Session D

Interactions of top-down expectations and bottom-up sensory inputs in early stages of visual-orthographic processing

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How and when top-down information modulates visual-orthographic processing is an essential question in reading research with implications for learning and education. In a previous study, we showed that task modulation of print-tuning started in N1 offset of the ERP, while the N1 onset was yet unaffected. Here we test how prior expectation affects visual-orthographic processing. Familiar, left/right-structured Chinese characters and stroke number matched, unfamiliar Korean characters were presented, while expectation about the upcoming stimuli was manipulated with green and blue colored frames (high Chinese vs. high Korean expectation). EEG data of 18 native Chinese speakers were recorded while participants performed an expectation judgment task. Results from occipito-temporal and whole map analyses suggest that effects of prior expectation changes throughout the N1. Accordingly in the N1 onset, a print tuning main effect was found, with a stronger N1 to Chinese characters than Korean characters, irrespective of expectation. In the N1 offset, an expectation-by-character interaction was observed at the whole map level, with a more negative N1 to Korean characters than Chinese characters when expecting to see a Chinese character, but no such difference when expecting to see a Korean character. Taken together, the current study provides evidence that prior expectation based on general perceptual information in the context or environment starts to influence visual-orthographic processing at an earlier stage even within 250 ms, suggesting that word recognition is an inferential process integrating expectation and sensory inputs.

Inhibitory control and the neural correlates of science and maths reasoning in children

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Recent evidence suggests that when learning new scientific concepts, adults suppress previous misconceptions using inhibitory control. For instance, adult physics experts activate brain areas associated with inhibitory control (namely the prefrontal cortex) to a greater degree than novices when correctly judging physics misconceptions. However, the degree to which inhibitory control could lead to better science and maths learning during development remains under-investigated. The present study aimed to assess the neural correlates of science and maths reasoning in primary school children and to investigate whether suppression of perceptually irrelevant information and intuitive reasoning involves the activation of inhibitory control circuits. Participants were recruited as part of the UnLocke project (www.unlocke.org), which assesses the impact of a 10-week "Stop and Think" classroom intervention. The intervention trains Year 3 and Year 5 pupils to suppress perceptually irrelevant information when responding to science and maths questions covered by the national curriculum. Twenty-five children responded to questions involving science and maths misconceptions and performed semantic and response inhibition tasks while undergoing functional magnetic resonance imaging (fMRI) scanning. We first expect that increased accuracy in responding to the science and maths questions will be linked to increased prefrontal engagement, indicative of increased inhibitory control. Second, we expect that brain activity during the science and maths misconceptions task will overlap with the activity observed during semantic and response inhibition tasks. These findings would indicate that engagement of inhibitory control circuits may be associated with evaluating complex problems in maths and science domains during early academic learning.

Integrating memories: How congruency and reactivation aid integration of old and new memories

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In education we continuously build up knowledge. Successful knowledge building has been suggested to occur through reactivation of prior knowledge during new learning in item-specific perceptual brain areas. This reactivation is proposed to yield integration of new with old memories, supported by the medial prefrontal cortex (mPFC) and medial temporal lobe (MTL). Possibly as a consequence, congruency of new information with prior knowledge is known to enhance subsequent memory. Yet, it is unknown how reactivation and congruency interact to influence memory integration, and how these factors affect educational learning. To investigate this question, we used an AB-AC inference paradigm in both an educational and an fMRI setting. University students first studied an AB-association followed by an AC-association, so B and C were indirectly linked through their common association with A, an unknown (pseudo)word. Moreover, BC-associations were either congruent or incongruent with prior knowledge, and participants were asked to report subjective reactivation strength for B while learning AC. Behaviourally, we expected both congruency and reactivation to enhance subsequent associative memory for the inferred BC-association. This was corroborated in both the behavioural and fMRI studies. In the brain, we found parametric effects of congruency and reactivation on univariate and multivariate activity patterns in perceptual areas, MTL, and mPFC. These outcomes show beneficial effects of both congruency and reactivation strength on memory formation, and provide insights into the neural mechanisms underlying these processes. Additionally, we will present data from a current experiment examining how these factors can improve statistics learning in university students.

Assessing the relationship between executive functions, emotional traits and educational attainment during adolescence

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Both impaired executive functions (EFs) and emotion dysregulation are associated with increased risk of psychopathology and lower educational attainment (EA). EFs are a set of cognitive processes, necessary for the control of behaviour and successful achievement of goals. Research in early infancy suggests that poor EFs may make individuals more susceptible to emotional dysregulation. However, it remains unclear how these constructs relate to each other. This study investigates the relationship between EFs and emotional traits and their impact on EA during adolescence, a period which is marked by a time of great change in EFs and emotional reactivity. Principal component analysis was used to create latent, summary, variables from a range of measures of emotion and cognition across adolescence in the Avon Longitudinal Study of Parents and Children sample (N = 6,998). EA was assessed using English, maths and science national curriculum levels at ages 11 and 14. Working memory, inhibitory control and processing speed cognitive factors were obtained, as well as internalising, externalising, anxiety, extroversion and conscientiousness emotional traits factors. Preliminary results suggest that many of these latent factors independently predict EA with some subjects specificity, but that there is also some interaction between them, in particular between externalising, disruptive behaviour directed into an individual's environment, and working memory, the ability to hold and manipulate something in mind over a short period of time. These results highlight the shared and independent influences of emotional traits and cognitive ability on academic performance during adolescence.

Elucidating the role of executive functioning and metacognition on academic outcomes

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Executive functioning (EF) and metacognition (MC) are two cognitive domains that are imperative to academic success. Although they share several theoretical characteristics in the literature and are both documented to play significant roles in learning, their unique contribution to different academic variables remains less explored. Moreover, previous EF and MC studies often focused on a single academic outcome (e.g. literacy, numeracy), leading to a paucity of research elucidating on their impact across diverse academic areas. Taking a latent-variable approach, this study develops and tests the first theoretical model that delineates the structural relationship between EF, MC, and four education-related domains. Four EF performance-based tasks on planning, working memory, inhibition, and flexibility; one self-reported questionnaire on MC; and fours standardised tests were administered to 475 children (M age = 11.92; SD age =0.94). Confirmatory factor analysis suggests that EF is best explained by a one-factor model in this sample. Structural equation modelling suggests that EF and MC have both unique and shared contributions to different academic outcomes. These findings provide further insight concerning the unique and shared contribution of EF and MC on different areas that are important to academic outcomes, informing future research and intervention design.

Phonological awareness in children developing dyslexia – a longitudinal fMRI study

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Learning to read changes the language system in the brain. Here we investigate how acquisition of literacy affects the neural correlates of phonological awareness, i.e. ability to identify and manipulate speech sounds. We focus on either typically reading or dyslexic children, who either present or lack familial history of dyslexia (FHD).

Young beginning readers (N = 92) repeated reading-related tasks three times with a year-long interval, and their brain activity during auditory rhyme judgement was measured at first and last time-point. We contrast children who developed dyslexia (n = 20) with their typically reading peers (n = 72). Independently, we compare children who had familial history of dyslexia (FHD+, n = 56) with children who did not present such risk factor (FHD-, n = 36).

We found that children with dyslexia show decreased reading and phonological awareness skills even at the very beginning of formal reading instruction. Literacy acquisition reduced brain activation to phonological awareness in typical readers in left dorsal structures, whereas in dyslexia it increased activation of right dorsal areas.

Regarding familial history of dyslexia, we found that FHD+ and FHD- children present similar level of reading and phonological awareness skills. Learning to read reduced brain activation to phonological awareness in FHD- children in left perisylvian areas, whereas in FHD+ an increase was present in left motor and somatosensory cortex. As beginning readers, FHD+ children despite typical phonological skills show extensive hypoactivation in the speech processing cortex compared to FHD- group.

Brain structure in elementary school late talking children with and without developmental dyslexia

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Late time of speech emergence constitutes a risk factor for later reading deficits (Scarborough & Dobrich, 1990). Additionally brain structure alterations in preschool children who were late talkers were reported (Raschle et al., 2015), however previous studies didn't consider whether or not children turned out to be dyslexics.

In order to check common and distinct neuronal correlates of late speech emergence and dyslexia we investigated gray matter volume (GMV) in 119 elementary school children aged 7.23-10.7 (M=9.14, SD=0.61). Four groups were selected: dyslexic late talkers (N=17), typically reading late talkers (N=26), dyslexic on-time talkers (N=38) and typically reading on-time talkers (N=38).

The preliminary analyses using voxel based morphometry (VBM) showed main effect of age of speech emergence in right inferior frontal gyrus (IFG, increased GMV in late talkers'), consistent with the role of IFG in speech processing (Giraud & Poeppel, 2012). Late talkers showed also increased GMV in left planum temporale, previously found altered in children with language disorders (Preis et al., 1998).

The main effect of dyslexia was found in increased GMV in right gyrus rectus which was one of the structures found to be less activated by dyslexics in comparison to controls during the phoneme deletion task (Pernet, et al., 2009). There was no interaction between the age of speech emergence and dyslexia on GMV.

Current results show that correlates of late speech emergence may be observed in elementary school children' brain structure and that the effects of the age of speech emergence and dyslexia are independent.

Exploring the role of the hypersensitivity-to-interference in memory hypothesis in adults

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Arithmetic facts (e.g., 4 x 2 = 8) provide an important basis for acquiring comprehensive mathematical skills. However, there are large individual differences in arithmetic fact knowledge. Recently, a new hypothesis on the origins of these individual differences in arithmetic fact learning was proposed: the hypersensitivity-to-interference (STI) in memory hypothesis.
In the present study, we aimed to further explore the STI hypothesis by investigating its behavioral effects in healthy adults. Specifically, we tested 179 participants with a large battery of psychometric tests (including intelligence structure tests) to answer the question in which intelligence components individuals with high levels of STI differ from individuals with low levels of STI. For measuring individual differences in STI, we used an adapted version of an associative memory task. Cluster analysis based on participants' accuracy in the associative memory task revealed two distinct groups differing in their levels of STI (high vs. low). Further analysis showed that individuals with high levels of STI display lower numerical-mathematical intelligence than the low STI group, whereas no group differences emerged for verbal and figural intelligence. Specifically, the low STI group showed poorer performance in three numerical-mathematical tasks: (1) continuing number series, (2) finding different operands for a given arithmetic solution and (3) subtracting double-digit numbers.
This result suggests that STI does not only play a role in children's arithmetic fact learning but is also related to adults' numerical-mathematical intelligence. Therefore, further studies should investigate how STI could be reduced to foster impaired mathematical abilities.

Visual and audiovisual processing of artificial letters in the prereading brain is related to early reading outcome

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Developmental dyslexia affects up to 17% of children with access to adequate schooling. Dyslexia has a neurobiological origin and is known to be associated with atypical development of the neural reading network. However, it remains largely unclear which developmental abnormalities of brain function are already evident in prereaders and which arise later, in the course of reading acquisition.
In a longitudinal study, we tested 28 prereading children at familial risk for dyslexia in their last year of kindergarten (6.7±0.3 years) and in the middle of first grade (7.3±0.3 years). In a short session (20 min), prereaders trained artificial letter and speech sound correspondences. In a subsequent simultaneous EEG-fMRI session, prereaders solved an implicit audiovisual task, including trained and untrained artificial letter – speech sound correspondences. After half a year of formal reading instruction, children's initial reading fluency was assessed and used to analyse the prereading data regarding early reading outcome.
We show training induced plastic changes in brain networks of prereaders and how they are related to initial reading skills. During visual processing of trained stimuli, activation in the left ventral occipitotemporal cortex was significantly stronger for prereaders who would later develop normal reading skills than for those with poor reading skills. In addition, audiovisual integration in the left planum temporale also depended on initial reading outcome.
These results demonstrate neurobiological differences between normal and poor readers that precede reading acquisition. Understanding early deviations of brain functioning in dyslexia could improve early identification and intervention for children with dyslexia.

Early cerebral constraint on reading and on inhibitory control development

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School learning (such as reading) and intense and prolonged training produce functional and structural changes in the brain. We will present studies investigating the converse issue namely whether fundamental school learning and the receptivity to executive (inhibitory control) training are constraint by the anatomy of the brain. In particular, we will first present converging evidence that the sulcal morphology (i.e., a qualitative feature of the brain determined in utero and not affected by brain maturation, learning and training) of the left lateral occipito-temporal sulcus (OTS) hosting the visual word form area (VWFA) predicts reading skills in typically developing children and in literate and ex-illiterate adults. In addition, we will present data from three studies showing that inhibitory control efficiency is constrained by the sulcal morphology of two key regions of the inhibitory control network namely of the anterior cingulate cortex and of the inferior frontal sulcus in children and adolescents. Finally, we will present preliminary data suggesting that the sulcal morphology of these two regions (ACC and IFS) predicts in part the receptivity to inhibitory control training in children (9-year-old) and adolescents (16-year-old).

Is metacognition of 'desirable difficulties' and applied to 'self-efficacy' the key to unlocking test anxiety in 10 – 12 year olds?

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Test anxiety affects girls more than boys (Hembree 1988) and from as young an age as 7-8. Test anxiety is a transactional construct (Zeidner 1998), which affects performance of the working memory (Eysenck 1992). High Test Anxious students are more self-centred and more self-critical than Low Test Anxious students (Zeidner and Matthews 2005). One aspect of Bandura's self-efficacy theory (1997) is that self-belief, belief in capability can raise performance. A 12 week intervention using metacognition of 'desirable difficulties' in 'the testing effect' (Bjork 1974) and 'interleaved spaced retrieval' (Karpicke and Roediger 2011) was delivered to a small group of Year 6 girls prior to a high stakes (entrance to Senior School) examination. This pilot intervention aimed to enable 10-12 year olds to believe that as you face an important exam, new metacognitive knowledge can be used to give self-efficacy in test taking; to believe that testing routes in the brain have been primed and that belief in oneself is possible because of the 'mastery' of the metacognition of self-efficacy.

Similarity in motivation between friends at high school: Investigating behaviour and the brain

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This research aimed to gain perspective on similarities between friends across measures of motivation. Survey data was collected from 225 students, assessing motivation using subject specific and subject general scales. A subset of the participants (N = 62) from two of the year groups also came to an fMRI session, where they performed a child friendly version of the monetary incentive delay task, without monetary incentives. This task allows us to gain the neural index of students' intrinsic motivation for the task. Critically, we also assessed students' social networks by asking them to nominate friends or rate their closeness to other students. To assess similarity between friends we calculated an assortativity index between friends for each construct. This measure gives a correlation between the scores of individuals connected to each other via friendship ties. Overall, we identified that separate cohorts do not show comparable patterns of similarity in motivation, rather, they each have their own individual patterns of similarity. For example, in subject specific measures, 13-14 year olds show a positive assortativity index for math anxiety, suggesting that anxiety levels towards math are similar between connected friends. Moreover, 14-15 year olds have a positive assortativity index for math competence. In subject general measures, we identified that 12-13 year olds show similar levels of agentic engagement, while 11-12 year olds show similar levels of intrinsic value. The results contribute to our understanding of motivation dynamics in school cohorts and reveal new insights into the influence of friendship on the brain.

Symbolic approximate arithmetic relies more on number semantic processing: A training study of preschooler

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Number semantic and spatial processing are important for exact arithmetic ability. However, whether the two processing contribute differently to approximate arithmetic remains unclear. Here, we conducted a training study to investigate this question. We tested 96 preschoolers by two-digit number comparison task to test number semantic processing, 0-100 number line estimation task to test number spatial processing and approximate arithmetic task. The participants were divided into three groups basing on their performance of approximate arithmetic. Two groups were trained by paper games. One of the game trained the ability of number semantic processing. Another one trained the ability of number spatial processing. The third group was the control group, which didn't receive any training. The results showed that compared to the pre-test, (1) number comparison and approximate arithmetic performance were improved for the number semantic training group; (2) number comparison, number line estimation and approximate arithmetic performance were improved for the number spatial training group; (3) there were no any improvement of the three tasks for the control group. Compared to number spatial training group, the number semantic training group had significant improvement in approximate arithmetic, which showed that approximate arithmetic depended more on number semantic processing. What's more, we found the transfer effect of number spatial training. That is, the training of number spatial processing could also improve the ability of number semantic processing. Educational implications of the study were discussed.

Exposing practicing teachers to neuroscience concepts: Impact on teaching and classroom management

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In recent years, there has been an increasing number of voices seeking to use knowledge and evidence from brain research and neuroscience in order to implement them in education and teaching. It is argued that information on the manner in which the brain operates and develops, acquires, processes and preserves information can change teaching, and it is therefore desirable that teachers become familiar with the processes by which the human brain operates and processes the information to which it is exposed. This will pave the way to turning teaching from art based on experience into a science grounded on the research of cognition and brain processes. Integration of knowledge from the cognitive sciences, psychology and educational research may enrich teachers' pedagogical knowledge and improve their abilities.

The proposed presentation will show an experience of practicing teachers who have studied selected topics in brain research that are relevant to teaching and learning. The course was given to teachers within their professional development framework. One of the main objectives of the experience was to answer the question of whether the teachers, after their exposure to the neuro-cognitive processes involved in learning, found that they had used, or are using erroneous teaching practices, and if so, what were these erroneous practices and what new practices did they change and adopt in light of what they learned in this course. Three teacher populations were tested: those who are participating in this course this year, teachers who participated in this course last year, and teachers who participated in the course two years ago.

Proportional reasoning: Improving students' performance by reducing the interference of natural numbers

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Proportional reasoning is important in school and in everyday life and is known to be difficult for schoolchildren and adults. Previous behavioral and fMRI brain-imaging studies have shown that difficulties in proportional reasoning may stem from the interference of the automatic comparison of the salient natural numbers.

We designed two equivalent tests that were visually very similar. In the Drops test, students compared the intensity of color of mixtures of red and white paint drops. In the Juice test, students compared the amount of juice each child receives when equally dividing the contents of cups of juice among children in each group. The Juice test was aimed at directing students to calculate "rate per unit," thereby reducing the interference of the automatic comparison of the salient natural numbers. We studied whether the Juice test would yield a higher success rate than would the Drops test among tenth graders. Moreover, we explored whether performing the Juice test before the Drops test would improve students' success in the Drops test. The findings indicated that, indeed, success in the Juice test was higher than in the Drops test. Moreover, success in the Drops test was higher when performed after the Juice test.

The current study, based on previous fMRI findings, suggests that using modes of presentation that direct students to use appropriate solution strategies aids them in overcoming difficulties. Using modes or orders of presentation could serve as important tools for educators and could lead to higher academic achievements among their students.

Pretend play and the development of children's self-regulation skills: Are the results real of simply made-up?

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There has been increasing interest in the contribution of pretend play towards children's cognitive development. The present study examines the efficacy of a pretend play intervention on the self-regulation skills of 4- to 5-year-olds. Pretend play includes a pretender projecting a mental representation onto reality. The study's sample consisted of 60 children from a school in the east of England, and the children were randomized into two groups: (a) Pretend play intervention; and (b) Art activities. The intervention included sixteen 30-minute sessions over 13 weeks, in groups of six children. Each session included: (1) shared storybook reading; (2) role-playing; and (3) review. During shared story-book reading the children were read a book and explicit phonological awareness (PA) and vocabulary instruction were presented for six words. Role-playing included providing the children with props to partake in pretend play. The review component comprised of questions that were used to go over the PA and vocabulary of the target words, and the activities that the children engaged in. Three measures were used pre- and post-intervention to evaluate children's self- regulation skills– Head, Toes, Knees and Shoulders Task, Statue Task, and Gift Delay Task. The inclusion of self-regulation skills as presented in through pretend play was hypothesized to strengthen children's internal capacity by enabling them to use symbols as tools for self-regulation in managing their behaviour. The improvements that occurred in the children's self-regulation skills are considered alongside other cognitive and educational factors to better comprehend the role of pretend play in educational settings.

"Skies of Manawak": A videogame for cognitive training

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The Executive Functions (EF) can be defined as the set of mental processes that enable us to regulate functions and behaviours. Several studies showed a deficit in the EF domain associated with dyslexia. Therefore it is fundamental to consider these aspects to plan more effective intervention programs. On this issue, the training of EFs is supported by tools coming from several years of research. However these products could result to be not so stimulating when compared to what is offered by the video game industry.
For these reasons, we developed a new video game for cognitive training, called Skies of Manawak (SOM).

Since our aim was not simply to ameliorate the cognitive training with a game frame, the game structure not only comprises several mini-games in which different cognitive functions are trained (e.g. visual and auditory working memory, attention, planning and inhibition), but it also provides for sessions in which players need to flight from one world to another including several aspects of action video games.

SOM has been tested on a group of 151 Italian-speaking children (12 hours of play, over a 6-weeks span, at school), resulting in marked gains in reading abilities ($F(2, 144)=42.32$, $p<.001$, $\eta 2p=.37$) and attention ($F(2, 144)=63.76$, $p<.001$, $\eta 2p=.47$) at post-test and at follow-up, while no gains were observed in the active control group (Scratch, a gamified computer programming software). Importantly, the advantage in reading efficiency was maintained at a follow-up test 6-months later. Currently, the game is under testing with dyslexic children.

Structural frameworks of educational neuroscience: In search of the best approach

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Since Educational Neuroscience (EN) emerged, many scientists have raised their voices either in favor or against it, debating the qualifications or disqualifications of EN as a field of research. Why is it that EN is inciting such a polemical debate? Likewise, other analyses of the literature indicate that EN is detached from matters pertinent to educational practices, saying more about the promises and pitfalls of the field than about research products. Why is it that EN is triggering such a controversial literature?
In this study, I analyzed a variety of conceptual frameworks that have been proposed to explain the nature of EN. Broad observations of these frameworks show that EN implies either direct or indirect links among different disciplines (i.e., neuroscience, education, and psychology) or type of research (basic or applied). Closer observations, however, allow appreciations of unique emergent properties in terms of their conceptual and functional propositions. While some of these propose hierarchy and assume unidirectionality among disciplines, other endorse interdisciplinarity or even transdisciplinarity.
The results indicated that the theoretical and operational distinctions among these frameworks clearly mirror the larger dispute regarding EN. More importantly, they represent, most of the time, irreconcilable postures that cause confusion and give continuity to the long-lasting debate. The lack of a common conceptual framework threatens EN, because its productivity in terms of research is underestimated. There is a need to build agreement toward the best structural framework required for better implementations of EN.

The "Doppler" time management strategy in the context of a learning strategies and habits program

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Learning to learn needs to be based on reputable scientific theories in order to be effective, but they also need to be tested in real life teaching and learning situations.
A program was developed at the University of South Africa, as part of a pilot project rolled out in 37 South African Schools. This program addresses aspects of Identity (characteristics of the learner), Mastery (effective learning habits and strategies) and Legacy (using data, information and knowledge to address real life issues).
Two important learning strategies included in this program are “spaced repetition” and “interleaving”. The reality of learners’ busy schedules, however, makes it difficult to implement. This leads many learners to revert to “cramming”, often with very little long-term memory retention. The challenge is to translate the proven strategies into workable habits. For this reason the “Doppler” strategy was suggested and taught to learners in the 37 schools. It entails a strategy to schedule several subjects in times leading to tests and exams, in a way to study the content several times in shorter time-frames.
Feedback from focus groups pointed to positive results in terms of the following:
Feasibility: it did work in real life situations if students
Identity: it showed a positive effect on the learner’s mindset (Carol Dweck), and grit (Angela Duckworth)
Mastery: positive effect on long-term memory retention, but more important, on self-efficacy and confidence
Legacy: when followed, it had a positive effect on test and exam marks, but also on deep learning.

“The brain goes to school”: Evaluating the impact of neuroeducation training workshops

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Professionals responsible for children learning benefit with training workshops about the neuropsychological functions associated with the learning processes, to better plan contents and methodologies according to each student needs, promote self-fulfilled children and improve their individual potential. To evaluate the impact of the training workshops “The brain goes to school” (neuroeducation project that takes place in all Portuguese regions), we asked participants - teachers and therapists - to answer a questionnaire. In order to measure the impact of these sessions one needs to take into account multiple factors, such as: their motivations; their level of satisfaction with the workshops; beliefs about personal changes in their professional practices; desire to seek further information and continue studying about the “mind, brain and education” trilogy; the opportunity to share with colleagues what they learnt from the training workshops. The main reason indicated for enrolling in the workshops was professional enrichment and growth (76,9% of the participants considered this option). Concerning the beliefs of professional changes, teachers and therapists pointed out that the major changes are related to the methodologies and strategies used with students (47,1%) and the personal motivation to have an active role in the learning process of children (45,2%). Also, 79,8% of the participants continued exploring information in this field, and had already shared aspects they learnt with their peers (80,8%). This analysis gives us the responsibility to continue this project and the will to reach all of those who want to teach based on what science offers to education.

The design and optimization of SMART Spaces: A science revision program utilizing a spaced learning framework.

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Background:
There is evidence from neuroscience, cognitive psychology and educational practice that the delivery of information in a spaced format (i.e., presented over time with gaps) rather than in a massed format (presented all at once) leads to more effective learning even if the time spent on study is the same. This is known as spaced learning, or distributed practice.
Methods:
Cognitive psychology experiments have suggested that longer spacing intervals between repetitions of material (>24 hours) may be optimal for long-term memory formation. Whereas, the neuroscience suggests that shorter spaces (of around 10 minutes) may be beneficial. This information was used in a series of programme design workshops between researchers and teachers to develop three variants of a spaced learning programme with one utilising short 10 minute spaces one using longer 24hr spaces (and one using both short and longer spaces (10min/24hr combined).
Results:
All three variants were explored in four schools and found to be feasible to deliver. Feedback from the teachers and pupils was used to amend the programme materials, training and delivery method. Then, in order to identify the optimum version of the program, a randomised controlled trial of the three variants (with two control conditions) was conducted in 12 schools (n=408 pupils), which compared spacing effects to control conditions on pre-post science attainment measures.
Conclusions:
The trial found that the combined variant of the programme (10 minute and 24hr spaces) had a significant effect on attainment (effect size g=0.19). Implications and future research will be discussed.