovation for companies.

4 differentiating scientific axes for interdisciplinary synergies

The thematic field of cognition covers all cognitive functions, human and animal, natural and artificial, such as perception, attention, language, memory, intelligence, reasoning, learning, emotions, human/machine interactions, etc. This gives the Carnot Cognition Institute a strategic advantage because of its status as a national consortium that allows all laboratories to be questioned in a single process, in an interdisciplinary approach.

For a better readability of the socio-economic world, the scientific strategy of the Institute is declined in four scientific axes: « Cognitive enhancement technologies », « Cognitive behavioral assessments », « Collective cognition » and « Cognition and language » answer the technological and societal stakes of tomorrow's world.

Célestin SEDOGBO

Director
of the Carnot Cognition Institute

Building the economic world of the future together

The development of contractual research in this broad thematic field, which is often unknown to companies, is supported by the Carnot Cognition Institute, whose main mission is this. Indeed, the Institute has the capacity to identify the strategic interest that research in cognition can represent for companies. It then facilitates contacts and contracts with its laboratories by providing companies with a skills portal that enables them to better consider human capacities in the development of innovative technologies and services, to increase their innovation potential and their competitiveness.

Coordinated by the CNRS, the Carnot Cognition Institute brings together 22 research units spread across France (SCALAB, Lille; LISN, Orsay and Paris-Saclay; CHArt, IJN, LSP, LSCP, ENSAD-Lab, Paris ; Center BORELLI, Paris Saclay; LaPEA, Boulogne Billancourt; COSTECH, Compiègne; LEAD, Dijon; Gipsa-Lab, LIG, LPNC, Grenoble; IMS, Bordeaux; CeRCA, Poitiers; IRIT, CRCA, Toulouse; LIA, Avignon; LPC, LPL, LNC, Aix-Marseille).

High-quality research partnerships for business innovation

Having obtained the prestigious Carnot label delivered by the French National Research Agency (ANR) in 2020, the Cognition Institute is part of a unique network of 39 French public research structures recognized for their scientific and professional excellence as well as their capacity to meet the R&D needs of companies.

In conclusion, the intention of the Yearbook 2021, like the previous edition, is on the one hand to testify to the intense scientific activity through a few outstanding projects specific to the four scientific axes, and on the other hand to illustrate through concrete examples the richness of the relations with the industrial world.

In the name of the CoPil and on my own behalf, I wish you all a pleasant reading.

Cognitive enhancement technologies

« Cognitive enhancement » is a cross-cutting field of research at the frontier between human-computer interaction, psychology, ergonomics and neuroscience. It aims to create innovative interactions that help, supplement, or increase the capacities for human processing of information. The creation of such interactions comes from the ability to measure in real time human information processing and the cognitive states of users.

The development of new interactions makes it possible, for example, to design innovative uses, « affective » conversational agents or adaptive interfaces according to a user's profile or behavior.

Véronique Lespinet-Najib (IMS) and Bernard Oriola (IRIT) - Scientific Coordinator

Enriched environments to treat addiction

This project is the subject of a doctoral thesis carried out by Lila Barillot, and funded by the Nouvelle Aquitaine region (AAPR2020A-2019-8357510; PI : M. Solinas).

Scientific background

Environment plays a key role in the vulnerability to addiction, and several studies suggest that it could also be part of addiction treatment. Preclinical studies have demonstrated that environmental enrichment could treat addiction in animals, by promoting abstinence. The positive environment combines complex sensory, cognitive, social and physical stimulation and ensuring several stimulations at the same time could be one of the keys to the effectiveness of environmental enrichment. Major challenges arise in translating the therapeutic benefits of environmental enrichment to a clinical population with substance use disorders.

Method

The exposure of drug-addicted patients to an enriched environment relies on two innovative tools, combining several types of stimulation. The first tool allows mindfulness practice in a multisensory virtual environment. The patient is in a cabin which generates odors, air movement, sounds, and heat at the appropriate times during the exploration of a virtual reality environment in mindfulness. The second tool associates a crankset for cycling and a touch pad, to combine physical activity and cognitive training exercises. In addition to sensory and physical stimulation, the practice of mindfulness and cognitive exercises target executive functions wich are impaired in addiction.

Expected results

This study aims at evaluating the effectiveness of a new therapeutic strategy to reduce cravings for drugs and relapse. The enriched environment exposure sessions, through the presentation of multimodal stimulation, should reduce patients' craving.

Discussion

In the view of high relapse rates, new therapeutic interventions in addictology are needed to effectively treat addiction by promoting long term abstinence. To our knowledge, the effect of multidimensional environmental enrichment on craving has never been studied in humans. An enriched environment allows the presentation of rewarding stimulation as an alternative to drug taking, while also training cognitive and affective processes deregulated in addiction. Practice of the technique should provide learning that can be reused in other contexts, such as situations which raise the risk of relapse. This transdisciplinary study should enable a better understanding of the necessary components of environmental enrichment in humans, and the potential of this strategy to treat addiction.

For further information

Solinas M., Thiriet N., Chauvet C., & Jaber M. (2010). *Prevention and treatment of drug addiction by environmental enrichment. Progress in Neurobiology,* 92(4), 572–592. https://doi.org/10.1016/j.pneurobio.2010.08.002

Solinas M., Chauvet C., Lafay-Chebassier C., Jaafari N., & Thiriet N. (2021). *Environmental enrichment-inspired pharmacological tools for the treatment of addiction. Current Opinion in Pharmacology*, 56, 22-28

Chauvet C., Goldberg S. R., Jaber M., & Solinas M. (2012). *Effects of environmental enrichment on the incubation of cocaine craving. Neuropharmacology*, 63(4), 635-641.

Galaj E., Barrera E. D., & Ranaldi R. (2020). *Therapeutic efficacy of environmental enrichment for substance use disorders. Pharmacology Biochemistry and Behavior*, 188, 172829.

The Appprentices

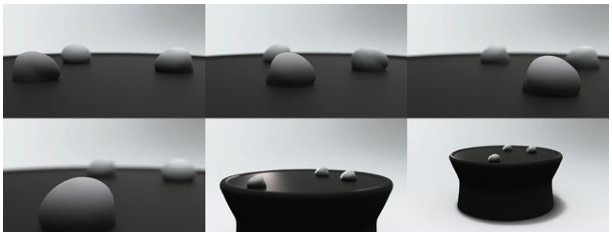
EnsadLab

Scientific background

The Appprentices is a research project led by multidisciplinary teams from Orange Innovation and EnsadLab (the laboratory of the École des Arts Décoratifs, Paris). The experimental approach combines human sciences (anthropology and cognitive sciences), robotics and computer sciences (machine learning) with digital creation and innovation, to explore new relationships between humans and our robotic environments enhanced by artificial intelligence techniques. If our everyday objects might be empowered with abilities of movement and learning, action and reaction, and a behavioral dimension, how can we design new relationships with these robotic artefacts but also between them? This work is part of a field of research on « Behavioral Objects », focusing more specifically on how we can account for the process of machine learning (AI) through the movement of an object - and, more specifically, through its rhythm - and how this learning can be shared with humans or with other learning objects.

Method

Multidisciplinary and design-led, this project is producing prototypes for experimentation followed by reflection and design of new developments. This « research and creation » approach leads to instruments allowing experiments for and with audiences that give rise to cognitive science studies which consider aesthetic dimensions and non-verbal interactions. The instrumental device is a large anthracite circular base which acts as a stage on which three objects move irregularly on its surface. Each object moves with intention, as if animated by a will to explore the environment and to relate or even synchronize with their fellows. All the same shape, these objects together compose different behavioral scenarios while trying to learn from each other, thanks to a program based on machine learning. Their movements appear even more rhythmic as they produce sound, both from their motorization and from the noise of their movements, and these sounds are converted and amplified by the vibratory space of the base to generate an almost musical environment to be shared by the objects and by the audience. While the system is autonomous, the public is - during dedicated sessions -, invited to interact with the objects via the edge of the stage which is offered as a percussion instrument.



Main results

We have designed an instrumental « dispositif » or device to experiment with « behavioral objects », focusing on an original dimension that allows movement and sound to be strongly paired: vibration, vibratory space are seen as a system of communication and interaction.

Discussion

In the age of growing robotization of our societies and the need to consider the role of non-human actors, The Appprentices proposes experiences with behavioral objects. Audiences share the perception of « animacy » (intentionality and personality) of artifacts within a vibratory space. Involving a multidisciplinary instrumental research and creation approach, this project reveals methods and tools to build the field of « agency design » which questions sensitive relations with our digital and physical environments.

For further information

Joffrey Becker, Samuel Bianchini, Hugo Scurto, Elena Tosi Brandi, *Picking Up Good Vibrations: Designing an Experimental Setup to Assess the Role of Vibrations in Human-Robot Interaction* présenté et publié dans le cadre de Sentimental Machines, ICRA-X Robotic Art Program, ICRA 2021 - IEEE International Conference on Robotics and Automation, June 4th 2021. https://roboticart.org/icra2021

Samuel Bianchini & Emanuele Quinz (Ed..), *Behavioral Objects I : Céleste Boursier-Mougenot, a Case Study*, Berlin / New York, Éd. Sternberg, 2016, distributed by MIT Press.

Les Appprenants v.01, At Home - Panorama de nos vies domestiques, 12ème Biennale internationale de design, Bifurcations - *Choisir l'essentiel*, Cité internationale du design, Saint-Étienne, 6 avril - 31 juillet 2022. https://biennale-design.com

Synchronizing ocular and electroencepha-lographic data

Scientific background

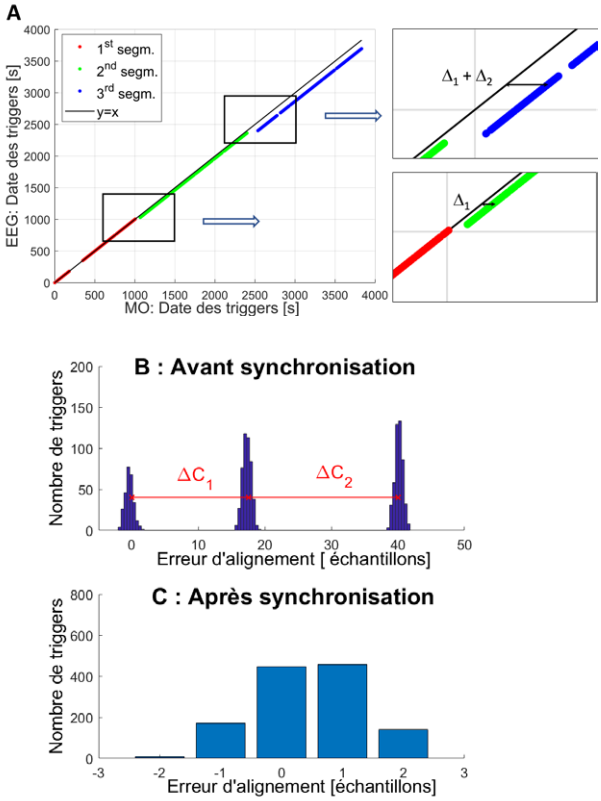
While ocular movements (OMs) are a significant source of noise for electroencephalographic (EEG) signals, they nevertheless provide enriching information. In order to use joint methods of analysis of EEG and eye signals, it is necessary to have signals from both modalities that are synchronized on the same time reference.

Method

Since OM and EEG use separate recording devices, a common time reference is needed for synchronization to compensate for clock offsets. Both signals can then be resampled at the same frequency and eye signals, such as position, velocity and pupil size, added to EEG signals as additional channels. The method capitalizes on a sequence of identical « triggers » in both modalities. These triggers are then matched by a search algorithm for the longest common subsequence, then aligned temporally by piecewise linear regressions. The result is an automatic synchronization method which allows the experimenter to use pauses to reduce the size of the recorded data.

Main results

We illustrate the results on the dataset shown here whose recording is interspersed with two pauses (Figures A and B). After matching the triggers, we observe the temporal shifts between their appearance in each modality (Figure B). After synchronization (Figure C), the distribution of the alignment error between the two modalities is refocused and limited to ±2 samples (due to computational rounding).



(A) Joint representation of the dates of each common trigger before synchronization; Histogram of alignment errors (B) before synchronization, (C) after synchronization.

Discussion

The software developed is a DOS application written in C++ language. The interest of this solution compared to synchronization proposed by EEGLAB (EYE-EEG Toolbox) is three-fold: it does not require any particular environment for its execution, it is entirely automatic, and it allows the experimenter to use pauses to reduce the size of the recorded data. The current version is available via a Zenodo link (http://doi.org/10.5281/zenodo.4897128) which includes a user guide, source codes, executable code and example data files. This version is restricted to ocular data from an EyeLink oculometer (SR Research).

For further information

Ionescu G., Frey A., Guyader N., Kristensen E., Andreev A. & Guérin-Dugué A. (2021). *Synchronization of acquisition devices in neuroimaging: An application using co-registration of eye movements and electroencephalography.* Behav Res Methods. doi: 10.3758/s13428-021-01756-6.

ACTIVmap

Institut de Recherche en Informatique de Toulouse

Scientific background

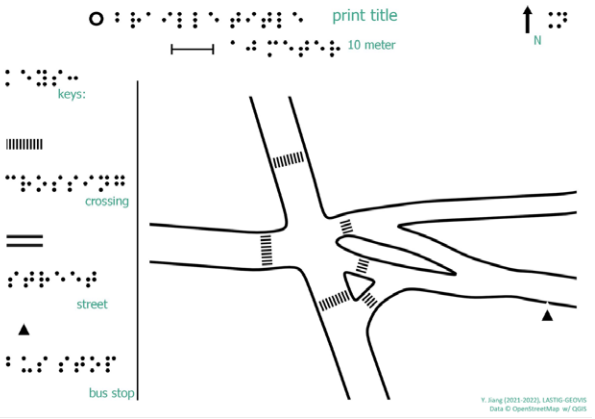
The appropriation of urban space is an essential element to improve the autonomy of people with visual impairment (PVIs), for whom outdoor travel is a major difficulty. Synthetic representations with tactile maps and diagrams with adapted interactions are essential for greater autonomy. The manufacture of these maps and diagrams remains traditional - hand crafting by professionals (mainly Orientation and Mobility Instructors (OMIs) and Tactile Document Makers (TDMs)) in insufficient numbers to cover real needs. Now, widespread use of open and collaborative data combined with diversification of means to produce physical artifacts of digital data are two key elements for computer science to be an effective tool in the design of multimodal relief maps for PVI.

Method

The exploration and understanding of a map by a PVI is based on multimodal representation (bigraphic, tactile, auditory) that must be adapted to abilities. Both content (number, size, shape and texture of map elements) and media (raised-lines, thermoformed, 3D printing, with or without interaction) must be adapted. Today, open and collaborative data combined with the diversification of means to produce physical artifacts augmented with adapted interactions, makes it possible to develop specialized methods and tools to design multimodal interactive maps in a semi-automatic way. This research work must be based on an interdisciplinary approach between HMI, cognitive sciences, geographic information sciences, computer science, professionals in the field of VI, and PVIs.

Main results

ACTIVmap aims to facilitate the task of map producers by reducing the level of technicality and time required for the design process. The results obtained in the ACTIVmap project will help to develop innovative products, by addressing the public space in general, including specific complexities such as open places or complex crossroads.



Map of a crossroads automatically adapted taking into account the constraints related to the production of tactile documents.

Discussion

The results in action: Maëlle is a blind high school student. She just moved to Clermont-Ferrand and attends a high school in the city center. This year, she will go once a week to the Poncillon dojo for her judo training. For her travels, she will print, with the help of a sighted friend, three raised lined maps. The first map is a simple overview of the whole travel. The two other maps are the most complex and dangerous places: one the crossing in front of her high school, and the other the neighborhood of the dojo. To prepare for the journey, she can place a large tactile map over her interactive table, at home and explore it independently with interactive verbal and sound descriptions. Once she is traveling, she can place reduced adapted tactile maps on her portable device to help her quickly and confidently familiarize herself.

For further information

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https://activmap.limos.fr

Partners :

- LIMOS, Université Clermont Auvergne/CNRS
- IRIT-Cherchons pour Voir, Université Toulouse 3/CNRS
- GeoVIS, IGN
- Entreprise FeelObject

Finger-tracker

Video recording and processing chain for the study of finger movements during a keyboard writing task

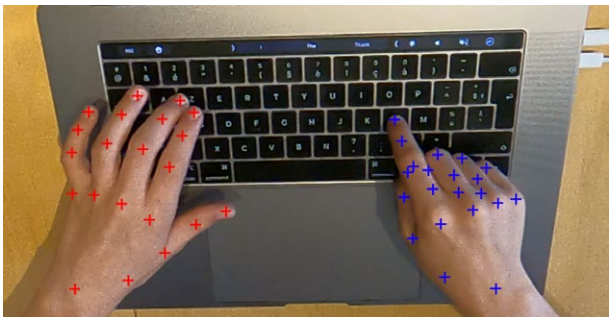


Image of the identified joints of the left (red crosses) and right (blue crosses) hands of an 11-year old child in both artificial (LED; from the ceiling on the left) and natural (from a window on the right) light conditions. With his right hand, the child writes only with his index finger, the last phalanx of which is well identified (blue cross on the nail). Although folded on themselves, the positions of the rest of the right hand fingers are inferred. In this entire video sequence, the folded fingers of the right hand were never used for writing.

Scientific background

Keyboard writing is a complex activity because it involves various cognitive and sensory-motor capacities: word recognition or retrieval, short-term memory, motor programming, keystrokes, and sensory feedback. It is mainly studied in expert participants to guarantee a low level of variability of the movements related to the keystrokes, reducing both intra- and inter- individual variability. However, without an independent motion measurement system, the stability of the writing gesture and the degree of temporal overlap between strokes cannot be assessed. To overcome this, computational vision and natural language processing can be used to construct a finger movement detection system.

Method

Finger-tracker is based on the joint use of 3 distinct tools in an automatic processing chain. The first measures hand movements by detecting the skeleton of the hands in a video stream, i.e. the spatial position of the joints from the wrist to the fingertips. The second tool measures, in the same video stream, the physical position and identity of the keyboard keys. The third tool measures the time of typing on the computer keyboard and the identity of the key typed. Using these 3 tools in an integrated measurement chain must be robust, to accommodate, for example, different possible video input sources as well as a variable lighting quality of the scene between the acquisition sequences.

Image of a French language (azerty) computer keyboard (GoPro 9, resolution 1080 x 1920 x 3, 200 frames per second). The identity of the letters on the keys is correctly defined (letters in green), except for the X key. Keys with symbols other than capital letters are correctly excluded. The outline of the keys is correctly marked (yellow lines).

Main results

With video streams from a webcam, a smartphone or an actioncam, the first results measured in the laboratory are in line with the expectations. The skeleton of the hand is identified, the letters of the keyboard are well located and identified, and the keystroke times are well recorded. The joint use of these three outputs can therefore be approached under variable experimental conditions.

Discussion

The principle of a new behavioral measurement tool, Finger-tracker, is validated. This tool uses recent developments in computational vision (extraction of the hand skeleton from an image) and natural language processing (extraction of text from an image). We can envisage its use in contexts other than scientific measurement. Finger-tracker could be useful for example in teaching print and cursive writing , with video feedback of results used to improve writing quality; or in speech therapy to aid diagnosis and remediation of language-related problems.

For further information

Scaltritti, M., Alario, F. X., & Longcamp, M. (2018). *The scope of planning serial actions during typing. Journal of cognitive neuroscience*, 30(11), 1620-1629.

Swift, E. J. (1909). *Review of The Psychology of Skill, with Special Reference to Its Acquisition in Typewriting [Review of the book The psychology of skill, with special reference to its acquisition in typewriting*, by W. F. Book]. Psychological Bulletin, 6(7), 240–241. https://doi.org/10.1037/h0066735

Virtual reality and user behaviour

Laboratoire de Psychologie et NeuroCognition

Scientific background

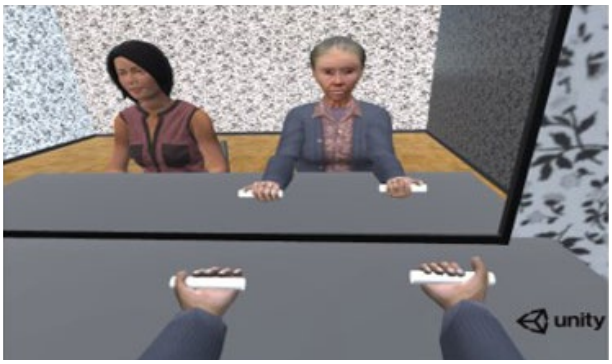
Virtual reality is a tool that is increasingly present in our contemporary lives, in recreational, professional and/or health activities. Its use, however, is not without behavioral consequences. An avatar as a representation of a user's identity in the virtual environment can lead to attitudes and/or implementation of cognitive, emotional or motor behaviors in accordance with the expectations of the avatar's characteristics (e.g., age, morphology, gender, ethnic origin etc.). The project developed at the LPNC within the Body & Space team aims to evaluate the impact of the embodiment of avatars on the motor behavior of the user and to deepen the understanding of the mechanisms involved in this effect, called the Proteus effect.

Method

We have developed a paradigm for immersing the user in a full body avatar. The avatar's movements are coupled to the user's movements through a motion capture system. The characteristics of the avatar and its proximity to the user can be manipulated at will, both in terms of the motor skills represented, the perspective (1st or 3rd perspective) and the coupling between the user's and the avatar's movements. The impact of this immersion is measured on the user's locomotor skills, which are assessed through a motor imagery task.

Main results

We have measured the impact of avatar embodiment associated with negative stereotypes relative to motor skills, e.g. elderly avatar. Users tend to adapt their locomotor behavior (in motor imagery) in coherence with their negative stereotypes towards the avatar (elderly avatar: Beaudoin et al 2020, obese avatar: Dupraz et al 2022).



Representation of the avatar as perceived in the first person perspective and in a mirror. A second avatar is always present to control any priming effect. Only one of the two avatars in the virtual scene is coupled to the movements (head, arm) of the user.

Motor imagery task: moving to a chair in a virtual corridor. Perspective here in 3rd person (external view of the virtual environment).

Discussion

This experimental paradigm allows us to manipulate many factors of user/avatar relationship and to test their impact on user behavior. It opens perspectives on the fine understanding of the cognitive mechanisms at play in the Proteus effect.

For further information

Beaudoin M, Barra J, Dupraz L, Mollier-Sabet P, Guerraz M (2020) *The impact of embodying an "elderly" body avatar on motor imagery. Experimental Brain Research*. 238: 1467–1478. https://doi.org/10.1007/s00221-020-05828-5.

Dupraz L, Barra J, Beaudoin B, Guerraz M (2022). *Impact of an overweight body representation in virtual reality on locomotion in a motor imagery task. Psychological Research*. https://doi.org/10.1007/s00426-022-01675-x

Decoding Musical Imagery from EEG recordings

Scientific background

Musical imagery is the voluntary internal hearing of music in the mind without the need for physical action or external stimulation. Numerous studies have revealed brain areas activated during imagery. Yet, it still remains unclear to what extent brain responses to imagined music contain detailed enough temporal dynamics to allow for accurate decoding.

Method

In this study, we collected EEG data on 21 professional musicians who passively listened to and actively imagined four Bach chorals while synced to a tactile metronome. We then used offline regression techniques (TRF) to predict the EEG signal from features extracted from the stimuli (acoustics and melodic expectation). A classification algorithm was designed to analyze all musical stimuli from all EEG trials and chose the best prediction for which song was listened to/imagined during a trial. A null model was computed by shuffling the song labels to assess significance.

Main results

We showed that it was possible to decide which song participants were imagining/listening to just by analyzing their EEG recordings. The mean accuracy was 76% for listening trials and 58% for imagery trials and was largely above the null model for each participant.

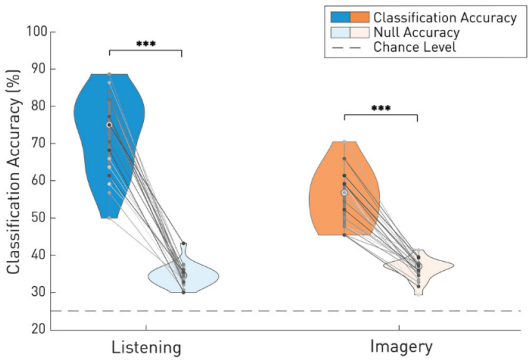


Figure 8. Piece classification accuracy. EEG predictions for note onsets and melodic expectations were combined to determine which song was being listened to or imagined. The data are shown for each participant and indicate overall significance. The null model was calculated from labels-shuffled data.

Discussion

Using EEG recordings to classify what song participants are imagining/listening to is of huge interest for Brain Computer Interface. Algorithms such as the ones used here could have other uses such as working in real time and use with people with language impairments in order to help them communicate what they feel. Our lab is currently working on a speech version of this paradigm which could be directly applied to language rehabilitation.

For further information

The music of Silence. Part I: Responses to Musical Imagery Encode Melodic Expectations and Acoustics, Guilhem Marion, Giovanni Di Liberto, Shihab Shamma, 2021, JNeurosci.

The music of silence. Part II: Cortical Predictions during Silent Musical Intervals, Giovanni Di Liberto, Guilhem Marion, Shihab Shamma, 2021, JNeurosci.

Accurate Decoding of Imagined and Heard Melodies, Giovanni Di Liberto, Guilhem Marion, Shihab Shamma, 2021, Frontiers in Neuroscience.

Cognitive behavioral assessments

Cognitive behavioral assessments are the methodological basis of cognitive sciences enabling the observation, study, understanding, characterization and, where appropriate, simulation of the mechanisms underlying the mental functioning of humans in interaction with their environment. Cognitive behavioral assessments are based on a body of knowledge, experimental methods, measurements (quantitative and qualitative) and instruments from a variety of disciplines: psychology, biology, neurosciences, medicine, mathematics, computer science, signal processing, linguistics, communication sciences, educational sciences, cognitive anthropology, philosophy, etc.

Measurement methodologies include subjective, behavioral (e.g. performance measures, non-verbal and verbal measures, etc.), psychophysical, eye tracking, as well as peripheral physiology (ECG, electrodermal activity, EMG, EOG, ...) and brain imaging (EEG, NIRS, fMRI, MEG, electrophysiology, ...). In addition to these measurement tools, other signal processing, modeling and advanced statistical methodologies (classifications, machine learning, etc.) are used.

Aurélie Campagne (LPNC) and Nathalie Guyader (GIPSA Lab) - Scientific Coordinator

Visuomotor adaptation

Scientific background

Adapting hand movements to changes in our body or the environment is essential for skilled motor behavior, as is the ability to flexibly combine experience gathered in separate contexts. However, it has been shown that when adapting hand movements to two different visuomotor perturbations in succession, interference effects can occur. Here, we investigate whether these interference effects compromise our ability to adapt to the superposition of the two disturbances.

Method

Participants tracked, a visual target that followed a smooth but an unpredictable trajectory with a joystick (Figure 1). Four independent groups of participants completed one block of 50 trials under each of three mappings: one in which the cursor was rotated by 90° (ROTATION), one in which the cursor mimicked the behavior of a mass-spring system (SPRING), and one in which the SPRING and ROTATION mappings were superimposed (SPROT). The order of the blocks differed across groups (Figure 2).

Main results

Although interference effects were found when switching between SPRING and ROTATION, participants who performed these blocks first performed better in SPROT than participants who had no prior experience with SPRING and ROTATION (i.e., composition). Additionally, participants who started with SPROT performed better in SPRING and ROTATION than participants who had no prior experience with each of these mappings (i.e., decomposition).

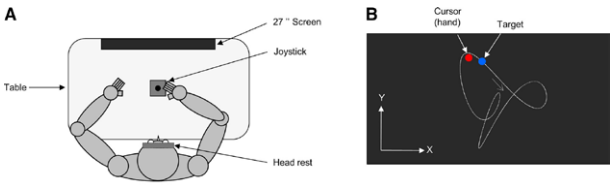


Figure 1. A: overhead view of the experimental setup. B: example trajectory of a moving target and a hand cursor on the screen. Note that the white trajectory was not presented to participants.

Figure 2. Experimental design. Each box represents one block, along with the number of trials in each block. Sprot, mapping in which the SPRING and ROTATION mappings were superimposed.

Discussion

The ability to compose/decompose tasks is critical for both cognitive and behavioral flexibility. Here, we show that this ability extends to two forms of visuomotor adaptation in which humans must perform visually guided hand movements. Despite the presence of interference effects when switching between visuomotor maps, participants could flexibly compose or decompose knowledge acquired in previous sessions. These results demonstrate flexibility of sensorimotor adaptation in humans.

For further information

P.M. Bernier J. Mathew, F.R. Danion (2021). *Composition and decomposition of visuomotor maps during manual tracking. Journal of Neurophysiology* 126(5) 1685-1697 https://doi.org/10.1152/jn.00058.2021

https://cerca.labo.univ-poitiers.fr/dispositif-experimental-hand-eye/

Monitoring the cognitive health of bees using « connected flowers »

Scientific background

Insect pollinators provide a vital service for terrestrial ecosystems. Research in ecotoxicology and neurosciences show that these insects are affected by many environmental stressors, such as pesticides and pathogens, that do not kill at low doses but significantly reduce cognitive capacities (Klein et al. 2017). A bee that cannot orient accurately or recognize flowers cannot nourish its larvae anymore and this can compromise entire populations. We aim to monitor the cognitive health of bees. This will help us better understand the natural cognitive diversity in these insects and the way it is affected by reduced environmental quality.

Method

Based on the approach of connected hives (Marchal et al. 2019), we developed an automated cognitive test to replicate routine lab-based visual conditioning experiments in the field. This « connected flower » is a Y maze in which an insect can enter and obtain sugar water based on the association between a color (or a combination of colors) and the reward (Figure 1). An insect that lands on the flower is recognized by a camera which reads a number tag carried by the insect. After recognition, the camera activates a door that lets the insect enter the Y maze. After the test, the insect is released and the result of its test is sent to a server for data storage. Another insect can then come and be tested.

Main results

We validated our approach by running experiments with bumblebees in the lab (Figure 2). The bees learned to associate a color with a sugar reward and another color with water and remembered this information for at least 24h. We then obtained preliminary results with honey bees and hornets in the field.

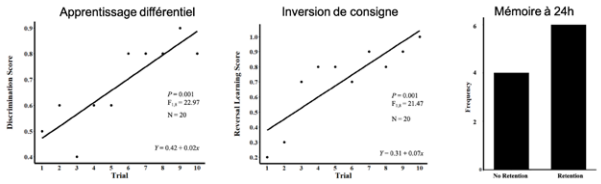


Figure 1 : Percentage of bumblebees responding to the correct visual stimulus in a differential learning, reversal learning, and 24h memory test. N = 20 bumblebees.

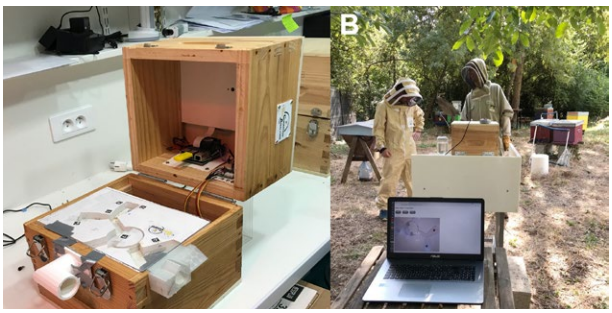


Figure 2 : A. Prototype of connected flower used in the lab to study bumblebee. The flower is open to show the Y maze. B. Connected flower deployed in the field to study the cognitive abilities of wild bees. The live stream of data is displayed on a computer in the front view.

Discussion

We developed a sensor to monitor the cognitive health of bees in the field. This automated system can generate unprecedented data on large numbers of individuals over long periods of time to understand the impact of environmental conditions on insect cognition. Our approach will also enable comparative research on the cognitive capacities of different wild pollinator species (Cauchoix et al. 2017). The “connected flower” is a tool for basic research to better understand the cognitive variability of insects and their resilience to stress but can also be used by beekeepers and stakeholders to estimate the health of local bees and the quality of the environment (Cabirol et al. 2021).

For further information

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THERADIA :

Digital Therapies augmented by Artificial Intelligence

Scientific background

Today's medicine is increasingly based on a Preventive, Personalized, Participatory and Predictive approach (i.e., 4Ps medicine), where digital plays a key role. An example is cognitive remediation, a digital therapy based on interactive and configurable stimulation exercises for people suffering from cognitive disorders. The efficiency of such treatments, which are mainly offered face-to-face, can be improved if patients pursue them at home. However, autonomous sessions where patients are left to their own devices can make adherence to treatment difficult. This may be overcome if patients can be « accompanied » throughout the course of therapy.

Method

THERADIA is a 5-year project for developing a virtual therapeutic assistant to relay and interface between patient and therapist, and also with caregivers. As in affective computing, such a virtual assistant must be both sensitive to patient emotions and general well-being throughout the digital therapy, and also able to respond appropriately. We designed the architecture of an empathic virtual agent to encompasses several modules (Fig. 1). The system acts like a video conference, but with data-driven modules to analyze patient expressions and generate appropriate responses from the virtual agent. Further, with a Wizard-of-Oz experimental framework we can collect interaction data. Here, the virtual assistant is driven in real-time by a human pilot, who is filmed (Fig. 2). Head movements, gaze, speech, and articulation of the pilot are captured to drive the 3D avatar whose rendering is cast to the patient's screen.

Main results

THERADIA is structured in three phases: (i) initialization, (ii) collection of real data, and optimization and (iii) clinical study. After two years, initialization led to the design of the Wizard-of-Oz experiment, and this collection of experimental data to the recording of 104 subjects, whose data are being used to train and optimize the systems composed in our video conference architecture (Fig. 1).

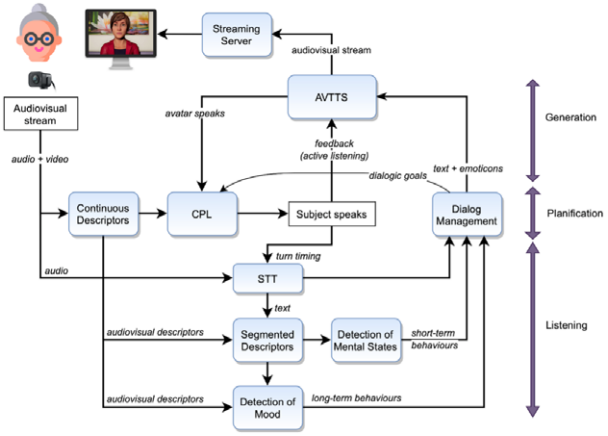

Figure 1: Flowchart of the THERADIA system designed for accompanying patients suffering from cognitive disorders when completing digital therapies; CPL: content process layers, STT: speech-to-text, AVTTS: audiovisual text-to-speech synthesis.

Discussion

The Wizard-of-Oz system can assess scripted dialogues and provide trainable components (e.g., turn management, dialogue, active listening) with ground truth behaviors. The human pilot continuously identifies failures of dialogue management and improvisation phases are constantly considered to improve the ability of the virtual assistant to appropriately act and interact. The various THERADIA systems are being optimized based on the data and will soon be able to handle natural interactions with home environments and on-demand exercises.

For further information

Franck Tarpin-Bernard, Joan Fruitet, Jean-Philippe Vigne, Patrick Constant, Hanna Chainay, Olivier Koenig, Fabien Ringeval, Béatrice Bouchot, Gérard Bailly, François Portet, Sina Alisamir, Yongxin Zhou, Jean Serre, Vincent Delerue, Hippolyte Fournier, Kévin Berenger, Isabella Zsoldos, Olivier Perrotin, Frédéric Elisei, Martin Lenglet, Charles Puaux, Léo Pacheco, Mélodie Fouillen, and Didier Ghenassia. *THERADIA: Digital Therapies Augmented by Artificial Intelligence. In Proceedings of the International Conference on Applied Human Factors and Ergonomics: Advances in Neuroergonomics and Cognitive Engineering*, pages 478–485, New York, USA, August 2021. Springer.

Perception-decision-action in movement control and adaptation

Application to interactive VR-based rehabilitation and ergonomics

Scientific background

Virtual Reality (VR)-based interactive environments for technical task learning consider adaptive processes that control the perception- decision-action loop for a precise motor behavior. For an operator or patient in this situation, constraint and perturbation immersive parameters must be specified for information processing, decision making and movement control. This means defining task difficulty criteria and measuring sensory and cognitive effects on the control of action, considering the expected behavior. The objective here is 1) to identify the sensorimotor and cognitive processes that characterize interactive behavior when critical predictive-reactive situations are to be resolved, to 2) to individualize and optimize the first-person interaction in gesture learning or movement rehabilitation.

Figure 1: The PIVVIT platform, a large VR-based field-of-view device using optic flow to stimulate the vision-balance interaction in therapeutic protocols.

Method

Two VR-based set-ups allow synchronization of immersive scenarios with real-time behavioral data (3D motion and balance capture, electrophysiological and ocular data). The PIVVIT platform (Fig.1), a large VR panoramic screen for interaction in static situations and the Ergo- Metrix platform (Fig.2), a head-mounted display (HMD) device for realistic immersion with specific goal-directed action-in-motion conditions. Various scenarios, from basic optokinetic stimulation to 3D hand-task areas and navigation spaces, stimulate adaptive vision-movement-locomotion interactions. The platforms expose subjects to cognitive-motor decisive situations (e.g., accuracy, complexity, conflict, uncertainty, stress), in which action decision and control is essential (fig.3). Data analysis evaluates the perception-decision-action parameters during the interaction.

Figure 2: The Ergo-Metrix platform, based on an HMD device for immersive first-person situations for specific goal-directed hand action scenarios: learning a technical intervention task by a novice operator.

Main results

The improvement of adaptive balance for the patient [1] and gesture for the operator demonstrates the effect of individualized VR protocols on interaction performance. The main effect is to reinforce multisensory-motor control and its cognitive supervision. Our analysis model based on task and behavior descriptors associated to sensory, cognitive and motor task prescriptions (Fig.4) allows identification of performance indicators for task success to differentiate immersive protocols.

Discussion

The key-idea that drives our proposal is this ergonomic consideration: « The more person-and task-related the virtual immersion is, the more the interaction performs ». Our VR platforms target these interaction requirements by 1) identification of functional criteria at task and behavioral levels, and 2) assessment of sensory-cognitive information and action processing to individualize protocols. The « input- output » analysis model, linking task parameters as input to behavioral datasets as output (for inter- variable scaling), allows modelling « learning plasticity » by adaptive control theories and transfer functions [1].

Figure 3: Vision-movement-balance interactions at the first person, in response to sensory and cognitive constraints and perturbations: complex anticipation-coincidence hand task.

ANALYSE de la PERFORMANCE D'INTERACTION en IMMERSION – COMPOSANTES ET DESCRIPTEURS

Environnement visuel virtuel immersif			Comportement de l'utilisateur			Analyse du comportement			Perspectives
Scénarii d'immersion pédagogique	Niveaux d'interaction[6]	Comportement (caractéristiques) de l'EVA (Environnement Virtuel d'Apprentissage)	Processus sensori-moteurs et cognitifs impliqués[7]	Comportements et attitudes observés	Confort et ergonomie[8]	Traitements sensori-moteurs	Traitements cognitifs	Comportements compensateurs	Solutions envisageables
# scénario	Vision Perception visuelle Orientation du regard Stratégies visuelles Apprentissage des procédures Geste manuel Equilibre statique-dynamique Locomotion Navigation Autres (préciser)	➢ Scènes et objets ➢ 2D, 3D ➢ Fixe, en mouvement ➢ Statique, dynamique ➢ Instabilité, dérive ➢ Images, flux ➢ Graphisme, rendu, réalisme ➢ Contenu sémantique ➢ Traitement de l'information ➢ Double-tâches, multitâches ➢ Réalité augmentée ➢ Compatibilité S-R ➢ Stimulation ➢ Interactivité ➢ Réactivité ➢ Traitement sensoriel, cognitif, moteur ➢ Délai, retard, mise à jour ➢ Interactivité ➢ Mouvement ➢ Asservissements images, gestes et déplacements ➢ …	➢ Détection ➢ Sensation ➢ Perception ➢ Identification ➢ Compréhension ➢ Décision ➢ Mémorisation ➢ Apprentissage ➢ Manipulation ➢ Coordination ➢ Stabilité ➢ Equilibre ➢ Déplacement ➢ Locomotion ➢ Orientation ➢ Navigation ➢ … … et d'autres (plus spécifiques de l'évaluation et de l'analyse effectuée)	➢ Inspection visuelle ➢ Découverte ➢ Manipulation ➢ Interaction ➢ Recherche d'informations ➢ Essais-erreurs ➢ Compréhension des procédures ➢ Incertitude ➢ Charge mentale, cognitive ➢ Prudence motrice ➢ Conflits inter-sensoriels ➢ Déséquilibre ➢ Imprécision ➢ Ralentissement ➢ Geste global ➢ Instabilité, inconfort ➢ Désorientation ➢ Confusion cognitive, spatiale ➢ … **… et d'autres (plus spécifiques de l'évaluation et de l'analyse effectuée)**	➢ Estimations ➢ Quantification ➢ Qualification ➢ Référencement ➢ …	➢ Flux optiques, visuels ➢ Défilements rétiniens ➢ Affordances et alertes sensorielles ➢ Saccades et fixations oculaires ➢ Dérives et poursuites oculaires ➢ Stabilisation et perception visuelle ➢ Traitement sensoriel subliminal ➢ Perturbation sensorielle ➢ Contrôle sensorimoteur ➢ Réactions réflexes ➢ Automatismes sensori-moteurs ➢ Ajustements compensateurs ➢ Distorsion visuo-proprio-vestibulaire ➢ Compensation-substitution sensorielles ➢ Réactions motrices et posturales ➢ Inconfort, nausée ➢ Dérives et calibration sensorielles ➢ …	➢ Réduction de l'incertitude ➢ Calculs cognitifs continus ➢ 'Remapping' visuo-manuel ➢ Surveillance des stimulations ➢ Perte des automatismes moteurs : visuo-posturaux et visuo-manuels ➢ Recherche d'indice/informations calibrantes, structurantes pour la perception et la prise de décisions motrices et le déclenchement de la tâche à réaliser ➢ Traitement de l'information sensorimotrice et sémantique ➢ Traitement conscient et subliminal ➢ Perception et analyse ➢ Stratégies d'interaction : – Attention focalisée – Intentionnalité du geste – Attente des retours d'informations (connaissance du résultat) ➢ Diverses stratégies : – Attention focalisée – Incertitude, hésitation ➢ Anticipation limitée ➢ …	➢ l'utilisateur « réfléchi » tous ses gestes, fige sa posture, réduit les amplitudes et vitesses 'naturelles' des gestes et de pas, etc. ➢ Passage d'un contrôle sensori-moteur à un contrôle cognitif de l'interaction ➢ Rupture des automatismes perceptifs => vigilance => augmentation de la charge mentale ➢ Regard 'flottant' ➢ Difficulté d'analyse ➢ NC. ➢ Geste ralenti, prudent ➢ Contrôle en ligne de la trajectoire main ➢ Contrôle final du geste => perte des automatismes gestuels ➢ Contrôle des APA ➢ Contrôle des APC => perte des automatismes posturaux ➢ Ralentissement des déplacements locomoteurs ➢ …	➢ Paramétrer la cinématique de l'environnement physique à partir des déplacements de la tête (et des yeux ?) ➢ Structurer l'espace visuel : – Eviter les horizons (azimut) infinis – Indiquer les points de localisation clés du poste gaz – Présenter des points d'ancrages fovéal fixe dans l'espace 3D ➢ Référentiel d'orientation/localisation spatiale ➢ Présenter un repère d'ancrage fovéal dans l'image (p.ex. un/des point/s ou objet/s 3D fixe/s référencé/s à la position absolue des blocs-caméras ➢ En lien avec les partenaires spécialistes d'apprentissage en EVA. ➢ Réduire/annuler les retards geste-image ➢ Améliorer les retours d'informations visuels (ou autres) ➢ Optimiser le gain (facteur d'échelle, coefficient) entre flux d'image et flux optique. ➢ Réduire/annuler les retards geste/équilibre-image ➢ Alerte/suppléance sensorielle ➢ Informer par d'autres modalités sensorielles (visuelle, sonore, tactile) ➢ Préférer la téléportation avec ralentissement-rotation terminale pour une remise à jour de la carte spatiale (donc des processus visuo-manuel et posturaux préparatoire) ➢ …

Figure 4: Model of task-behavior interaction analysis based on sensory, cognitive and motor descriptors for the environment and task determinants (in columns), and the corresponding behavior (in rows) with prescriptions for improvement.

For further information

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https://www.youtube.com/watch?v=F8yT-kNVndc - *Adaptation du comportement d'interaction en immersion visuelle virtuelle*. Capsule vidéo Institut Cognition, 2021

[1] https://hal.archives-ouvertes.fr/hal-02371059

EVOLEX

Institut de Recherche en Informatique de Toulouse

Scientific background

Cognitive complaints are frequently reported by patients in remission or treated long-term with targeted anti-cancer therapies, grouped under the term « chemobrain ». They usually seem mild, but are nevertheless disabling in everyday life or during professional recovery, constituting what is called an « invisible handicap » but nevertheless very real for patients. Their identification requires a speech-language or neuropsychological assessment, whose sensitivity can be improved by obtaining a patient's reaction time when performing tasks or by a qualitative analysis combining recorded responses during computerized testing with speech recognition for automated and accurate processing of recorded responses.

Example of fluency task evaluation

Method

Since 2013, a collaboration between SAMoVA and ToNIC allowed i) computerized processing of responses recorded during procurement followed by ii) software development , iii) a feasibility study on the lexical evocation task, then iv) two new linguistic tasks: image naming and semantic verbal generation. The amount of data and the complexity of the lexical and semantic processes involved required an opening towards the Octogone-Lordat team.

Discussion

The increasing number of users and registrations of our computerized tool has become difficult to manage. By involving a private partner, COVIRTUA Healthcare, the Evolex project aims to take its first version to the next level, i.e. to a version that could be used on a large scale, and marketed for even larger use.

Main results

The acoustic models of the speech transcription tool are more robust and can now consider heterogeneous voices (age, gender, accent, possible pathology, etc.). The statistical analyses of the assorted ests (fluences, naming, generation) now being finalized.

For further information

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Xavier de Boissezon, Lola Danet, Cécile Fabre, Jérôme Farinas, Bruno Gaume, et al.. *EVOLEX : approches psycholinguistique et computationnelle de l'accès au lexique et de la proximité sémantique entre paires de mots.* FORUM À LA CROISÉE DES SCIENCES : Interagissez, Imaginez, Innovez - FACS3I, Jan 2019, Toulouse, France. {hal-02047651}

Xavier de Boissezon, Lola Danet, Cécile Fabre, Jérôme Farinas, Bruno Gaume, et al.. *Le projet EvoLex : Aller plus loin dans l'étude de la fluence et de l'accès au lexique* (2018). Demie-Journée scientifique 2018 «Langage, Culture, Société» : Qui-Quoi-Où de la recherche sur langage, culture & société, Toulouse Mind and Brain Institute (TMBI), CHU Purpan, pavillon Baudot, Toulouse, France; URI Octogone-Lordat (EA4156), Maison de la Recherche Université de Toulouse 2 Jean-Jaurès, Toulouse, France, May 2018, Toulouse, France. {hal-03044265}

Environment and the perception of time and distance in mobility

Scientific background

The mechanisms of time and space perception do not seem to be independent in humans: the length of a stimulus influences the perception of its duration. Symmetrically, the duration of a stimulus biases the estimation of its spatial extent. These results suggest the existence of a common system for processing spatiotemporal magnitudes. However, no consensus has been reached regarding the existence of such a system, due to the variability of results depending on the estimation tasks. This study was part of the Wildtimes ANR project (ANR-18-CE22-0016) whose objective is to study the perception of time and space in real mobility situations. It proposed a new approach in studying the estimation of durations and the perception of distances. Here, the outdoor context (compared to the interior of a building) and virtual vs. real immersion were manipulated because of the systematic compression they cause on spatial perception.

Method

Adult participants estimated physical magnitudes (distances or durations, between 5 and 20m or 5.5 and 25.5 seconds, respectively) following the passive rectilinear movement of a robot maintained at constant speed. The participants first experienced a reference path and memorized the distance or duration (depending on the test). The participants then reproduced the reference magnitude by activating the robot themselves using a push button. They were then instructed to verbally estimate this magnitude once reproduced (meters or seconds). Half of the trials were conducted in indoors and the other half outdoors. In addition, half were performed in a virtual visual context (headset with stereoscopic screen and high fidelity virtual environments reproducing the appearance and scale of each experimental location) and the other half in a real condition.

Main results

For the magnitude reproduction task via robot movement, the effect of virtual reality on the compression of perceived distances was also observed on the compression of durations. However, this symmetry was not observed for the indoor/outdoor context: the compression of distances was not accompanied by a compression of durations. Regarding verbal estimations, the immersion in virtual reality produced similar results to those observed for the reproduction task, a compression of distances as well as durations compared to the real condition. No effect of the indoor/outdoor context was observed.

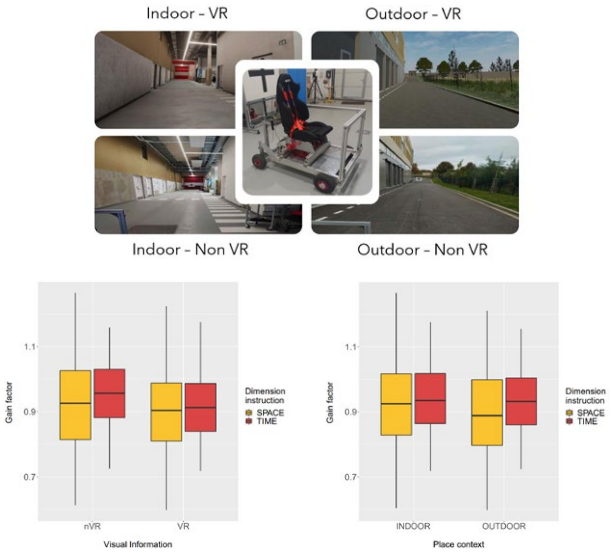

Figure 2: Interaction effect between the virtual context and the dimension: virtual reality causes a compression of distance and duration. This effect is more important for duration than for distance.

Figure 3: Interaction effect between location context and dimension: the external context causes a compression of perceived distances but does not affect duration estimates.

Discussion

The results suggest that the observed spatiotemporal interferences result from more complex mechanisms than those predicted by the existence of a common system of magnitudes. The level of processing associated with a source of perceptual distortion or a response mode seems to modulate the existence and the amplitude of spatiotemporal interactions.

For further information

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Being Touched by a Virtual Agent (ETAV)

LISN
LABORATOIRE INTERDISCIPLINAIRE DES SCIENCES DU NUMÉRIQUE

Scientific background

Touch is an essential pathway for social interactions between individuals (Morrison et al., 2010). Social touch is of great importance in myriad situations, ranging from interpersonal communication to cognitive pathologies. However, our knowledge of the key parameters that promote the experience of being touched during an interaction (human-human or human-agent) is limited, which hinders our ability to simulate social touch gestures in virtual reality (VR). The objective of our project is to study the contextual parameters that enhance the experience of being touched by a virtual agent.

Method

We conducted two experimental studies on anticipation of a social touch gesture performed by a virtual agent. These experiments showed participants a virtual agent initiating a movement to shake hands with another virtual agent. The movement of the first virtual agent was either caused by the participant or performed autonomously. Perceptual anticipation measures were then collected. For this, we used the paradigms of « Intentional Binding » (compression of the perceived time between the action and its effect) (Haggard, 2005) and « Representational Momentum » (memory bias of the last seen image of the movement) (Freyd & Finke, 1984). The first experiment included 25 participants and the second 28. The two experiments differed in the social context of the interaction: in the first experiment, the context favored the interaction (the two agents were close enough to shake hands and the second agent held out her hand for the first to shake); in the second, the context did not favor the interaction (the two agents were too far apart and the second agent did not hold out her hand towards the first).

Main results

The results of the first experiment showed that when the participant was the instigator of the agent's action, she/he anticipated the social action to a higher extent. The second experiment showed that this anticipation was modulated by the social context, i.e. when the social context did not favor the interaction, the anticipation decreased.

Discussion

These results suggest that visual perception was modulated by the participant's agency and by the social context. When we perform a social action, our perception is biased by our intention to act and by the affordance of the social context in which the action takes place.

For further information

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Haggard, P. (2005). *Conscious intention and motor cognition. Trends in Cognitive Sciences*, 9(6), 290-295. https://doi.org/10.1016/j.tics.2005.04.012

Morrison, I., Löken, L. S., & Olausson, H. (2010). *The skin as a social organ. Experimental Brain Research*, 204(3), 305-314. https://doi.org/10.1007/s00221-009-2007-y

Cognition in the characterization of creative profile

LABORATOIRE DE NEUROSCIENCES COGNITIVES

Scientific background

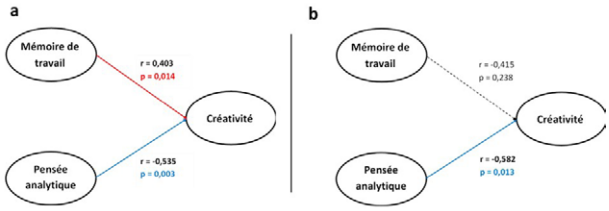
In the handicap field, creativity can be seen as a tool that allows the individual to better « bounce back » from difficult events. This view places creativity at the center of the adaptive process. Thus, creativity and adaptation would act in concert to develop new ideas into useful solutions and become a source of resilience. In this context, it becomes essential to characterize the individual's creative potential in detail to promote creativity in low-potential individuals through targeted training. To better evaluate this potential, we propose a global approach based on a model of cognitive and cerebral functioning.

Method

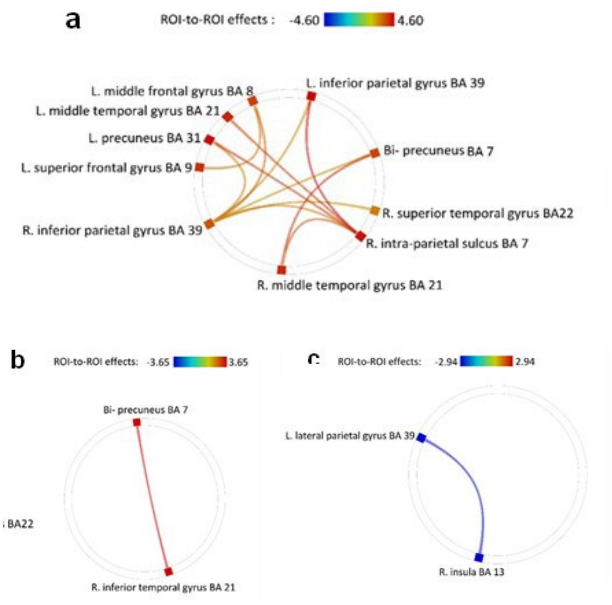
We differentiated between individuals with high and low creativity potential using the structural equation model (PLS-SEM) assuming an influence of working memory and analytical thinking on creativity assessed by the Torrance test (TTCT). Resting brain functional connectivity was assessed by fMRI.

Main results

Analytical thinking is negatively correlated with creativity for both high and low creative potential individuals. Working memory is positively correlated with creativity but only for the high creative potential group. The fMRI study shows that high creative people have increased resting brain connectivity in the attention network and in the default mode network and decreased brain connectivity in the salience network.



Structural model: direct effects of working memory and analytic thought, on creativity in (a) people with high creative potential, (b) people with low creative potential. Red: positive correlation, Blue: negative correlation.



Contrast of functional connectivity between high and low creative people (High creative potential > Low creative potential).
a) Attentional network b)Default mode network c) Salience network. Red line represents positive correlation and blue line corresponds to negative correlation. The degree of red or blue correspond to the correlation's level.

Discussion

The functional cognitive and brain connectivity of creative people underlines the existence of an active link between mental imagery, introspection processes and working memory. Decision-making appears to be less influenced by past experiences, which allows for the emergence of creative responses.

For further information

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A psychoacoustic test for misophonia assessment

LABORATOIRE DE NEUROSCIENCES COGNITIVES

Scientific background

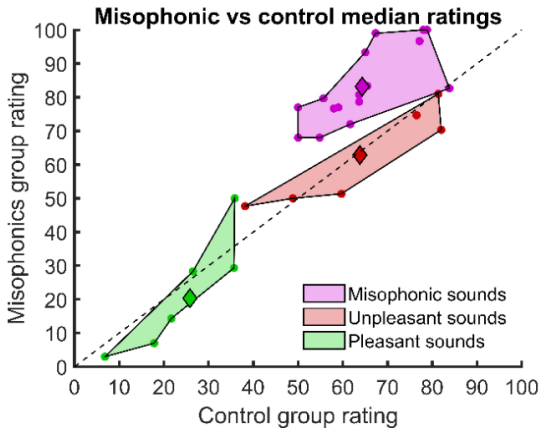
Misophonia is defined by the fact that certain very specific sounds can trigger very intense emotions, namely anger or more rarely disgust. The subject's attention is also captured and trapped by the misophonic sounds, causing extreme discomfort with no possibility to escape. The trigger sounds for a misophonic reaction are usually produced by humans and are most often associated with mouth (chewing etc.) or throat (scraping etc.) sounds. The disorder can affect the quality of life of the subjects, who may avoid situations that that cause their discomfort.
The prevalence of misophonia is not yet very clear and varies according to studies between 6 and 49%. Misophonia lies at the interface between hearing and mental disorders. It is probably because of its « mixed » character that there are no psychoacoustic methods for understanding auditory perception in misophonic subjects. The aim of this project is to fill this gap and to develop a method for diagnosing misophonia.

Method

The study was conducted online on many subjects, who were categorized using a questionnaire (Misoquest) and the simple question « Are you a misophonic? » In the end, we collected data from 78 misophone subjects and 55 controls. The subjects' task was to estimate whether the sound presented at a comfortable level was pleasant or unpleasant using a visual analogue scale. The sounds presented were sounds known to trigger misophonic reactions (chewing, sniffing, snoring etc.) and other sounds that are typically pleasant (water) or unpleasant (engine).

Main results

Our results show that subjects categorized as misophonic rated misophonic sounds as more unpleasant than control subjects. In contrast, pleasant and unpleasant non-misophonic sounds were rated equally in both groups. We also selected the most discriminating sounds to differentiate the two groups. and calculated a score to diagnose misophonia in a given subject.



Misophonic vs Control median ratings for each sound. Ratings vary between 0 (Pleasant) and 100 (Unpleasant). Each dot represents the median rating of a sound for the control (x-axis) group and the misophonic (y-axis) group. Sounds are colored and grouped as misophonic (magenta), unpleasant (red), and pleasant (green). The median of individual medians of sound ratings within the same category is shown as a diamond. As a visual reference, the y = x line is drawn in dotted black. Sounds close to this line have similar ratings for the two groups.

Discussion

Our study validated a psychoacoustic method for understanding auditory perception in misophonic subjects and for diagnosing this disorder. It is interesting to note that misophonic subjects perceive (by definition) misophonic sounds as more unpleasant than control subjects, but that other sounds are not more unpleasant than in control subjects. This result underlines the highly specific nature of misophonia. The psychological mechanisms of misophonia are far from being understood. Misophonia resembles phobia except that the emotion aroused is not fear but anger. It is possible that this anger is the result of an extreme sensitivity to a « moral » and « social » form of the sound environment. In this context, mouth noise (for example) would be to hearing what bad smell would be to smelling: a kind of rudeness or break from social convention.

For further information

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Somatosensory information in holding and controlling an object: A pen during a graphic task

LABORATOIRE DE NEUROSCIENCES COGNITIVES

Scientific background

What is the role of somatosensory information when we hold an object in our fingers to move it precisely? For example, what happens if we squeeze a pen too hard when we are writing or drawing? Here we tested the hypothesis that loss of precision in the graphic task is not due to a stronger motor command to grip the pen per se, but rather to the decrease in tactile information from the mechanoreceptors in the finger's skin resulting from the overpressure. To do this, we compared a condition in which the participant applied natural pressure with two others: one in which the participant actively applied overpressure to the pen and one in which the overpressure was applied passively. While the participants performed the task, we electrically stimulated the median nerve in the forearm of the effector limb to study the EEG-recorded somatosensory evoked potentials (SEPs). This allowed estimation of the weight given to somatosensory information according to the amplitude of the evoked potential.

Method

We asked 15 right-handed adults to draw a simple graphic shape (« Movement » condition) or to hold the pen in a static position (« Static ») while holding it either naturally (« Natural »), voluntarily squeezing the pen (« Active »), or passively maintaining this overpressure (« Passive », with an overpressure comparable to the active condition). We simultaneously recorded the movement and pressure of the pen tip on the chart table, the pressure exerted by the fingers on the pen using sensors positioned on the pen, and the EEG activity.

Main results

The SEP amplitude was not significantly different between the natural and the two overpressure conditions. However, behavioral results showed that drawing accuracy was impaired when pen pressure was increased (passively or actively). Cortical source analyses revealed that superior parietal area (SPL) activity increased in both overpressure conditions.

Discussion

Our results suggest that the lack of accuracy observed in an overpressure condition does not originate from motor processes as it is present in the passive overpressure condition (i.e., without motor command to hold the pen). Thus tactile-kinesthetic sensory processing would be at the origin of this decrease in precision. In this context, the increase in activity at the SPL would be critical for updating the pressure state of the fingers on the pen. These cortical changes could reflect the deficit in updating the representation of the finger-pen interaction force for those graphic actions that are visually controlled.

For further information

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https://www.gdr.tact.uha.fr

Using Virtual Reality to measure reading fluency in children

Scientific background

The digitization and automation of standard tests offers both improved performance (such as the addition of physiological measures to behavioral measures) and comfort for both the child and the examiner conducting the test. This study used a virtual reality headset to present visual stimuli in a controlled environment.

Method

102 children aged 7 to 9 years recruited from two schools in Marseille (France) participated in this study. Stimuli (50 words and 50 pseudowords (pronounceable words that do not exist in French)) were presented through the virtual reality helmet « Fove0 » which offers a large immersive visual field (100°) and integrates an eye tracker directly into the helmet. Two experimental tasks were performed. In the first, children had to decide whether the words that appeared in the virtual reality headset were words or pseudowords using a joystick. The second was a paper-based word and pseudoword reading task: children had one minute to read as many items as possible and an examiner annotated their performance for number of items read correctly to obtain the reading speed. The two tests were performed individually and counterbalanced between the experimental groups. Presentation of the stimuli was controlled and randomized.

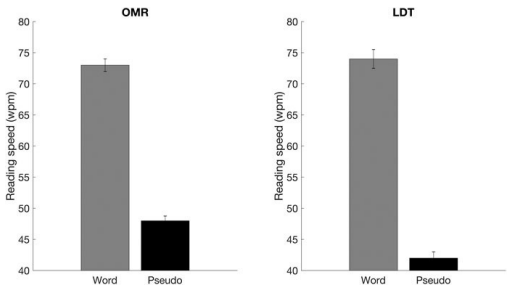

Figure 1: Average reading speeds (words per minute) for words and pseudowords during the One-Minute Reading test (OMR) on the left and the Lexical Decision Task (LDT) on the right. The error bars represent the 95% confidence intervals.

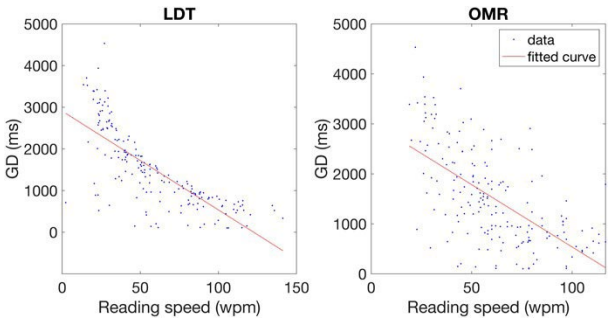

Figure 2: Graphical representation of the relationship between gaze duration (GD) and reading speed (words per minute) in the One-Minute Reading (OMR) and Lexical Decision Task (LDT) tasks.

Main results

Children made more recognition errors and took longer to respond to pseudowords compared to words (Fig. 1). The lexical decision task performed in virtual reality and the one-minute reading task (paper-based) produced very similar lexical effects. Finally, there was a strong correlation between reading speed (words per minute) and gaze fixation time at the single word level (Fig. 2).

Discussion

The objective of this study was to provide a proof of concept to verify that virtual reality technology can be developed as a reliable and valid measure with children. Here, we demonstrated that it is possible and relevant to use virtual reality with eye-tracking during a word recognition task.

For further information

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Electrophysiological mechanisms of perceptual and self-consciousness

Laboratoire de Psychologie et NeuroCognition

Scientific background

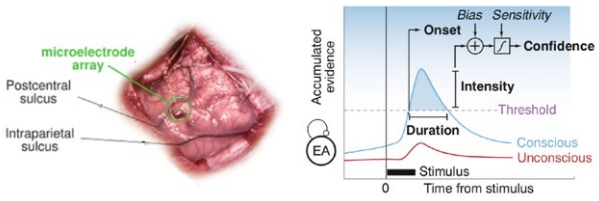
The way we perceive the world and ourselves is a major subject of philosophical and scientific study. Recently, cognitive neurosciences have taken up these questions. They propose to describe the cerebral correlates of perceptual consciousness, i.e. the subjective experience associated with the processing of a sensory stimulus and of self-consciousness, i.e. the capacity to evaluate and control our mental states. We propose that beyond simple brain correlates, perceptual and self-consciousness involve a common neural mechanism: the accumulation of evidence.

Method

We recorded the brain activity of neurological patients receiving intracranial implants. While measuring the activity of single neurons or populations of neurons, patients were asked to detect visual or tactile stimuli of very low amplitude and then report the confidence they attributed to each of their responses. The combination of detection and confidence judgments allowed us to study perceptual consciousness and self-consciousness simultaneously. We identified evidence-accumulating parietal neurons whose activity varied systematically according to the detection and confidence responses. We reproduced these results in healthy volunteers and in silico, by developing a computational model that considered that a stimulus is consciously detected if the accumulated evidence reaches a threshold, and that derived confidence as the distance between the maximum of the accumulated evidence over time and this threshold.

Main results

The accumulation of evidence by parietal neurons helps explain how a sensory stimulus becomes conscious, as well as the degree of confidence associated with it.



Left panel: Intraoperative photo of the microelectrode array posterior to the postcentral sulcus and dorsal to the intraparietal sulcus. Right panel: Leaky evidence accumulation processes (LEAP). Average evidence accumulation traces locked on stimulus onset. A conscious percept occurs when accumulated evidence (blue trace) reaches a threshold (broken line) and lasts until leakage pulls it back below threshold. The perceived intensity is proportional to the maximal accumulated evidence above the threshold. The stimulus remains unconscious when accumulated evidence (red trace) fails to reach threshold. Confidence is read from the distance between maximal evidence and detection threshold.

Discussion

Our results provide behavioral, neural, and computational evidence that perceptual consciousness and self-consciousness are deeply linked and rely on evidence accumulation mechanisms essential for decision making. We are now exploring how this mechanism is implemented in different brain regions, and how it could explain qualitative aspects of conscious perception, including intensity and duration. These results have potential impact beyond basic research, as the signature of consciousness through evidence accumulation could serve as an objective marker in individuals who cannot report their conscious experience, such as non-communicating patients, newborns, or non-human animals.

For further information

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Collective cognition

To study natural and artificial interactions in different contexts (emotional, cultural, etc.) in order to understand the underlying processes (cognition, communication, etc.), social, belief and emotional regulations in individual and social contexts, stereotypes, effect of the social context on cognition and human- human/animal/virtual agent/ robot interactions.

Lucia Bosone (LaPEA) - Scientific Coordinator

PRIM Project

Playing and Recording with Interactivity and Multisensoriality

Scientific background

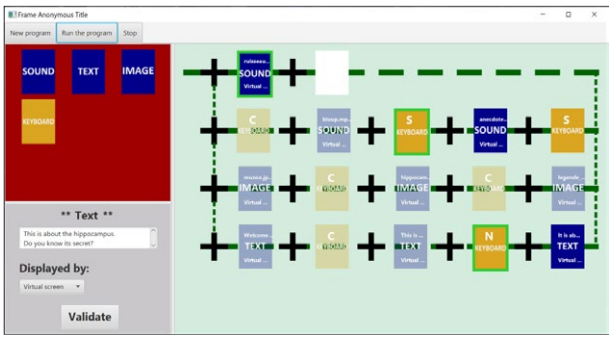
In their daily activities, many people create interactive scenarios for e.g., learning, rehabilitation, research or creation using technology, e.g., teachers, therapists, researchers or artists. Currently, these people must train themselves in programming, which is time consuming, or outsource to computer scientists, which requires a budget. The PRIM project aims at designing a software that allows the creation of « scenagrams », i.e. interaction sequences between a human and a computer system, with a cognitive purpose. The idea is to propose a vision based on uses and interactions, and not on algorithms, in order to be able to easily use the functionalities of digital devices.

Method

The PRIM project follows a user-centered design approach placing the user at the heart of all stages of the project to obtain a software that will maximize user experience. The first step is the creation of a prototype that offers an original vision of computer creation based on experience gained from previous projects. The second step is to test this prototype with different user panels to finalize the definition of the functional scope, to generate new ideas and to target remaining needs. The third step is the development of a software, following an agile methodology allowing the solution to be tested regularly by future users in order to refine it as it progresses. Finally, the fourth step is a large-scale evaluation to validate the proposal.

Main results

The expected result is a software inspired by video editing and music composition software which allow creation without learning or using algorithms.



Prototype to create interactions on a timeline based on relative time.

Discussion

A preliminary study allowed validation of the basic concept which is to use a system hybridizing a timeline, as in video editing software, and a score, as in music composition software. The major issue was to verify if it is possible to use these metaphors, already known and validated, in a different context. The major difference is the notion of time, which is continuous and without interruption in video and music composition editing, but which is relative when the actions of the human or the computer system are carried out unpredictably. Next, it will be necessary to enrich the existing prototype and to measure its use with different audiences, remembering the two categories of users: the creators and the end users.

For further information

C. Jost, J. Debloos, D. Archambault, B. Le Pévédic, J. Sagot, R. Sohier, C. Tijus, I. Truck, G. *Uzan : PRIM Project: Playing and Recording with Interactivity and Multisensoriality in Work-in-Progress category of IMX* 2021, ACM international conference on Interactive Media Experiences, 21st-23rd June – Virtual (New York City, USA).

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Moralization and Attitude Extremity Amplify « Myside » Sharing

Scientific background

In many countries, liberals and conservatives are increasingly unable to reach policy agreements on polarized issues. This phenomenon is partly anchored in disagreements about facts. For example, liberals estimate lower levels of illegal immigration than conservatives, while liberals estimate higher crime rates. Here we experimentally investigate a mechanism that may, at a collective level, help account for such polarization around factual claims. We ask whether moral convictions may amplify a preference to share facts that are consistent with one's pre-existing beliefs.

Method

In 11 online studies involving more than 6000 US participants, we examined participants' self-reported decisions to share news stories. These stories related to four controversial issues - gun control, abortion, sex and racial equality - on simulated social media.

Main results

Respondents consistently showed a « Myside » preference to share news headlines whose conclusions supported their prior position on the topic. This was independently amplified by their degree of moralization and attitude extremity on the issue. Thus people showed the strongest « Myside » sharing preference when they were also morally invested in the topic. These effects generalized across both real and « fake news » items, and they also held across manipulations of the political orientation of the audience, and of the reputational consequences of sharing. Exposure to messages warning against the myside bias and myside sharing did moderate myside sharing for both real and fake news.

Discussion

We knew before this work that people preferentially believe evidence which aligns with their own pre-existing views, and that moral conviction can cause erroneous inferences even from unambiguous evidence. These are « consumption side » biases linked to how people uptake morally charged information. The current study highlights a « production side » bias that can interface with these consumption side biases, with the collective net result of information distortion and polarization.

For further information

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https://osf.io/twq3y

PERITIA Policy, Expertise and Trust in Action

Scientific background

PERITIA is a European project that studies public trust in expertise. Our multidisciplinary team seeks to help citizens and policy makers understand trust in science and identify trustworthy expertise. In doing so, we aim to build trust in better democratic governance for the future of Europe. The key hypothesis of PERITIA is that affective and normative factors play a central role in decisions to trust. This applies even in cases where trustworthiness judgements may appear to be based on knowledge-based considerations, such as professional reputation, reliability and objectivity. Our team explores this hypothesis conceptually and tests it empirically.

Method

Phase 1: Theory

- Trust and the conditions for successful policy advice mechanisms
- Trust in a changing media landscape
- The ethics of trust
- Scientific reputation and trust
- The psychology of trust

Phase 2: Experimentation

- Data collection through surveys and analysis of existing data on trust: Ireland, UK, Norway, Germany, Poland, Italy, France.
- Experimental measures of trust
- Behavioral determinants of trust and mistrust

Phase 3: Recommendations and dissemination

- Behavioral tools for building trust
- Citizens' forums
- Essay competition « European Youth on Trust ».
- Policy recommendations and dialogue with policy makers

Main results

From 2020 to 2023, the PERITIA team is producing research results to study the conditions under which people trust the expertise used to inform the public.

Discussion

The question « Why trust the experts? » invites everyone to reflect on the role of expertise in our daily lives. We have all seen the key role played by experts in advising citizens and politicians during the pandemic. Perhaps it is time to ask ourselves some pertinent questions about trust in expertise. How does trust in experts work? How is trust in science related to trust in the media? Why is trust in expertise important for democracies? How can we learn to trust trustworthy experts? Answering these questions may help build trust in expertise and limit the growing effect of fake news.

For further information

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https://peritia-trust.eu/about-peritia/

https://youtu.be/hr3jghs8ZxI?list=TLGGVEQFPj8ki_cxMzA1MjAyMg

ArTiculation

EnsadLab

Scientific background

ArTiculation is an interdisciplinary project of virtual reality experience designers, neuroscientists, dancers, anthropologists and interaction design specialists. This project aims to identify how a collective becomes creative through its gestural interactions. To isolate, stimulate and analyze gesture, we employ virtual reality, designing experimental paradigms deployable in artistic, scientific or clinical situations. ArTiculation is supported by the École Universitaire de Recherche ArTeC and conducted by the laboratory Structures Formelles du Langage, in partnership with the University of California Davis and the École nationale supérieure des Arts Décoratifs.

Method

To isolate, stimulate and analyze artistic gesture we use a minimalist virtual reality device (SHIVR) in which two people, each represented by three spheres, dance freely together. The real- time capture and analysis of their movements and physiology and the collection of their experiences allow identification of intersubjective forms and dynamics of creative interactions. On this basis, we will create a virtual agent with whom it will be possible to interact.

Main results

This research theorized and tested several concepts such as the Shared Diminished Reality (SDR), inspired by minimalist approaches in art (dance, theater, animation, plastic arts). It has been presented in several venues. The results suggest that the minimization of self-representation, associated with open-ended exploration scenarios, has a positive impact on relational dynamics, and stimulates creativity and improvisation.

ArTiculation workshop at Larret (Périgord), experimentation of the concept of median in co-presence. Rémi Sagot-Duvauroux, PhD student SACRe ENSAD/PSL, Alexandra Endaltseva socio-anthropologist CNRS, May 2021. Photo © François Garnier

Discussion

Following the concept of « white rabbit », a guide to link the sensory, physical or virtual layers of a mixed reality device, a synthetic representation visualizes, monitors, and qualifys an intersubjective relationship. This research could find applications in the fields of communication (immersive experience piloting, flow management) and in the health sector (e.g. Autism, ADHD).

For further information

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H2020 TAILOR

Trustworthy AI Integrating Learning, Optimisation and Reasoning

Institut de Recherche en Informatique de Toulouse

Scientific background

TAILOR focuses on the foundations of Trustworthy AI, unlikr other projects addressing complementary foundational aspects, such as intelligent robots, human-centric AI systems, or edge computing and AI hardware. The purpose of TAILOR is to provide the scientific foundations for Trustworthy AI in Europe by developing a network of research excellence centers combining learning, optimization and reasoning.

Method

The TAILOR research program is divided into five themes: Trustworthy AI, AI Paradigms & Representations, Acting, Social, and AutoAI. The tools to be used are:

- Mechanisms supporting innovation, commercialization and knowledge transfer to industry such as thematic workshops, industrial PhD students and joint academic-industrial research labs.
- Mechanisms supporting effective collaboration within the network such as AI-Powered Collaboration Tools, PhD and training programs.
- A connectivity fund to support active dissemination across Europe through for example research visits and joint workshops.

Main results

The network provides two innovative state-of-the- art mechanisms:

- A multi-stakeholder strategic research and innovation roadmap continually collecting and monitoring the challenges to achieve Trustworthy AI.
- Virtual research environments with the best AI researchers in Europe addressing the major scientific challenges.

Discussion

Deciding and Learning how to Act, Trustworthy AI, AI Paradigms & Representations, and Social AI will contribute to bring the TAILOR project to the public.

For further information
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https://tailor-network.eu

Cognitive Planning in Persuasive Multimodal Communication (CoPains)

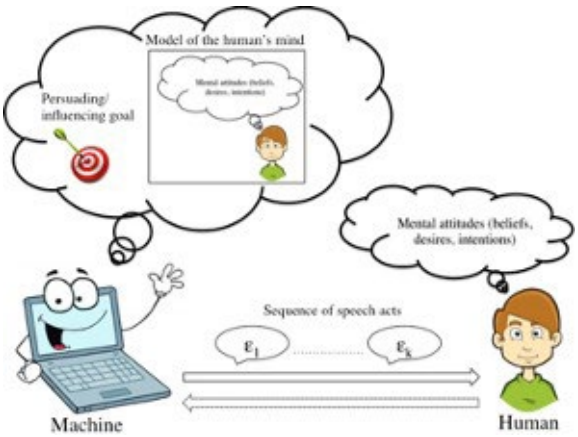
Institut de Recherche en Informatique de Toulouse

Scientific background

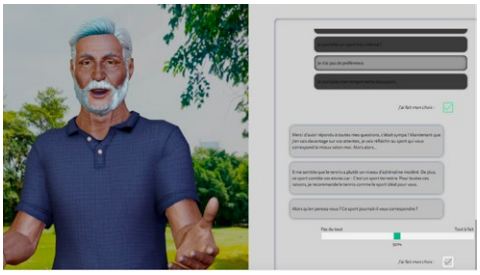
Planning is the subfield of artificial intelligence (AI) that consists of finding a sequence of actions to reach a goal. In classical planning, the actions of the planning agent are ontic: they change the physical world in which the agent is located (for example, the actions of moving a robot in space). More recently, AI researchers have been interested in epistemic planning in which actions are informative: they change the beliefs of the agent. Cognitive planning in the ANR project PRCE CoPains enlarges classical and epistemic planning. It aims to change not only the environment (physical world) and beliefs of the target agent, but more globally its cognitive state, including its epistemic attitudes (i.e., its knowledge and beliefs), its motivations (i.e., its intentions) and its emotions.

Method

The logical model of cognitive planning in the CoPains project aimed to have a conversational agent capable of 1) motivating a user to practice a regular physical activity and 2) helping the user to find an activity compatible with their preferences and desires.



Cognitive planning: concept diagram



Example of virtual agent conversation

Main results

A model and an algorithm for cognitive planning were developed. The algorithm searches a sequence of speech acts in order aiming to change the user's cognitive state.

Discussion

The CoPains project is building an artificial agent capable of encouraging human users to adopt healthy behaviors and change their habits. To interact with the person effectively, the agent must be equipped with a sophisticated model of human cognition that allows it to be persuasive and plan a sequence of actions to influence the user's behavior. The agent must « understand » the user's cognitive attitudes and affective states to do this. Applications of persuasive technology are in the health domain (e.g., taking medication, engaging in regular physical activity, eating healthy foods) in which a conversational agent interacts with a person in a nmultimodal way to support his/her activity and to ensure his/her well-being.

For further information

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Green Time

Influence of contact with nature on emotions and perception of time

Scientific background

Understanding how time perception can be influenced by context is important, indeed, research has demonstrated that individuals feeling negative emotions overestimate time, whereas individuals feeling positive emotions underestimate it. Since being in a natural environment increases positive emotional states (Neill et al., 2018), contact with nature should result in an underestimation of time. This preliminary study will analyze the emotional states triggered by contact with nature and their impact on time perception.

Method

We studieed three experimental conditions: real plant vs fake plant vs control. Each participant had to complete six tasks of counting the number of objects presented and estimating the number of seconds each image had been shown. Participants in the real plant condition had to count an image with real trees, participants in the fake plant condition counted fake trees, and participants in the control condition counted statues. To control for cognitive overload, the the number of objects presented (18 vs 23 vs 31) and the time the image was presented (10.2 vs 14.2 seconds) varied. After the counting tasks, participants answered a questionnaire measuring their emotional state and their connectedness to nature.

Condition control: statue | False Nature Condition: Plastic Oak | True nature condition: real oak image

Type of image participants should count

Main results

Data collection is finished (N= 275), analyses are ongoing.

For further information

Lucia Bosone, Nadine Chaurand, Simon Lhuillier, Haouria Basiyd Fellahi - Contact : lucia.bosone@univ-eiffel.fr

LaPEA, Université Gustave Eiffel, Université Paris Cité

Cognition and language

Considering linguistic cognitive processes in automatic language processing systems to improve human-machine interaction (speech, language and language processing, learning, multimodality, gestures, multilingualism, assisted translation, affects, language and speaker identification, conversational agents).

Corinne Fredouille (LIA) and Núria Gala (LPL) - Scientific Coordinator

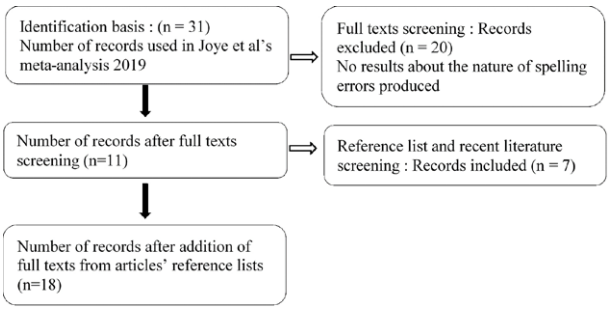
The nature of spelling errors in Developmental Language Disorder

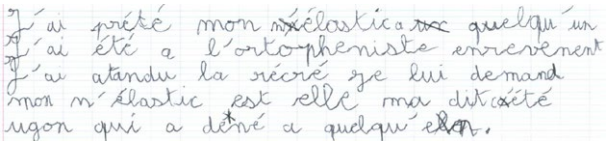
Scientific background

This work aims to identify and analyze the nature of spelling errors produced by children with Developmental Language Disorder (DLD) across different orthographies. Building on a previous meta-analysis (Joye et al., 2019), the review extends our understanding. Three questions are addressed: Do spelling difficulties in children with DLD stem from weak phonological, orthographic, or morphological representations? What are the patterns of spelling performance in DLD depending on orthographic depth? Do comorbid difficulties with DLD impact spelling?

Method

The scoping review followed the 5 phases outlined by Arksey and O'Malley (2005) and extended by Levac et al. (2010): (a) specifying the research question; (b) identifying relevant studies; (c) selecting studies; (d) charting the data; and (e) collating, summarizing, and reporting the results. Eighteen studies that provided a qualitative description of the nature of spelling errors produced by children and adolescents with DLD were identified. Spelling performance was examined in relation to control groups that were matched for age, language features (language, spelling or reading age) and co-occurring difficulties.





Written production from an 8 ½ year old child.

Main results

The qualitative analyses indicated that three factors should be considered when practitioners evaluate spelling performance in children or adolescents with DLD: phonological representations, morphological awareness, and reading skills.

Discussion

We present a set of recommendations that practitioners might consider when assessing and planning intervention for school-aged children and young people with DLD:
STEP 1: Capture information about the child's history with language difficulties. Are there difficulties with phonological representations? Are there difficulties with morphological awareness?
STEP 2: Qualitatively analyze the child's spelling errors (phonological and morphological spelling errors) to underpin targeted interventions.
STEP 3: Consider the presence of co-occurring problems, as dyslexia for instance.

For further information

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RUGBI

Scientific background

Speech production disorders can cause a serious loss of intelligibility, making it difficult for patients to communicate with those around them and limiting their professional and/or social life. These disorders may result from ENT cancers, neurological, sensory or structural pathologies. Classically, intelligibility is assessed with a global perceptual clinical evaluation - deemed unsatisfactory by its subjectivity, lack of precision and duration – that often leads to erroneous measures of patient intelligibility. The speech production tasks (repetition of words, sentences, reading) of these evaluations are not useful for precise measures of intelligibility and instead allow only an overall evaluation of the speech functional impairment.

Method

The objective of the RUGBI project is to make improvements to the measurement of speech intelligibility deficits. RUGBI is developing an objective evaluation tool based on i) the identification of relevant linguistic units from an acoustic and prosodic point of view, and ii) the identification of sensitive linguistic tasks. Datasets containing speech production of healthy subjects (190) and patients (365) with structural (VADS cancers) and neurological (Parkinson's disease) pathologies in the execution of different linguistic tasks, and for some, at different stages of the disease. These data are a considerable asset for understanding i) perception of speech intelligibility and ii) automatic speech processing modeling, and Deep Learning and its data representation properties that will have to be exploited here.

Main results

Several PhD theses have come from this work, including:

- « Measurement of communication impairment by automatic analyses of spontaneous speech after treatment of oral or oropharyngeal cancer »,
- « Modeling the severity index of speech impairment using deep learning methods: from modeling from a few examples to self-supervised learning via entropic measurement »,
- « Deep Recording of a session in the soundproof booth of the IUCT Learning Approaches to Assess Head and Neck Cancer Speech Intelligibility »,
- « Contribution of deep learning in the search for relevant linguistic units in the acoustic signal to improve the measurement of speech intelligibility impaired by pathological production disorders »,
- « Towards an objective measurement of altered speech after ENT cancer treatment: perceptual and acoustic analysis ».

Recording of a session in the soundproof booth of the IUCT

Discussion

RUGBI's aim is to supplement the therapist's tools with a precise, robust and rapid measurement for developing optimized therapy and tangible improvements of intelligibility. The project brings together members from the medical field, language sciences and speech and language engineering to meet the challenges of biology and health.

For further information

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https://www.irit.fr/rugbi

ALAIA

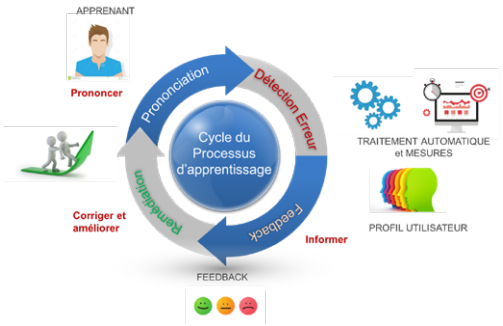
Institut de Recherche en Informatique de Toulouse

Scientific background

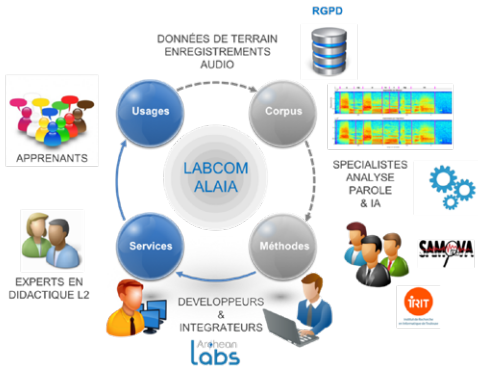
Developing and deploying innovative software for foreign language learning requires a strongly interdisciplinary approach combining didactics, linguistics, computer science and learner interaction techniques. Oral expression and comprehension are at the heart of the work. The objective is to offer services dedicated to learners and language teachers to evaluate the quality of pronunciation and the comprehensibility of learners' productions on the one hand, and to co-construct correction exercises with teachers that are adapted to the profile of each learner on the other. The ALAIA joint laboratory (2019-2023) is based on a partnership between IRIT and the company Archean Technologies.

Method

The acquisition of oral skills (comprehension and expression), from pronunciation of simple words to more complex utterances in oral interactions with native speakers, requires exploiting systemic differences between the learner's native language (L1) and the target foreign language (L2). Knowledge of the L1/L2 language pair allows focus on the frequent and recurring errors in the transition from one language to the other (difficulty in pronouncing a particular sound, for example). It also allows targeting the most relevant content and exercises for the learner (L1, L2, profile and level of the learner). We are now exploring artificial intelligence and machine learning methods to process non-native speech and to develop features for detecting, localizing and characterizing pronunciation errors. The definition of automatic (i.e. objective) measures dedicated to the evaluation of pronunciation in linguistic contexts of increasing complexity (words, sentences, spontaneous speech) is also at the center of our work.



Iterative learning process



Articulation between partners and users

Main results

The first language pair studied (Japanese-L1/French-L2) reinforces an existing collaboration with Waseda University in Japan. The algorithms developed and tested will be integrated into the software platform developed and deployed by Archean Technologies.

Discussion

The methodology developed for Japanese L1/French L2 can be applied to other language pairs. The initial priority of tools for learning French, could be extended to French-speaking varieties. The definition of an architecture adapted to the types of services will make it possible to carry out these technological transfers.

For further information

Co-responsables : Isabelle Ferrané (IRIT) Lionel Fontan (Archean Labs)

https://www.irit.fr/SAMOVA/site/projects/current/labcom-alaia/

Why do children refuse to eat new foods, especially fruits and vegetables?

Scientific background

Health authorities recommend that children eat at least 5 portions of fruits and vegetables. In many Western countries this is often far from true. An obstacle to dietary diversification, especially of fruits and vegetables in young children, can be neophobia, i.e. the refusal to eat new foods. A cause of neophobia could be cognitive difficulties, notably related to the correct categorization of foods by the most neophobic children.

Method

The task was to categorize foods (e.g., strawberries) and non-foods (e.g., marbles) into the correct boxes (see Figure 1). Children were asked to help a character eat without making a classification error (« what is edible »).

Figure 1

Main results

There was a negative correlation between classification performance and neophobia scores (the most neophobic children classify less well).

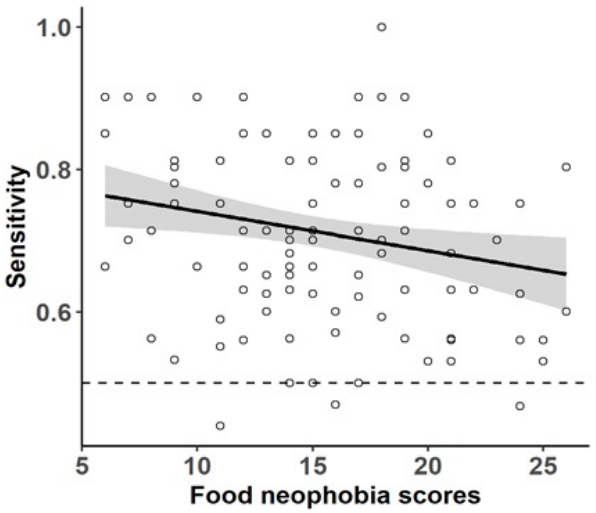


Figure 2: Negative correlation between the neophobia score and the accuracy of correct answers and false alarms classification.

Discussion

The correlation between the task and neophobia supports that the cognitive underpinnings of neophobia are associated with lower food discrimination. Other results also show that neophobes reason less well about foods and their properties. This suggests an approach in which neophobic children could receive more systematic food education with the objective of increasing food familiarity to reduce food rejection.

For further information

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Foinant, D., Lafraire, F., & Thibaut, J. P. (2021). *Fatal errors in the food domain: children's categorization performance and strategy depend on both food processing and neophobic dispositions.* In Proceedings of the Annual Meeting of the Cognitive Science Society (Vol. 43, No. 43).

Lafraire, J., Rioux, C., Giboreau, A., & Picard, D. (2016). *Food rejections in children: Cognitive and social/environmental factors involved in food neophobia and picky/fussy eating behavior.* Appetite, 96, 347-357.

PROPICTO

PRojection of Oral Language into PICTOgraphic Units

Scientific background

The aim is to develop applications of alternative and augmented communication based on the translation of speech into pictograms. Such communication would be useful for people with disabilities and for the medical field (emergencies). People with disabilities often cannot communicate in the traditional way by voice, or even sometimes with gestures. The Grenoble Computer Science Laboratory in association with the Geneva Translation Laboratory and with funding from the French National Research Agency is working on this through the Propicto project.

Method

The heart of the project is assistance for oral communication. The contribution to new tools for automatic speech recognition, syntactic analysis of speech, automatic simplification of spontaneous speech, database linking pictograms and wordnet meaning.

Main results

We are specifically interested in the generation of pictograms from spoken natural language. Our objective is solutions that allow projecting natural language into a set of pictograms, automatically and from the voice.

Discussion

Their cognitive capacities differ, but for the disabled the implementation of a communication system, even a rudimentary one, is almost always possible; communication via pictograms is thus increasingly used in institutions and seems to be starting to move towards standardization. A strong will is to propose approaches developed in partnership with institutes and families.

For further information

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Solène Evain, Benjamin Lecouteux, François Portet, Isabelle Estève, Marion Fabre. *Towards Automatic Captioning of University Lectures for French Students who are Deaf*. ACM SIGACCESS Conference on Computers and Accessibility, 2020, Athènes, Greece.

Lucie Chasseur, Marion Dohen, Benjamin Lecouteux, Sébastien Riou, Amélie Rochet-Capellan, et al.. *Evaluation of the acceptability and usability of augmentative and alternative communication (AAC) tools: the example of pictogram grid communication systems with voice output.* ACM SIGACCESS 2020 - Conference on Computers and Accessibility, Oct 2020, Athènes, Greece. pp.Article 68.

LeBenchmark

Scientific background

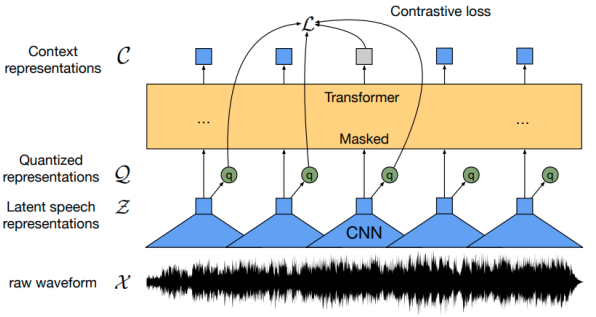
Self-supervised learning allows learning information representations from unannotated data. By exploiting very efficient deep neural models such as Transformers [1], this technique has made it possible to learn representations from huge quantities of text [2], images [3], or audio [4,5]. These models have been learned for English or in a multilingual context [6] but their evaluation is not homogeneous and coherent. LeBenchmark fills this gap: it provides self-supervised models for French and proposes a simple and rigorous model evaluation framework based on classical speech processing tasks.

Method

We collected French audio datasets from several genres: reading, spontaneous, radio programs, etc. These were organized in three corpora of increasing size: 1000 hours of signal (1K), 3000 hours (3K) and 7000 hours (7K). With these data, we learned models with the wav2vec2 architecture [4] in two variants: basic and large, differentiated by their size and number of layers in the neural model. This resulted in 6 models, 2 per corpus, to which was added a seventh model trained on 2.6K hours of audio, obtained from the 2 largest datasets of the 3K corpus. All models were trained with the CNRS Jean Zay supercomputer (https://www.cnrs.fr/fr/jean- zay-le-supercalculateur-le-plus-puissant-de-france- pour-la-recherche) and were made available to the community (https://huggingface.co/LeBenchmark). All models have been evaluated with 4 classical signal processing tasks: automatic speech recognition, automatic emotion recognition, automatic speech understanding and automatic speech translation.

Main results

All models led to remarkable improvements in the tasks compared to using classical audio features, such as MFCCs.



Discussion

The project resulted in two very high-profile publications [7,8] and made available to the community the first self-supervised models for spoken French, as well as all the systems for the downstream tasks and the data to learn the models. However, some questions were raised about the efficiency of the procedure to learn SSL models, as the community seems to rely mostly and blindly on the amount of data used and their size in number of parameters. A continuation of our project thus aims at improving the architecture of the models so that they learn the targeted data representations more efficiently.

For further information

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[1] *Attention is all you need*. Ashish Vaswani and Noam Shazeer and al. Neural Information Processing Systems, 2017. [2] *ERT: Pre-training of Deep Bidirectional Transformers for Language Understanding*. Jacob Devlin and Ming-Wei Chang and al. North American chapter of the Association for Computational Linguistics, 2019. [3] *Learning Image Embeddings using Convolutional Neural Networks for Improved Multi-Modal Semantics*. Douwe Kiela and Léon Bottou and al. Association for Computational Linguistics, 2014. [4] *Wav2Vec 2.0: A Framework for Self-Supervised Learning of Speech Representations*. Alexei Baevski and Henry Zhou and al. Neural Information Processing Systems, 2020. [5] *HuBERT: Self-Supervised Speech Representation Learning by Masked Prediction of Hidden Units*. Wei-Ning Hsu and Benjamin Bolte and al. Arxiv preprint, 2021. [6] *XLS-R: Self-supervised Cross-lingual Speech Representation Learning at Scale*. Arun Babu and Changhan Wang and al. Arxiv preprint, 2021. [7] *LeBenchmark: A Reproducible Framework for Assessing Self-Supervised Representation Learning from Speech* Solène Evain and Ha Nguyen and al. Interspeech, 2021 [8] *Task-Agnostic and Task Specific Self-Supervised Learning from Speech with LeBenchmark*. Solène Evain and Ha Nguyen and al. Neural Information Processing Systems, 2021.

HIBOU

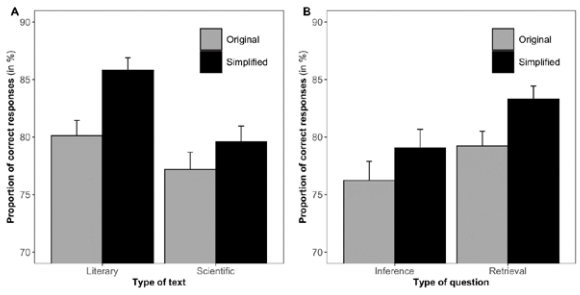
An interactive book with graduated and simplified texts with the company ISI

Scientific background

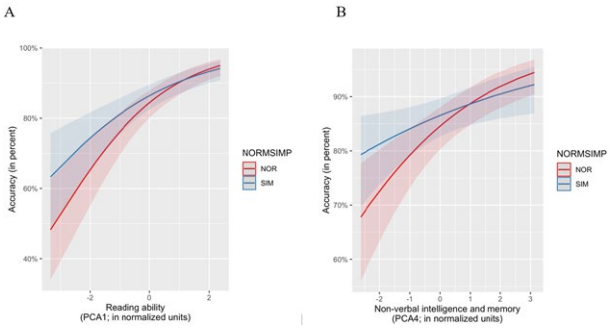
Reading comprehension is essential for successful learning and throughout life. The challenge is to get pupils, especially weak readers, to read more, to read more efficiently, and even to read with pleasure. The LPC and the Laboratoire Parole et Langage (LPL) are researching the simplification of texts. The hypothesis is that a simplified text offers easier reading for children with difficulties, i.e. more fluid reading and improved comprehension. Thus, 69 texts were simplified to make them more comprehensible by reducing their lexical, syntactic and discourse complexity, while retaining the main information and original meaning.

Method

The study on the benefits of reading was conducted in two phases: (a) an individual testing phase, to obtain a variety of linguistic, cognitive and psycholinguistic measures for each participant and (b) a classroom phase, in which the children read the texts from the ALECTOR corpus silently and independently. Each student read 20 texts in total, 10 were literary (5 original and 5 simplified) and 10 were scientific documentaries (5 original and 5 simplified). ISI imported all 69 literary and scientific texts into a standard EPUB format using its platform for creating EPUBs and their enrichments as well as its ISIaccess platform for classroom reading of HIBOU, an RGPD-compliant and GAR-certified platform already used in secondary schools.



Results from the comprehension test. A. Proportion of correct responses (in percent) for simplified and original literacy and scientific texts. B. Proportion of correct responses for the simplified and original texts as a function of the type of question (retrieval-type versus inference-type). Error bars are standard errors.



Text comprehension accuracy (percent correct, y-axis) as a function of reading ability (A) and nonverbal intelligence (B). Solid and dashed curves are the estimated accuracies at different levels of the component variable (in standardized units, x-axis). Semi-transparent areas are confidence intervals.

Main results

The results showed that fluency and reading comprehension were significantly better for simplified texts than for normal texts. Poor readers and children with lower cognitive abilities benefited most from simplification. All texts are available: https://lib.isiaccess.com/HIBOU/library

Discussion

Text simplification significantly improves both comprehension and reading speed in beginning readers. Children with poor reading skills found the greatest benefit in reading fluency from simplification and, to a lesser extent, in comprehension (marginally significant effect). This confirms our prediction that text simplification should be particularly beneficial for poor readers. The results suggest that children with lower non-verbal intelligence and/or memory skills benefit to a greater extent from simplification.

For further information

Contact : Ludivine Javourey, Nuria Gala, Sétphane Dufau, Johannes Ziegler

Javourey-Drevet, L., Dufau, S., François, T., Gala, N., Ginestié, J., & Ziegler, J. (2022). *Simplification of literary and scientific texts to improve reading fluency and comprehension in beginning readers of French.* Applied Psycholinguistics, 43(2), 485-512. doi:10.1017/S014271642100062X

LUM

Missing links and functional unification between language and memory

Laboratoire de Psychologie et NeuroCognition

Scientific background

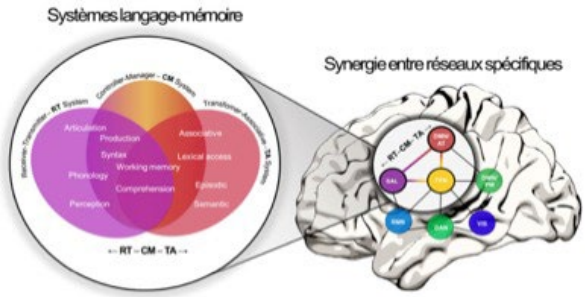
Neurocognition is shifting toward an integrative and dynamic view of cognitive domains traditionally considered distinct. Language and memory, although distinct functions supported by specific neural systems, also share common cognitive structures and processes. Here we propose an integrative LUM (language/union/memory) model situated within this new perspective.

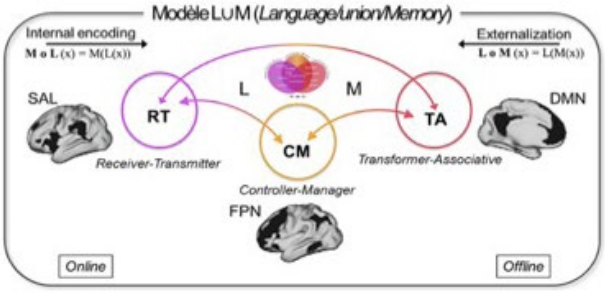
Method

Functional brain maps derived from meta-analyses associated with language and declarative memory were analyzed to reveal the language-memory continuum's factorial composition. A functional connectivity approach was used to identify the interactive architecture based on three systems underpinned by specific brain networks.

Main results

LUM integrates three modules, Embodiment (EMB), Formulation (FORM), and Internalization (INT), that communicate with each other. EMB refers to the sensory-motor dimension of language as an embodied process. FORM refers to the control processes that underlie the organization, elaboration, and active maintenance of language representations in memory. And INT includes the operations that enable the integration of multimodal, highly dimensional mental representations. In a simplified way, EMB would be a « Receiver-Transmitter », FORM a « Controller-Manager », and INT a « Transformer-Associative ».





Functional brain maps derived from meta-analyses associated with language and declarative memory were analyzed to reveal the language-memory continuum's factorial composition. Three fundamental systems were identified: 1. Receiver-Transmitter (RT) - 2. Controller-Manager (CM) - 3. Transformer-Associative (TA)»; and labeled according to their composition (refer to the article for a detailed description). The proposed triptych is supported by observations from functional connectivity, attesting to its neurobiological relevance. Dynamic and continuous interactions between brain networks specific to each system (ventral attentional network, SAL; frontoparietal network, FPN, and default mode network, DMN) ensure the unity between language and memory.

Discussion

LUM improves our understanding of brain-behavior relationships for language and memory interaction. By confronting this model with patient data, we demonstrate the value of this new theoretical framework for capturing, anticipating and interpreting interindividual differences. The consideration of a broader perspective, based on the latest brain connectivity approaches, is an essential step for developing integrative neurobiological models that better approximate cognition in natural settings and the neuropsychological symptoms presented by patients. This new taxonomy allows us to move beyond the modular view of cognitive functioning.

For further information

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Roger E, Banjac S, Thiebaut de Schotten M, Baciu M. *Missing links: The functional unification of language and memory (LUM)*. Neurosci Biobehav Rev. 2022 Feb; 133:104489. doi: 10.1016/j.neubiorev.2021.12.012. Epub 2021 Dec 17. PMID: 34929226.

Open-source child-centered daylong recordings

LSCP Laboratoire de Sciences Cognitives et Psycholinguistique

Scientific background

Spontaneous conversations in real-world settings are amongst the most challenging audio files to process. Now, child-worn recorders are a central tool for studying how children learn language, but little effort has been made in robust and bias-free speech processing models to analyze such data. Researchers mostly rely on the Language ENvironment Analysis (LENA) software [1] to extract meaningful information. However, LENA has several limitations: closed source software and models trained only in American English make it difficult to generalize to other languages. Our work aims to propose a viable open-source alternative to LENA for classifying audio frames into segments of child vocalizations, adult male and female speech, and silence.

Method

The voice type classification problem is the task of identifying voice sources in an audio stream (more technical details in the paper). Our case considers 5 classes or sources: 1) KCHI, for key-child vocalizations, i.e., vocalizations produced by the child wearing the recording device; 2) OCH, for all the vocalizations produced by other children in the environment; 3) FEM, for adult female speech; 4) MAL, for adult male speech; and 5) SPEECH, for when there is speech. To train our model, we gathered multiple child-centered corpora data [3 as an example] drawn from various child-centered sources. Importantly, the recordings cover a wide range of environments, conditions and languages and were collected and annotated by numerous field researchers. To ensure that our models generalize well to unseen data, and to compare to the LENA system, we kept the ACLEW-Random as a hold-out data set. For each class, we use the F-measure between precision and recall (the higher the F-measure, the better).

Train/Dev.	System	KCHI	OCH	MAL	FEM	SPEECH	Ave.
english (USA)	LENA	54.9	28.5	37.2	42.6	70.2	46.7
without Paido	binary	67.6	23.0	31.6	62.6	77.6	52.5
with Paido	multi	66.4	19.9	39.9	63.0	77.6	53.3
without Paido	multi	**68.7**	**33.2**	**42.9**	**63.4**	**78.4**	**57.3**

Results Table: Performance on the hold-out data set in terms of F measure between precision and recall. « Ave ». column represents the F-measure averaged across the 5 classes. The holdout data set was never seen during the training, not by LENA, nor by our model.

Main results

Results indicate that the proposed model works better than the LENA software. Furthermore, we show that a single model trained to predict the 5 classes together performs better than 5 models trained separately on each class.

Discussion

Our model outperformed LENA by a large margin and will, we hope, lead to more accurate observations of early linguistic environments. Our work is part of an effort to strengthen collaborations between the speech processing and the child language acquisition communities. Our code, including easy-to-use scripts to classify your own recordings, can be found on our GitHub repository: https://github.com/MarvinLvn/voice-type-classifier

For further information

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[2]. D. Xu, U. Yapanel, S. Gray, et C. T. Baer, *The lena language environment analysis system : the interpreted time segments (its) file*, 2008

[3]. H. Bredin, R. Yin, J. M. Coria, G. Gelly, P. Korshunov, M. Lavechin, D. Fustes, H. Titeux, W. Bouaziz, and M.-P. Gill, *Pyannote.audio: neural building blocks for speaker diarization*, in International Conference on Acoustics, Speech, and Signal Processing (ICASSP), 2020

Predicting clinical scores in Huntington's Disease: a lightweight speech test

LSCP Laboratoire de Sciences Cognitives et Psycholinguistique

Scientific background

Huntington's disease (HD) is a rare inherited neurodegenerative disease which is characterized by motor, psychiatric, and cognitive disorders. Despite the development of innovative and promising clinical therapies, a major challenge is the identification of markers sensitive to disease progression. Thanks to increasing computing power, machine learning models can provide an effective way to improve screenings and evaluations of the disease by capturing its the different clinical dimensions. In this context, speech and language offer an appealing alternative unlocking potential remote evaluation and offering a relevant multi-domain approach. In this study, we test the capacity of speech to predict the main clinical variables of the UHDRS score in Huntington's patients.

Method

Participants were French native speakers (N=103) with at least 36 CAG repeats on the mutant Htt gene of HD. They performed a quick speech test of counting forward and backward. This yielded 126 samples (35 were discarded because of too much acoustic noise). We extracted several speech deficits reported in HD: articulatory and phonatory deficiencies, rhythm and temporal disturbances, filled pauses and vocalization additions, sequence (the order of numbers), and perseveration errors. In total, we examined 60 features that can be adapted to other languages (Figure 1). We trained machine-learning systems, with auto-sklearn to predict clinical variables from speech features, such as the cUHDRS (main clinical endpoint in HD) and the Total Motor Score (TMS). To validate the models, we used both the Mean Absolute Error (MAE) and the Intraclass Correlation Coefficient (ICC) between predicted and observed scores (provided by clinicians).

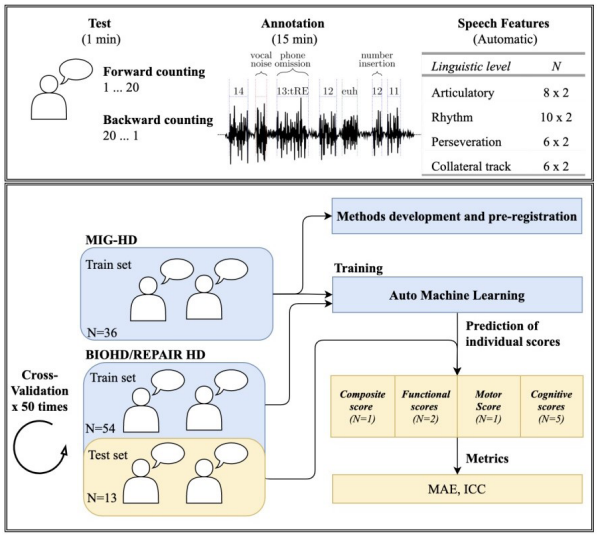

Figure 1: Illustration of the experimental protocol and speech analysis

Main results

Using speech features from counting protocols, we showed that measures of speech production accurately predict clinical measures in HD, within the 12% to 20% range for the functional, motor, and cognitive, and composite cUHDRS. We also found significant correlations between striatal volumes (neuroanatomic hallmark in HD) and speech features.

Discussion

The forward and backward counting tasks accurately predict clinical features of HD patients. These tests last less than 40s and do not require the involvement of any expert. This audio data can be collected over the phone, allowing not only remote but also out-of-sync assessments between health professionals and patients.

For further information

Riad, R., Lunven, M., Titeux, H., Cao, X-N., Hamet Bagnou, J., Lemoine, L., Montillot, J., Sliwinski, A., Youssov, K., Cleret de Langavant, L., Dupoux, E. & Bachoud-Lévi, A.C. (2022). *Prédire les scores cliniques dans la maladie de Huntington : un test de parole léger.* Journal of Neurology.

Speaking with a Virtual Agent to Assess Social Cognition in Traumatic Brain Injury

UMR 7309 • CNRS • AMU
PAROLE ET LANGAGE

Scientific background

A head injury may affect social cognition, leading to difficulties for individuals with traumatic brain injury in interacting with others. These difficulties are currently assessed by traditional tasks involving conscious and deliberate reasoning about characters' mental states (e.g., intention, belief, knowledge) that do not reflect the way social cognition is used in everyday interactions. This project aims to study social cognition with a task that actively engages patients in a real interaction with a partner.

Method

A novel task called EVICog was designed and tested in individuals with a traumatic brain injury. During this task, participants were engaged in real audio-visual conversations with two virtual agents who expressed emotions and produced speech that required participants to make inferences about their mental states. The results of the EVICog task were compared to two classically used tasks: photographs to test participants' recognition of emotions or short comic strips to test their attribution of intentions.

Main results

ROC (Receiver Operating Characteristic) curves analysis showed that the EVICog task has a much higher discriminating power than the two classical tasks.

Interface for the participant in the EVICog task during a conversation with the virtual agent Marie. © Maud Champagne-Lavau / Emmanuelle Taché / Noémie Moreau

Discussion

Social cognition is impaired in individuals with traumatic brain injury when they are actively engaged in real interactions with a partner. The use of tools providing a complete overview of participants' social abilities and reflecting the way social cognition is involved in daily life can be more useful than current test.

For further information

Moreau, N., Taché, E., & Champagne-Lavau, M. (2022). *Speaking with virtual humans: Assessing social cognition in traumatic brain injury with a second-person perspective task.* Journal of neuropsychology, 16(1), 75-96.

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Research partnerships

The Cognition Institute's 2021 directory of scientific research would be incomplete without reference to the intense contractual research activity. We have chosen to illustrate the 130 research contracts by presenting a subgroup that does not claim to be representative or emblematic.

These are just a few examples to illustrate the mobilization of the 665 permanent FTEs and 1267 non-permanent FTEs from the Institute alongside partners from the social and economic world, thus contributing to their competitive innovation.

Memory and emotional determinants of human-human and human-system dialogue

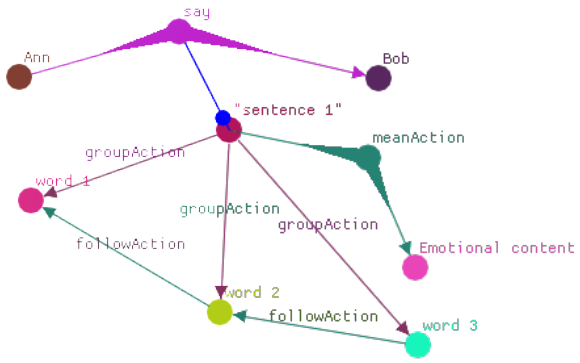
SCIENTIFIC AXIS: Cognition & language
MARKET SEGMENT: AI, Naturel language, Human-system interaction

Industrial context

Spir Ops is a company dedicated to research and development in artificial intelligence. Its work is based on the idea that a system should reason, decide and interact like a human. Therefore, Spir Ops is resolutely oriented towards modeling human intelligence in its natural functioning, whether it is conscious and controlled by cognition or unconscious and automatic. One of its areas of activity is dedicated to the development of AI related to language in interaction situations, memory and emotions.

Objectives

Language interaction between two partners is a common but complex activity. It is notably dependent on cognitive and emotional processes specific to each partner but also inherent to the shared situation. During a dialogue, each interlocutor makes efforts to adapt as efficiently as possible to the other, thus contributing to the success of a given task. The objective of the CIFRE thesis is to understand to what extent memory and emotional processes are involved in the construction of mutually shared knowledge during a dialogue, whether the partners are human or not.



Modelling of a speech turn in the representation of the word

Results obtained/expected

The methodology is based on collaborative tasks of arrangement of emotional stimuli, performed between humans or between a human and an artificial (simulated) system. Analysis of results showed that several factors influence memorizing a piece of information, such as the person who produced it (self or other), the emotional character of this information (negative or neutral) and/or the emotional state of the interlocutors. These results make it possible to construct a careful modelling of the processes (especially memory) at work during a dialogue. Each element of a speech turn (speaker, interlocutor, lexicon, meaning of the sentence, etc.) can be modelled and then preserved or merged with others (forgotten), according to the associated emotional characteristics. These models could be integrated into a semantic aggregation engine aiming for symbolic learning of a world representation.

Scientific and technical managers

Laboratory: Centre de Recherches sur la Cognition et l'Apprentissage (univ. Poitiers)

Doctoral student: Cléo Bangoura (CIFRE)

Scientific Director: Ludovic Le Bigot et Sandrine Gil (Professeurs univ. Poitiers)

Company: Spir Ops (Paris)

Scientific Manager: Edouard Emberger (Language and Dialogue team)

Psychology of domestic waste management behaviors

Interventions in the Grand Poitiers area

SCIENTIFIC AXIS: Social cognition
MARKET SEGMENT: Behavioral change, Informed decision-making, Impact assessment

Industrial context

Grand Poitiers is an urban community grouping 40 municipalities, whose Déchets Economie Circulaire department manages, among other things, waste collection and the waste prevention and reduction program. To meet European and national recommendations encouraging the reduction of waste production and bio-waste separation, this department is remodeling its user services.

Objectives

The department has the technical and economic knowledge but remodeling its services also implies understanding what determines the (non)desired behaviors of users and determining the best conditions for the appropriation of new practices. We provide expertise here by carrying out quantitative studies to identify the barriers and drivers of desired behaviors; proposing behavioral actions that are scientifically based and adapted to the target population; and evaluating the impact of these actions.

Results obtained/expected

These studies have so far described the attitudes and preferences of inhabitants (e.g., they are convinced of the need to reduce waste and are ready to use a compost bin); to identify the most relevant mechanisms to encourage behavioral change (e.g., reinforcing the feeling of being capable and morally obligated to compost). We have therefore increased the distribution of compost bins in households to maximize acceptance of their use and the appropriation of new sorting instructions (communication supports, additional equipment). Evaluation of the impact of this action on sorting behaviors is ongoing.

Scientific and technical managers

PhD student: Emilie Guichard

Laboratory: Centre de Recherches sur la cognition et l'Apprentissage (UMR 7295, CNRS, Université de Poitiers, Université de Tours)

Scientific supervisors: Frédérique Autin (MCF université de Poitiers) & Cédric Bouquet (PU université de Poitiers)

Company: Grand Poitiers Communauté Urbaine

Scientific supervisors: Céline Besnard (head of the Déchets Economie Circulaire department)

Driving in serenity: designing an efficient virtual assistant

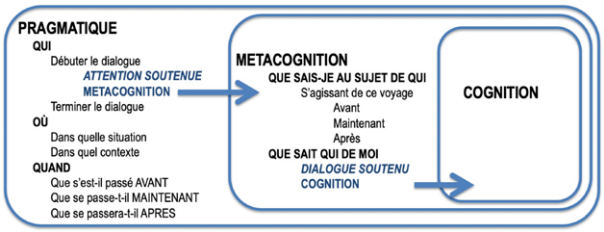
AXES SCIENTIFIQUES : Cognitive augmentation Technologies, Behavioral and Cognitive assessments
MARKET SEGMENT: Driving automated vehicle

Industrial context

Smart Things means daily life is connected to objects dedicated to making life simpler by being adapted to their users. These are based on Cognitive Technologies which include knowledge about people and their human cognition in order to process data provided when users are interacting with Smart Things. In the context of automobile driving, this project aims to extend physical ergonomics by designing a cognitively ergonomic assistant. This digital twin of the human would have sufficiently complete knowledge of tasks, objects and procedures that it could take the physical and cognitive place of the person and model-simulate them to interact in an appropriate and empathetic way.

Objectives

With this work we aim to: (i) define an interaction with the occupants which is empathetic and pleasant, capable of making the driver calm, committed and motivated: (ii) define the concept of digital assistant, the logic of interaction, of dialogue and, for this, (iii) build a thesaurus of driving tasks and a grammar of driving actions, which together serve as an ontology to generate dialogue by considering pragmatic, metacognitive, semantic and cognitive dimensions.



Results obtained/expected

The virtual assistant will be trained through a grammar of driving tasks. With user evaluations, we will improve usefulness, accessibility, acceptability and use. Thus state-of-the-art technology will allow us to operationalize the concept of serenity in car driving and conceptualize the empathetic vehicle.

Scientific and technical managers

Laboratory: François JOUEN et Charles TIJUS, CHArt
Company: Fabienne MASSON, VALEO

Dealing with fake news and information vagueness

A hybrid approach between symbolic AI and deep learning

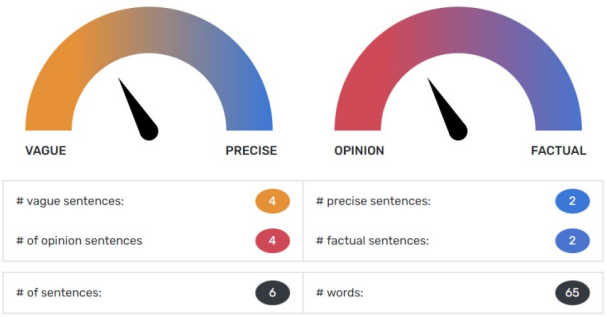
SCIENTIFIC AXIS: Cognition & language
MARKET SEGMENT: Information Communication and Defense sector

Industrial context

DIEKB (2019-2022) is a RAPID project whose goal is to mix fundamental and industrial research to help detect fake news or misinformation in textual documents. The project involves many specialists including the CoLoR team at Institut Jean Nicod (IJN), MONDECA, and Airbus Defense and Space who are emphasizing symbolic IA methods for text analysis. HYBRINFOX (2022-2025) is an ANR Astrid AI project that is the continuation of DIEKB. It involves the same partners as well as LinkMedia from IRISA who are specialized in Deep Learning methods for Natural Language Processing.

Objectives

For DIEKB, the goal was to develop a framework for the analysis of informational quality in texts, with emphasis on measuring vagueness and subjectivity in discourse. The main objective was for the IJN to create and develop the architecture and typology of VAGO, an online tool used to provide that measure. For Hybrinfox, the goal is to develop hybrid methods of NLP relying both on deep learning and on expert systems like VAGO, to obtain generic and explainable methods of classification of texts as reliable vs unreliable.



This figure shows an example of the VAGO outputs on a fake news article relayed on the social media concerning Coronavirus. The barometers show the prevalence of subjective vague lexical items with a measure of their relative weight in the discourse, with the detected items here in bold.

Results obtained/expected

In 2021, IJN and MONDECA released the first version of VAGO, an annotated lexical database used to measure vagueness and subjectivity in discourse. VAGO rests on a four-fold typology of vague expressions, distinguishing generality, approximation, one-dimensional and multi-dimensional vagueness. Currently, the database consists of adjectives and of a limited lexicon for English and French (about 1500 words in each language). VAGO can help the classification of opinion-like vs fact-like statements (https://research.mondeca.com/demo/vago/). The results of VAGO were compared with those of a neural network classifier developed by AIRBUS, based on deep learning. Those results showed a positive correlation on a large set of corpora consisting of textual documents, indicating that texts classified as biased were those containing a higher proportion of subjective vocabulary. In HYBRINFOX, the goal is to develop hybrid methods to improve that result, in particular methods of early information fusion to orient attention mechanisms in neural networks with the annotated lexicon of VAGO, and conversely to enriching the typology of VAGO with the outputs of neural networks.

Scientific and technical managers

Égré Paul (DR CNRS), Institut Jean-Nicod, PSL Université, Paris - Atemezing Ghislain, Mondeca, Paris - Gatepaille Sylvain, Airbus Defense and Space, Élancourt - Claveau Vincent (CR CNRS), IRISA, Rennes.

CogIdo, EVOLEX, RAPortho

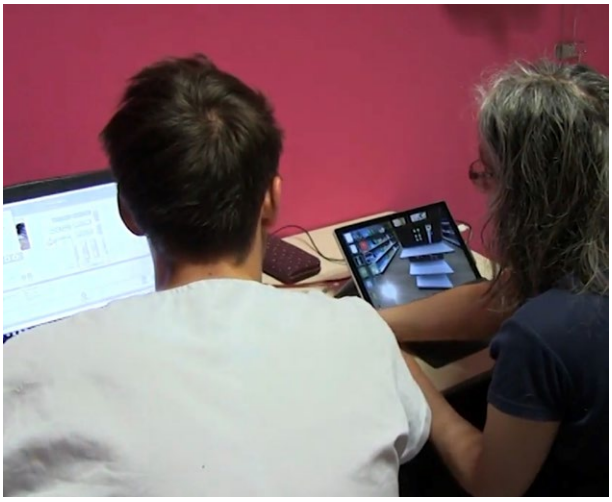
SCIENTIFIC AXIS: Cognitive enhancement technologies, Cognitive behavioral assessments, Cognition & language
MARKET SEGMENT: Start-up MedTech

Industrial context

COVIRTUA Healthcare, a medtech start-up revolutionizing the treatment of cognitive disorders, was awarded the French Tech Seed label by the Occitanie Tech Seed consortium led by SATT AxLR. As such, it will benefit from this real boost to recruit new R&D staff, especially engineers and researchers in neuroscience.

Objectives

Founded in 2017, COVIRTUA Healthcare is a European MedTech that has developed a remotely controllable virtual reality immersion technology. This allows a therapist to work with a patient remotely (telecare) by immersing him or her in realistic and adaptable situations in real time. To accompany patients throughout their treatment, COVIRTUA Healthcare is also developing a function for patients to perform cognitive activities between their therapy sessions. COVIRTUA is collaborating with the research teams Étude de L'Interaction Personne SystèmE (ELIPSE) and Structuration, Analyse et Modélisation de documents Vidéo et Audio (SAMOVA) of IRIT to enrich the COVIRTUA Cognition software by: addition of new methods to assess cognition, increasing the people who can be aided by the software, and automation of the assessments.



Overview of the virtual reality software COVIRTUA Cognition: simulation of daily life situations in 3D to evaluate cognitive difficulties after stroke

Results obtained/expected

- EVOLEX: a server technology for doctor/patient management platforms. This project aims at developing lexical evocation, image naming and semantic verbal generation runs. These will give speech therapists more efficient tools to perform assessments, in particular when normalizations have been established by researchers. This will enrich the COVIRTUA Cognition software.
- CogIdo: expertise in the field of HMI and user-centered design. This collaborative project will allow adaptation of the cognitive training software COVIRTUA Cognition, to the elderly population and develop the mode of use between sessions.
- RAPortho: Automatic speech recognition to improve a system for people with speech disorders. Automatic speech transcription services adapted to different patients are developed by the SAMOVA team of IRIT.

Scientific and technical managers

Laboratory: IRIT (Nadine Vigouroux, Julien Pinquier, Jérôme Farinas)

Company: CoVirtua HealthCare (Christelle et Nicolas Monnier)

Improving reading through morphemes with the interactive book Basaffix

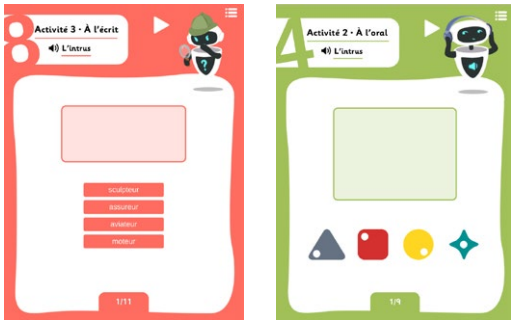
SCIENTIFIC AXIS: Cognition & language
MARKET SEGMENT: Education

Industrial context

Skilled reading is one of the main factors of social and professional integration. Yet, some of the French population cannot read and understand at the expected level, including those with dyslexia (Information note from the DPP N°21.27, June 2021). Dyslexia affects about 6% of the French population (INSERM report, 2007). Speech therapy does not always give the expected results and research reports persistent reading deficits for most adults with dyslexia.
The Basaffix book was designed to meet the needs of young people with reading difficulties (dyslexia, allophones, «poor comprehenders»). It was designed as a series of remedial exercises to be performed independently by school children in cycle 3 (9-12 years), cycle 4, or young students with French language difficulties. Session follow-ups can be coordinated by a schoolteacher, a French language teacher, a ULIS (for children with educational needs) teacher in secondary school, or by a dyslexia professional (private or in hospital speech therapist, neuropsychologist). The Basaffix interactive book allows semantic information to be processed efficiently to better understand what is being read. Basaffix is an interactive digital book, in epub3 format, which offers 15 remediation sessions on radicals and most frequent French language prefixes and suffixes. Each session includes several activities (morphemes identification, segmentation in words), with the first series taking place exclusively in oral form. This book can be used with a smartphone, a tablet or a computer.

Objectives

The Basaffix interactive book builds on our research which shows that morphological knowledge is well developed in individuals with dyslexia, in contrast to phonological knowledge, and that the former is actively used in the reading of compensated university students with dyslexia. The aim of the Basaffix interactive book to be marketed bdentifying morphemes in words to be read (e.g. chat+on meaning little cat) to make individuals with dyslexia reading easier. Two windows from this book are provided below.



Some examples of activities from the interactive book Basaffix

Results obtained/expected

The LPC and MOBIDYS aim to scientifically validate the use of this interactive book. An experimental protocol has been developed and is currently being administered to 150 secondary school students in the 5th and 6th grades. The results are expected by the end of June 2022. The marketing of Basaffix is planned for September 2023.

Scientific and technical managers

Laboratory: Pr Pascale Colé, Laboratoire de Psychologie Cognitive (UMR 7290 of the CNRS) et Aix-Marseille Université

Company: Mobidys (Nantes) - Scientific leaders: Marion Berthaut (Director), Jérôme Terrien (Digital editing) Sophie Hamon (Innovation Manager).

Bio-Inspired Artificial Intelligence for robust and efficienct real-world applications

SCIENTIFIC AXIS: Modelization, Cognitive enhancement technologies
MARKET SEGMENT: Learning

Industrial context

Unlike humans, artificial neural networks, including Deep Learning, suffer from catastrophic forgetting: a neural network that learns task A then sequentially task B will completely forget task A. This is the reason why current AIs are sometimes described as « weak » in the sense that they can learn a task (e.g. play chess, recognize faces or drive a car) but not several different tasks in a sequential way such as humans during life-long learning.

Objectives

Psychological work in the 90s aimed to understand why artificial neural networks, although inspired by the human brain, suffer catastrophic forgetting while humans overcome it without a problem. They showed that Multi-Layer Perceptrons (the ancestor of Deep Learning) could also overcome this problem by imitating a double memory inspired by the human brain.

Results obtained/expected

Different methods exist to overcome catastrophic forgetting, yet bio-psycho-inspiration may give the most decisive advantages. At the level of psycho-inspiration, this AI, like humans, does not need any a priori knowledge of the data and it can learn continuously and agnostically regardless of the environment in which it operates. At the level of bio- inspiration, unlike most alternative methods, it does not need neurogenesis, or even the creation of whole new parts of the neural network (e.g., multi-heads). It is therefore a realistic, simple, robust, efficient and easily embeddable in silico solution for continuous learning or personalization. With MIAI (Multidisciplinary Institute in Artificial Intelligence of Grenoble), CEA-LETI and CEA-LIST, we have adapted this principle of dual memory to Deep Learning and have shown that these new AIs can do incremental learning without catastrophic forgetting.

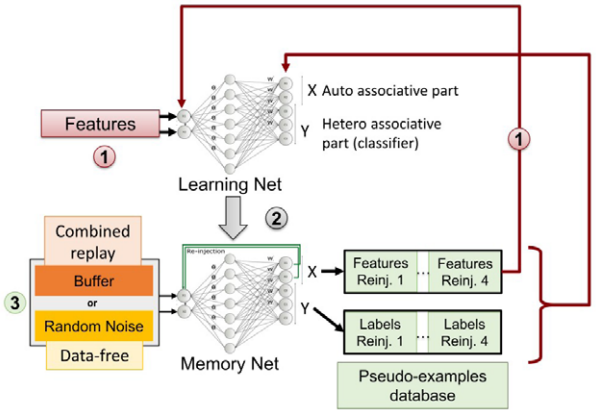


Figure 1: The dual neural network is capable of life-long learning without resorting to neurogenesis or an oracle about the data to be learned. Current simulations show its robustness to all forms of learning scenarios (personalization, streaming, etc.) but also different tasks (classification, time series prediction, reinforcement, etc.) It may therefore be the elementary brick towards strong AIs.

Scientific and technical managers

Laboratory: Martial Mermillod, LPNC (Chaire «Neuromorphic Systems» du Multidisciplinary Institute in Artificial Intelligence), UGA

Company: Marina Reyboz, CEA-LIST

The Zero Resource Speech Challenge 2021

Spoken language modelling

SCIENTIFIC AXIS: Cognition & language
MARKET SEGMENT: Language modelling, Low-resource, Unsupervised speech, Cognitive benchmarks

Industrial context

Infants learn their native language(s) through observation and interaction before they learn to read and write. They show that in principle it is possible to build a language model from sensory data alone, in the absence of textual resources. Reproducing this achievement automatically would open speech and language technology to most of the world's languages - which do not have enough textual resources to be served by current text-driven approaches. The Zero Resource Speech Challenge Series aims at developing the building blocks necessary to construct textless AI applications.

Objectives

Previous iterations of the challenge have focused on the discovery of sub-word units (ZR15,17,19,20) and word units (ZR15,17,20). Here, we aim at learning a language model directly from audio without any annotation nor text. Participants can use any training set, provided they do not use textual labels besides the identity of the speaker. The training set can be used to discover discrete units (pseudo-text) and then train a language model from it, or learn everything end-to-end without discrete units. Following previous strategies, evaluation is done through zero-shot metrics based on human psycholinguistics which do not require any training. Here we examine four linguistic levels: acoustic (ABX - Libri-light), lexical (spot-the-word - sWUGGY), syntactic (acceptability judgment-sBLIMP) and semantic (similarity judgment - sSIMI). We provide baseline systems which are the nexus of three unsupervised components: self-supervised contrastive representational learning (CPC), clustering (k-means) and language modeling (LSTM or BERT). To consider the computing resources of participants, we distinguish submissions by the amount of GPU budget used for training.

			ABX-with.		ABX-across		sWUGGY	sBLIMP	sSIMI	
System	Budget	Set	clean	other	clean	other			synth.	Libri.
Random Baseline	0	dev	0.49	0.5	0.5	0.5	0.5	0.49	-1.48	6.79
		test	0.5	0.49	0.5	0.5	0.5	0.5	0.17	6.44
Bert Baseline	1536	dev	0.03	0.05	0.04	0.08	0.68	0.56	6.25	4.35
		test	0.03	0.05	0.04	0.08	0.68	0.56	5.17	2.48
LSTM Baseline	60	dev	(idem)	(idem)	(idem)	(idem)	0.61	0.52	4.42	7.07
		test	(idem)	(idem)	(idem)	(idem)	0.61	0.53	7.35	2.38
BN	60	dev	0.05	0.09	0.07	0.13	**0.64**	**0.54**	4.29	7.69
		test	0.05	0.09	0.07	0.13	**0.65**	**0.54**	**9.23**	-1.14
JC1	60	dev	**0.03**	0.05	**0.04**	0.08	0.63	0.52	**5.90**	**10.20**
		test	**0.03**	0.05	**0.04**	0.08	0.64	0.53	2.42	**9.02**
JC2	60	dev	**0.03**	**0.04**	**0.04**	**0.07**	**0.64**	0.53	-7.75	4.60
		test	**0.03**	**0.04**	**0.04**	**0.07**	0.64	0.53	5.15	-0.85
AL	60	dev	0.17	0.20	0.25	0.30	0.51	0.52	3.16	1.79
		test	0.17	0.20	0.24	0.31	0.52	0.52	7.30	-4.33
TM1	60	dev	**0.03**	0.05	**0.04**	0.08	0.61	**0.54**	-0.81	5.45
		test	**0.03**	0.05	**0.04**	0.09	0.61	**0.54**	7.00	-1.47
TM2	60	dev	**0.03**	0.05	**0.04**	0.08	0.58	**0.54**	-1.65	4.81
		test	**0.03**	0.05	**0.04**	0.08	0.59	**0.54**	2.89	-1.67
TM3	60	dev	0.04	0.06	0.05	0.10	0.62	0.53	-0.17	7.07
		test	0.04	0.06	0.05	0.11	0.62	0.53	5.93	0.56
TM4	60	dev	0.04	0.06	0.05	0.10	0.60	0.53	-2.10	8.89
		test	0.04	0.06	0.05	0.10	0.60	0.53	6.74	2.03
Top: Frame labels	1536	dev	0	0	0	0	0.92	0.64	7.92	4.54
		test	0	0	0	0	0.92	0.63	8.52	2.41
Top: Phone labels	1536	dev	-	-	-	-	0.98	0.67	9.86	16.11
		test					0.98	0.67	12.23	20.16
Top: RoBERTa	24576	dev	-	-	-	-	0.97	0.82	32.28	28.96
		test	-	-	-	-	0.96	0.82	33.16	27.82

Leaderboard. Bolded results have the best score in the column among the submitted systems for the given task.

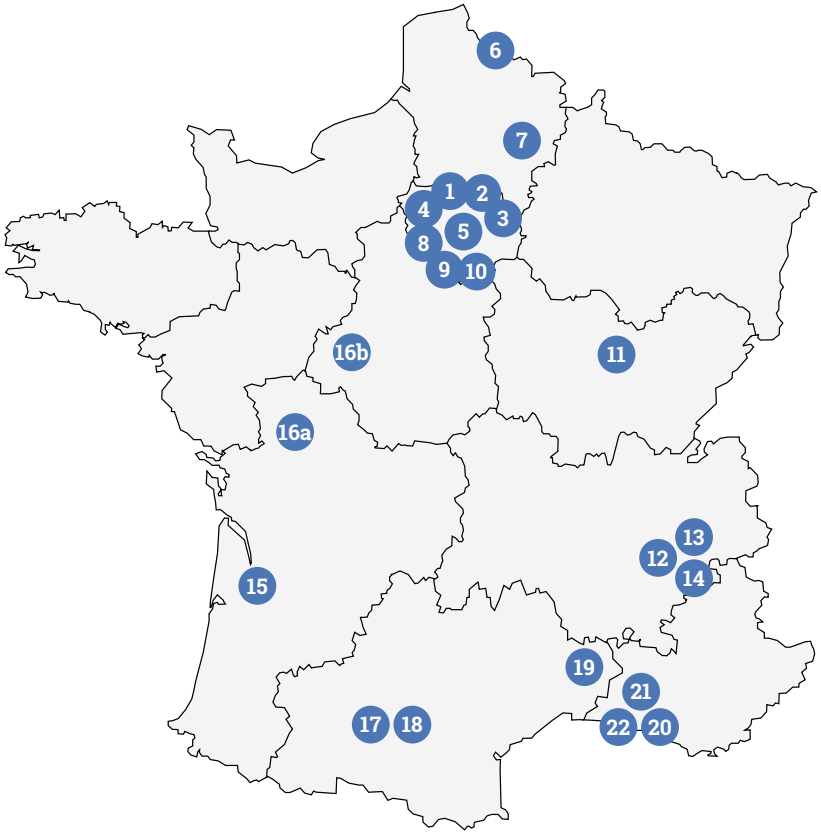
Results obtained/expected

Eight low budget systems were submitted. Results (Table 1) show that systems starting from CPC modelling (all but one) achieve extremely good ABX scores. Most prominently, progress was made on the sWUGGY (lexical) metric. This is great news for LM applications that are heavily driven by the lexicon. Thus, the approaches taken here should already be helpful for ASR decoding. Above the word level, things are harder. As for sWUGGY, sBLIMP performance shows promising improvements over the baselines. Still, the gaps with text-based approaches are more pronounced for both sBLIMP and sSIMI. Speech-based language modelling needs to make more progress before being applicable to tasks like translation and dialogue, for which good language modelling depends on making syntactic and semantic predictions. One possible missing piece in both tasks is words. Future challenges may do well to introduce a distinction between fine-grained (« character »- based) and coarse-grained (« word »-based) metrics.

Scientific and technical managers

Laboratory : Dunbar Ewan - Université de Toronto, Canada - Company : Dupoux Emmanuel - Cognitive Machine Learning (ENS-CNRS-EHESS-INRIA-PSL Research University), France & Facebook AI Research, France

OUR LABORATORIES



1 **CHArt**
Laboratoire Cognitions Humaine et Artificielle, Saint-Denis

2 **IJN**
Institut Jean Nicod, Paris

3 **LSP**
Laboratoire des Systèmes Perceptifs, Paris

4 **LSCP**
Laboratoire de Sciences Cognitives et Psycholinguistique, Paris

5 **ENSADLab**
Laboratoire de recherche de l'EnsAD, Paris

6 **SCALAB**
Laboratoire sciences cognitives et sciences affectives, Villeneuve d'Ascq

7 **COSTECH**
Connaissance, Organisation et Systèmes Techniques, Compiègne

8 **LaPEA**
Laboratoire de Psychologie et d'Ergonomie Appliquée, Boulogne Billancourt

9 **LISN**
Laboratoire Interdisciplinaire des Sciences du Numérique, Orsay et Gif-sur-Yvette

10 **Centre Borelli**
Gif-sur-Yvette

11 **LEAD**
Laboratoire d'Étude de l'Apprentissage et du Développement, Dijon

12 **GIPSA LAB**
Laboratoire Grenoble Images Parole Signal Automatique, Grenoble

13 **LIG**
Laboratoire d'Informatique de Grenoble, Grenoble

14 **LPNC**
Laboratoire de Psychologie et Neurocognition, Grenoble

15 **IMS**
Laboratoire de l'Intégration du Matériau au Système, Talence

16a 16b **CeRCA**
Le Centre de Recherches sur la Cognition et l'Apprentissage, Poitiers et Tours

17 **IRIT**
l'Institut de Recherche en Informatique de Toulouse, Toulouse

18 **CRCA**
Centre de Recherches sur la Cognition Animale, Toulouse

19 **LIA**
Laboratoire Informatique d'Avignon, Avignon

20 **LPC**
Laboratoire de Psychologie Cognitive, Marseille

21 **LPL**
Laboratoire Parole et Langage, Aix en Provence

22 **LNC**
Laboratoire de Neurosciences Cognitives, Marseille

Our supervision

Our institutional partners

NOTES

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In order to facilitate the reading of certain texts, we sometimes use feminine and masculine forms to designate persons. We use neutral forms as much as possible It goes without saying that we are always talking about women and men.

institut cognition

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