II INTERNATIONAL MEETING: WORKING MEMORY

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INVITED LECTURES

THE EVOLVING CONCEPT OF WORKING MEMORY

Alan Baddeley

It is now over 35 years since we introduced the concept of a multi component working memory, expecting it to have a relatively short lifespan. I will give a brief overview of the theory and its development, giving examples of a wide range of applications. I will then discuss some of the competing theories, arguing that the multi component model should be seen as a theoretical framework within which other more detailed models can develop and compete.

WORKING MEMORY: DEVELOPMENTAL AND INDIVIDUAL DIFFERENCES

Graham Hitch

One reason the working memory system has attracted considerable interest is evidence that it plays an important role in children's cognitive development. A range of complex span tasks is widely used to measure working memory capacity in children and has been shown to be a useful predictor of a variety of cognitive abilities. These tasks emphasise executive processes and suggest that the overall capacity of working memory increases continuously as children develop. In contrast, simpler span tasks tapping into the phonological and visuo-spatial storage components of working memory reveal interesting qualitative changes as children develop. It seems that communication between the phonological and visuo-spatial stores is highly restricted early on in development, the emergence of full communication between the subsystems being a developmental marker of some sort. This change in binding information across modalities may be related to a change in the operation of a multi-modal episodic buffer.

Abstracts in order of presentation

DISORDERS AND DRUGS THAT AFFECT WORKING MEMORY

MULTITASKING: HOW CAN PERFORMANCE ON THE MULTIPLE ERRANDS TEST (MET) BE EXPLAINED BY THE WORKING MEMORY MODEL

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The fundamental components of executive functions exemplified in dual tasks and multitasking are the abilities to initiate steps of a task, plan steps of the task, shift attention between the steps, detect and correct errors and complete the task in a timely manner. The Supervisory Attentional System Model (SAS) (Norman & Shallice, 1986; Shallice & Burgess, 1996; Burgess et al, 2006) was hypothesized to explain this complex but everyday functioning. The MET was constructed to assess multitasking while completing a complex shopping task in a real mall (Burgess & Schalice, 1991; Alderman et al, 2003; Knight et al, 2002). The MET consists of three assignments that the user is required to perform while shopping in a mall-like setting while following certain rules (i.e., buy six items, find out four items of information and meet the tester at a certain time and location). The tester observes the participant, recording mistakes of different kinds (inefficiency; rule breaking; Task failures and use of strategies). What is required to be able to complete the task successfully; How does the Working Memory model (WM) explain the performance of the task? Would it require the central executive as well as the slave systems (Baddeley & Hitch, 1974) the verbal phonological and the visuospatial systems; to what extent? The presentation will include some data from studies utilizing the MET as well as virtual reality versions in various patient populations and controls. The issue of WM model explanation will be raised and discussed.

EXECUTIVE FUNCTIONS AND WORKING MEMORY ASSESSMENT OF ADHD BRAZILIAN SAMPLES

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Despite controversial findings described in the literature, several studies have shown that Attention Deficit Hyperactivity Disorder (ADHD) might occur with neuropsychological deficits. Executive Functions (EFs) and attention deficits have been described among ADHD individuals, but those deficits are neither necessary nor sufficient to predict such a diagnosis. Some studies have also shown working memory (WM) deficits to be frequently found among children and adults with ADHD, but few Brazilian studies have investigated this subject. The scarcity of available Brazilian neuropsychological tasks with the purpose of evaluating attention and EFs (including WM) is an important limitation for clinicians in everyday clinical practice. We aimed to present findings of studies that evaluated attention and EFs in Brazilian samples with ADHD children and adults, both from clinical and non-clinical populations. We also aimed to evaluate discriminant validity of tests that had already been validated for use in Brazil – TAVIS-3, Digit Span and Arithmetic tests – intended to assess attention and WM functions in children and adolescents.

PROCESSING SPEED, DEPRESSIVE SYMPTOMS AND WORKING MEMORY IN AGED INDIVIDUALS AND MULTIPLE SCLEROSIS PATIENTS.

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Damage to the hemispheric white matter is observed both in multiple sclerosis (MS) and normal aging, causing neuropsychological deficits in tasks of executive functions, working memory (WM), and speed of information processing (SPEED). Two main hypotheses were investigated: 1) that SPEED may constitute a determining factor of WM impairment in MS and aged individuals; and 2) that self-reported depressive symptoms may aggravate cognitive deficits in MS patients. The study investigated 31 MS patients without depression, 36 MS individuals with depressive symptoms, 108 demographically comparable controls and 100 community recruited senior participants. Performance of the groups were compared on a self-report measure of depression (Beck Depression Inventory) and on the Working Memory Assessment Battery (BAMT-UFMG). The BAMT is based on a processing model of WM, according to which two components, represented by Operations Coordination (Arithmetic and syntactic listening span tasks) and Storage (Simple digit and word span tasks), are modulated by processing speed (Speed of resolving simple arithmetic and syntactic comprehension problems). Results showed that WM performance depends on SPEED (explaining more than 40% of variance in different groups), age, and schooling, with these variables interacting in complex ways. WM performance in MS patients was moderated by depressive symptoms.

EMOTIONAL WORKING MEMORY IN ALZHEIMER DISEASE

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Alzheimer's disease (AD) has been associated with a deficit in working memory (WM) for verbal and visual information. This study examined differences in WM for emotional information in 24 subjects (12 with AD, matched to controls according to age and education) using a computerized delayed (non) matching-to-sample (DMTS/DNMTS) task with trial-unique stimuli and short delay intervals. Thirty-six IAPS photographs were grouped in pairs into 3 sets of 12 pictures (neutral, highly pleasant-arousing/relaxing and highly unpleasant-arousing), plus 12 geometric figures for each task. The mean correct responses were not above chance level in AD for DMTS and DNMTS tasks, indicating a low performance compared to controls (DMTS, $p<0.005$; DNMTS, $p<0.001$). Pairs of stimuli, classified as congruent/divergent, showed an interaction with the factor task displaying more correct responses for congruent condition in DMTS and divergent condition in DNMTS, regardless of group. Considering the sample stimuli (emotional/neutral), controls but not AD, in both tasks, showed a tendency to perform more correct responses when the sample was an emotional one. These findings suggest a WM deficit in AD subjects, indicating a lack of benefit of emotion for this paradigm.

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ARE THERE DIFFERENT BUFFERS FOR VERBAL WORKING MEMORY? A CASE STUDY OF CONDUCTION APHASIA.

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Objective : Our aim is to use a case study of a patient with Conduction Aphasia (CA) to evaluate how semantic and phonological domains are related in processing verbal information. We will discuss how our results can be explained by working memory models. Participants and Methods: HR, male, 34 years-old, suffered brain injury with temporal and parietal lesions at cortical and sub cortical levels. He was submitted to neuropsychological and language evaluation, with CA diagnosis and a curious predominance of semantic paraphasias (SP). In order to investigate the nature of his deficit, he was submitted to the following language tests: Word Repetition (WR); Sentence Repetition (SR); Pseudoword Repetition (PwR); and Recognition by Visual Confrontation (RVC) (with pictures and words). Results: The neuropsychological evaluation showed: verbal working memory difficulties with poor phonological rehearsal; executive functions deficits when language abilities were involved; and good performance at visual tasks. The language evaluation showed: word repetition difficulties, with semantic paraphasias and worse scores in abstract words: 9/21 versus 98/147 to concrete words; Sentence Repetition difficulties, with semantic paraphasias and theme-related sentences. In the RVC tests he also made several semantic errors by pointing theme or category related pictures or writing words. Discussion: HR's worse performance in verbal working memory tests suggested that he could not use the phonological loop to rehearse information. His answers to repetition tests, and specially his worse performance in abstract and pseudowords suggested that he could activate his semantic memory, despite not being able to maintain the exact phonological form to achieve the target. His performance suggested that he can access the input form of the phonological buffer, but he cannot use it for his production because he has difficulty in retrieving the output form. Conclusion: The observed occurrence of SP, even for non-verbal answers (RVC test), as well as the worse performance in pseudowords and in abstract words, suggest there are multiple levels of representation in verbal working memory: with phonological and semantic buffers.

RELATIONSHIP OF COGNITIVE FUNCTIONS AND BEHAVIORAL DISTURBANCES ON CHILDREN AND ADOLESCENTS WITH PRADER-WILLI SYNDROME.

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Prader-Willi syndrome (PWS) is a genetic disorder caused by the loss of the paternal contribution of the proximal part (15q11-q13) of the long arm of chromosome 15. The syndrome is associated with mild to moderate mental retardation, behavioral disturbances and deficits in executive functions. This study aims to explore the relationship of cognitive functions, assessed by WISC-III, and behavioral disturbances determined by the Child Behavior Checklist (CBCL/6-18), of 13 children and adolescents (average age = 12.3 years) with clinical, cytogenetic and molecular diagnosis of PWS. Spearman nonparametric correlation were determined between pondered scores of WISC subtests, QI (Verbal, Performance and Total), and CBCL scores. The main results showed a behavioral profile of inattention classified as clinical in different behavioral scales. Significant correlations was observed on somatic complaints and Digits (0.66; p=0.01), Verbal IQ (r=0.54; p=0.05), Verbal Behavior (r=0.57; p=0.04) and resistance to distraction (r=0.67, p<0,01) that constitute attentional and working memory measures. On the other hand, rule-breaking behavior showed a significant correlation to attention problems (r=0.79; p<0.01); aggressive behavior (r=0.64; p=0.02) and ADHD problems (r=0.78; p<0.01). These results characterizes PWS as a psychiatric risk group with inhibitory control deficits involving executive functions and conduct problems, expressed by attention problems, rule-breaking behavior and aggressiveness.

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VISUOSPATIAL WORKING MEMORY

ACUTE EFFECTS OF DONEPEZIL UNDERLINE THE FRACTIONATION OF EXECUTIVE FUNCTIONING

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Rationale: The cholinergic system is involved in the modulation of top-down and bottom-up attention in paradigms that study perception. Top-down attention also involves controlled processes such as executive functions, but few studies have investigated the role of the cholinergic system in performance on such processes, especially as regards the proposal of fractionation of executive functions. Objective: To investigate the acute effects of the pro-cholinergic donepezil in young, healthy volunteers in distinct subtypes of executive functions. Methods: We conducted a double-blind, placebo-controlled, independent groups design study including 36 young healthy male participants, who were randomly assigned to one of three oral treatments: glucose (placebo), donepezil 5 mg or donepezil 7.5 mg. The test battery included measures of different subtypes of executive functions (shifting, updating, inhibition, dual-task performance, planning, access to long-term memory), and tasks used to evaluate arousal/vigilance/visuomotor performance. Results: Donepezil improved sustained attention, reaction times, decreased number of lapses in an attentional task, improved dual-task performance and the executive component of the digit span. The positive effects in these executive tasks did not correlate with other attentional arousal/visuomotor/vigilance measures. Conclusions: Among the various executive domains investigated donepezil selectively increased dual-task performance in a manner that could not be ascribed to improvement in arousal/vigilance/visuomotor performance. Other executive tasks may be modulated by the cholinergic system when they rely heavily on visuospatial processing.

Financial Support: AFIP, CAPES, CNPq.

VISUOSPATIAL WORKING MEMORY

ACUTE COGNITIVE EFFECTS OF DONEPEZIL IN VISUOSPATIAL WORKING MEMORY

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Objective*:* Drugs such as donepezil that increase the availability of acetylcholine (Ach) are known to improve various cognitive processes, but the acute nootropic potential of this drug in young, healthy volunteers has not been shown, possibly because effects were evaluated before peak-plasma concentration was reached.. Here we evaluated the cognitive effects of an acute oral dose of donepezil in young, healthy volunteers at peak-plasma concentration. Methods: This was a double-blind, placebo controlled, parallel group design study of cognitive effects of acute oral donepezil (5 mg). Subjects were tested twice after donepezil ingestion: 90 min (time that coincides with previous testing in the literature) and 210 min. (theoretical peak-plasma concentration). The test battery included tasks that tap cognitive domains that are sensitive to ACh manipulations. Results: Most of donepezil's effects were observed at both testing times and included improvement in mood, long-term recall of prose, objects recall, recall of spatial locations and integration of objects with their locations. However, improvement of performance in the central executive measure (backward digit span) occurred only at 210 min. Conclusion: positive cognitive effects of acute donepezil can be observed in various cognitive domains but its full nootropic potential is more clearly found at peak-plasma concentration.

Financial Support: FAPESP, AFIP, CAPES, CNPq.

AUTOMATIC ATTENTION EFFECTS AND WORKING MEMORY

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Automatic attention effects are commonly observed after the presentation of a spatially non-informative peripheral visual stimulus immediately before the presentation of a visual target stimulus in the same location or in a distant location. In some conditions, however, these effects do not appear. For instance, when the prime stimulus features are different from those of the target stimulus it does not usually produce any attentional effect. It can be supposed that the representation of the target stimulus in working memory causes similar prime-stimuli but not very different prime-stimuli to be processed to the point of mobilizing automatic attention. Another possibility is that the brain tends to filter out all stimuli that are irrelevant for task performance by inhibiting their processing so as to let the representation of the target stimulus stand out. This filtering would be difficult to perform when similar prime and other irrelevant stimuli occur but very easy to perform when different prime or other irrelevant stimuli occur. In this last case the prime-stimulus would not mobilize attention and the attentional effect would not appear. We performed an experiment in which we used Posner procedure and a go/no-go reaction time task to evaluate automatic attention. We observed an attentional effect for a relatively difficult to discriminate target stimulus and no attentional effect for a relatively easy to discriminate target stimulus. Both hypotheses above could explain these contrasting results. In a second experiment, using the same procedures, we demonstrated that by increasing the discrimination difficulty of the second target stimulus the attentional effect could be obtained. This result suggests that the brain tends indeed to inhibit processing of irrelevant stimuli, reducing their influence on behavior. This would be achieved, however, only when these stimuli are relatively distinct from the target stimulus.

Cesar Galera will present the following papers:

INTEGRATION OF VISUAL AND VERBAL FEATURES IN WORKING MEMORY.

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The dual tasks paradigm was used to investigate the involvement of attention in the binding of verbal and visual information in working memory, and the specific role of these components when they are integrated. Two experiments were carried out, with 33 subjects, who memorized sequences of Faces, Names, or face-name Conjunctions. In the Experiment 1, these conditions were performed in separate blocks, either alone or with a backward counting in threes (CR3). In Experiment 2, these conditions were performed in separate blocks, with Articulatory Suppression (AS) and Dynamic Visual Noise (DVN). The CR3 caused greater loss in the Conjunction than in the Faces and Names condition (Exp.1). The SA and the DVN have equivalent effect and they show more relevant effects in the Conjunction condition. The SA revealed more relevant effect than the DVN in the Face and Name conditions (Exp.2). The greater prejudice of CR3 in binding, compared to that obtained in Names and Faces suggested that the integration of visual and verbal features demanded the involvement of attention. Moreover, the differential effect of SA towards DVN in the storage of isolated visual and verbal features, suggests that they may be stored in different ways when integrated.

Financial Support: CAPES

APPEARANCE AND LOCATION ARE AUTOMATICALLY INTEGRATED IN VISUO-SPATIAL WORKING MEMORY.

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The separation between systems supporting memory for object and memory for location seems to be well established. However, there are several evidences suggesting that object and location are automatically integrated in visual working memory. We investigated this question in a recognition task that required the participants to memorize, in sequences of four objects, just the objects information (appearance or name) or just objects location. We suppose that, if recognition based on a relevant dimension (e.g. appearance) is disrupted by a change in an irrelevant dimension (e.g. location), we can infer that both dimensions have been automatically integrated in memory. The recognition of sequences based on appearance, but not the recognition of sequences based on names, is affected by changing the location of one object in the sequence. The recognition based on location is affected by both changes in object appearance and name. The effect of a change in location on the recognition based on appearance is greater than the effect of a change in appearance on the recognition based on location. These results suggest that appearance and location are automatically integrated in visuo-spatial working memory, but location seems to play a more central role on recognition than appearence.

Financial Support: FAPESP.

AUTOMATIC CODING OF STIMULI ORDER IN A VISUAL-SPATIAL TASK

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We investigated whether the order of objects in a sequence is automatically encoded by the visual appearance and position in which these objects were presented. We consider that, if the recognition based on a relevant dimension of the stimulus is disturbed by a change in an irrelevant dimension, it is possible to assume that the stored representation keeps the integrated traces of the relevant and irrelevant dimensions. The participants (n=60) evaluated the sameness of two sequences of objects characterized by visual appearance, spatial position and the binding of both dimensions (relevant dimensions). The order of the objects presentation (irrelevant dimension) could be equal or different in the two sequences. The results indicated a better memory performance in the spatial task followed by visual-spatial and a worse performance in visual task. The recognition accuracy in equal sequences (hit) was better than in different sequences (correct rejection). The performance is affected by changes in the stimuli order, and this occurs in different degrees for each relevant dimension; the interaction between relevant and irrelevant dimensions occurs only in spatial and visual-spatial tasks. These results suggest that the order is stored automatically, depending on the memorized relevant dimension.

Financial Support: CNPq

MECHANISMS AND PHYSIOLOGICAL CHANGES IN TASK INVOLVING WORKING MEMORY

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INTERACTIONS BETWEEN CORTICAL ACTIVITIES AND CARDIAC FREQUENCY DURING THE PERFORMANCE OF WORKING MEMORY TASKS

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The participation of circuits of the frontal lobes in executive functions can be explained by working memory (WM) tasks that require distributed connections over the cortex. Additionally, the emotional factor can bring about the contribution of other neuronal substrates including the autonomic nervous system. This study aims to investigate the correlations between cortical activities and autonomic responses. Changes in cortical activity during WM tasks were examined with electroenphalogram (EEG) and recorded simultaneously with a frequency cardiac (FC) monitoring system during the performance of the delayed (non) matching-to-sample tasks (DMTS/DNMTS) using pictures from the International Affective Picture System (neutral and emotional) and others of geometric figures as stimuli. The results (n=12; 6 male; ages: 18-24; ~19.5+/-0.582) demonstrated a significant difference between the tasks (DNMTS>DMTS; p= 0,041), considering the average of power of frontal and parietal derivations of EEG recording, and the heart rate variability parameters - pNN50 (DMTS>DNMTS; p=0.038), LF/HF (DNMTS>DMTS; p=0,012). This preliminary study indicates a trend that the DNMTS task expresses higher cortical activation concomitantly with the excitability as a result of heart rate, and yielded better understanding of the interactions between the central nervous system and the autonomic nervous system.

THE ROLE OF THE BASAL GANGLIA ON WORKING MEMORY ACCORDING TO THE MOSAIC OF BROKEN MIRRORS MODEL

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The basal ganglia (BG) were traditionally related to motor control; however, more recently, they have been recognized by many as a system specialized in action selection, a function that affects the triggering of motor programs that implement the selected actions. There is evidence that the BG can also select a limited number of information items that can be handled by the prefrontal cortex in operations that depend on working memory. The “mosaic of broken mirrors model” provides a mechanism by which the BG can do such a selection (Behav. Brain Res.199:157, 2009). It proposes that units of information encoded by the neocortex, such as symbols, words, digits, objects of the environment which the subject can manipulate, and locations the subject can approach, are projected to the striatum in a fragmented and repeated way, like a mosaic made by fragmented images of broken mirrors. These units also represent plans and parts of the body which can perform an action. The selection of the unit related to the proper action depends on the activation of a striatal unit by cortical neurons that are active at the same time and send convergent projections to that unit. This selection also depends on the release of dopamine in the striatum. The striatal units encoding the same information-action association send convergent projections to the internal segment of the globus pallidus and to the substantia nigra pars reticulata that stimulate or hold on the action through a thalamus-frontal cortex pathway. It is also by this mechanism that the prefrontal cortex can reduce the number of informational units that can be manipulated by the working memory central executive. Therefore, this model can explain the working memory problems caused by the abnormal level of striatal dopamine and/or lesions in components of the BG, as observed in Parkinson’s disease, schizophrenia, attention-deficit hyperactivity disorder, and other psychiatric and neurological diseases.

ENHANCEMENT OF FRONTAL LOBE METABOLISM THROUGH BIO-INTERACTIVE GAMING

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Rationale**:** The authors, in a 6 year-long experience with HEG neurofeedback, have observed considerable gains in impulse control, short term memory and reaction time amongst the persons trained. A clear case is made for increases in prefrontal metabolism for practical cognitive and physical gains. Methods**:** In order to make HEG neurofeedback training more palatable and engaging, one of the authors (AMVD) has adapted existing, popular arcade style video games to be driven by the player's increase in brain blood perfusion. Based on this new creation, a 15 person Brain Championship was held, using the game's scoring as an index of competence. Sessions in the championship lasted 30 minutes of perfusion training. Decrease mental and muscle latency were observed pre and post testing; self-perception reports revealed that the task made nearly all participants feel cognitively enhanced. Results**:** Considering that functional memory is chiefly related to decreases in mental latency, and that changes in self-perception in part correspond to changes in organic functioning, this experiment leads to the conclusion that HEG neurofeedback in association with the new brain video games that we have introduced may represent a valid methodology for the enhancement of working memory amongst persons without specific cognitive abnormalities.

RESPONSE DELAY INVOLVEMENT IN RETROSPECTIVE TIME ESTIMATIONS FOR MUSIC TONAL MODULATIONS MAY REVEAL THE DUALITY OF EXPLICIT AND IMPLICIT EXPRESSIONS OF WORKING MEMORY

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Firmino and Bueno (2008) found time underestimations relative to music filled by tonal modulations. Longer distances between musical keys reduce the subjective time more than shorter ones. If such pathways include intermediate keys, the reduction impact is smaller. These results were explained by the expected development fraction model (EDF-model) containing an implicit working memory process, since both stimulus and behavior were non-verbal. Participants were instructed about the reproduction of the music duration through stopwatch immediately after listening. By contrast, a subsequent experiment showed that if the time between the ending of the stimulus and the beginning of the task is hardly shortened due to a very small instruction, occasional time overestimations appear, although maintaining the pattern of lesser time estimations in inverse function of interkey distances. In turn, we propose the Contextual EDF-model considering verbal/visual information captured from environment/thought during music listening. Such contextual information is weakly kept by a short-term central executive process during time estimation simultaneously with the implicit musical information provided by the EDF-model. Thus, the concern of an explicit and implicit working memory duality is discussed in light of the Contextual EDF-model, the multi-component model, and other models of psychological time and tonal sense.

Financial Support: CNPq.

WORKING MEMORY AND DEVELOPMENT

WORKING MEMORY AND LEARNING: A LONGITUDINAL STUDY OF TRILINGUAL CHILDREN

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The aim of the present study was to investigate the contribution of two working memory systems (the phonological loop and the central executive) to children's learning in the areas of vocabulary, language comprehension, reading, spelling, mathematical skills, and foreign language acquisition. The term working memory refers to the ability to store and manipulate information in mind for a brief period of time, in the course of ongoing cognitive activities (Baddeley, 2000). A sample of 119 Luxembourgish children, learning German and French as secondary languages were assessed longitudinally over a 3-year time period. In Luxembourg, children learn to speak, read, and write in two languages that are different from their native language Luxembourgish. A battery of working memory, and learning ability tests were administered. Children were tested in kindergarten (5 years of age), in first, and in second grade with a one year interval between each testing wave. Multiple assessments of each construct made it possible to construct latent variables, and apply structural equation modeling techniques to explore the underlying theoretical structure of working memory in young children, and possible links with learning. Results indicate that relations between the working memory measures were best characterized by a model consisting of two related but separable constructs corresponding to the phonological loop and the central executive. Individual differences in phonological loop functioning and the central executive were found to be remarkably stable from kindergarten through second grade. The data further showed that both memory components were differentially associated with learning: Whereas the phonological loop was more specifically linked to early language development and vocabulary in particular, the central executive appeared to make more general contributions to classroom related learning. The findings lend strong support to the position that the phonological loop is one of the main contributors to new word learning in both native and non-native languages by supporting the formation of stable phonological representations of new words in long-term memory. Furthermore the findings fit well with the position that the central executive might play an important role in the monitoring and processing of information during complex and

demanding activities present in many classroom situations. In conclusion, the presented evidence of (a) the stability of individual differences in young children's working memory capacity and, (b) causal relations of working memory with learning reinforces the value of early screening of working memory abilities to identify children who are at risk of poor academic progress over the coming years.

VISUAL WORKING MEMORY DEVELOPMENTAL TRAITS: VALIDITY EVIDENCE IN A BRAZILIAN SAMPLE

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Introduction*:* Development of working memory has been attributed to the protracted maturation of prefrontal cortex, beginning in early childhood and continuing into adult age. However, few studies have replicated such pattern of development in a Brazilian sample, and there is also lack of validity evidences of neuropsychological instruments in Brazil. This study examined the developmental trajectories of visual working memory (VWM) and sought for validity evidences of a computerized VWM task. Method*:* Participants were 626 individuals in nine age groups (6, 7, 8, 9, 10, 11, 12, 13, 14, and 20 or older but no older than 37 years old) who carried out one computerized VWM task. Results*:* Analysis of variance to examine developmental trends revealed that continuation of VWM performance was seen among 9, 10, 11, 12, and 13 years old. The group of participants with age between 20 and 37 had significant superior performance when compared to all other groups. Conclusion*:* These data suggest that VWM process develops at different rates and continue increasing into adult life. This corroborates development theories about trajectories of VWM in a Brazilian sample and provides validity evidences for this computerized way of evaluation, which showed sensitivity to discriminate individual performances through various ages.

Financial Support: FAPESP, CNPq.

MEMORY AND STRESS IN PRE-COLLEGE STUDENTS: EFFECTS OF MANUAL THERAPY.

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Career choice and college entrance exams are stressful situations for students, which may impair cognitive performance. Thus, therapeutic strategies to cope with stress could be useful. Here, the perceived stress index (PSI) and performance in tests of episodic and working memory were evaluated in 54 students, aged 17-27, allocated in two groups: one (MTG, n=26) that received manual therapy (lymphatic drainage and muscle mobilization) from September to November and the control group (CG, n=28) that received no therapy. Rey Auditory Learning Test (RALT), Logical Memory Test (LMT) and Digit Span Test were used to assess episodic and working memories in November, one week before the exams. There was significant reduction in the PSI for MTG (154.5±34.3 vs. 139.9±39.8; p=0.02; t-Student Test) after the period of manual therapy, but no difference was found for CG (137.6±27.6 vs. 144.3±37.5; p=0.45; t-Student Test). MTG performed better in RALT delayed recall (p=0.025; Mann-Whitney Test) and LMT immediate recall (p=0.005, ANOVA) as compared to CG. These results support manual therapy as an effective coping strategy in stress situation favoring more efficient cognitive performance.

WORKING MEMORY IN CHILDREN ASSESSED BY THE BROWN-PETERSON TASK.

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Working memory is a cognitive skill that contributes to development of language and reading and writing acquisition. Continuous evaluation of working memory in pre-school and school aged children is shown to be important for early identification of possible learning impairment. The present study aims to evaluate development of working memory along the first school grades of basic education and check the applicability of the Brown-Peterson Task in children's memory skills assessment. One hundred and three children, 63 males, with mean age of 9.75, recruited from 1st to 6th grade of basic school participated in the study. Participants were assessed with the Brown-Peterson Task, the Digit Span forward and the Digit Span Backward. Results were compared for the variables of sex, age and grade. The score on the Brow-Peterson Task showed increase along the grades and age groups. Linear decrease in scoring was shown in longer interference intervals. Positive correlation was found between the Brown-Peterson Task and Digit Span, yet the Brown-Peterson Task proved to differentiate better between school grades. The study confirmed continuous development of working memory during basic education indicating late maturation of related brain areas. The Brown-Peterson Task proved to be an adequate tool for assessment of working memory in children.

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Fernando Capovilla will present the following papers:

STANDARDIZATION OF COMPUTERIZED PICTURE RECOGNITION MEMORY TEST (PRMT): NORMS OF RECOGNITION SCORE, RECOGNITION DURATION, AND RECOGNITION RATE FOR 1ST-4TH ELEMENTARY-SCHOOL GRADERS

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The Computerized Picture Recognition Memory Test (PRMT) was standardized with 337 1st-4th elementary-school graders. PRMT requires memorization of 112 pictures under four exposure durations (.5, 1, 1.5, 2 sec) and three sequence sizes (4, 8, 16 pictures). Anovas followed by post-hoc pair-wise tests revealed PRMT scores and points-per-minute increased (while response times decreased) along successive school-grade levels. Norms are: For 1st graders: those very delayed (VD) (-3to-1dp) scored 45-60 points in 6,9-8,1 min (0-7 points/min); delayed (D) (-2to-1dp): 61-77 in 5,6-6,8 (8-15 points/min); average (M) (-1to+1do): 76-108 in 3,1-5,5 (16-31 points/min), advanced (A) (+1to+2dp): 109-112 in 1,8-30 (32-39 points/min), very advanced (VA) (+2to+3dp): 112 in 0,5-1,7 (40-48 points/min). For 2nd graders: VD: 66-76 in 5,2-5,9 (10-15 points/min); D: 77-88 in 4,4-5,1 (16-20 points/min); M: 89-11 in 2,9-4,3 (21-34 points/min); A: 110-112 in 2,1-2,8 (35-41 points/min), VA: 112 in 1,3-2,0 (42-47 points/min). For 3rd graders: VD: 67-78 in 5,5-6,4 (4-13 points/min); D: 79-89 in 4,5-5,4 (14-21 points/min); M: 90-110 in 2,6-4,4 (22-39 points/min); A: 110-112 in 1,6-2,5 (40-49 points/min), VA: 112 in 0,6-1,5 (50-57 points/min). For 4th graders: VD: 79-97 in 4,8-5,4 (12-17 points/min); D: 88-95 in 4,1-4,7 (18-24 points/min); M: 96-111 in 2,8-4,0 (25-39 points/min); A: 112 in 2,1-2,7 (40-45 points/min); VA: 112 in 1,4-2,0 (46-52 points/min).

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RELATIONSHIP BETWEEN PHONOLOGICAL LEXICON AND PICTURE RECOGNITION MEMORY IN ELEMENTARY-SCHOOL CHILDREN

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If sub-vocal naming is involved in picture memorization and subsequent recognition, then there must be positive correlation between phonological lexicon size (the repository of spoken names that allows one to sub-vocally label pictures) and picture recognition memory (RM) skill. In this study 337 1st-4th elementary-school graders were exposed to Picture Auditory Vocabulary Test (PAVT) and Picture Recognition Memory Test (PRMT). PRMT requires memorization of 112 pictures under four exposure durations (.5, 1, 1.5, 2 sec) and three sequence sizes (4, 8, 16 pictures). PAVT presented 92 sets of 4 pictures each and required students to choose pictures to match spoken words. Anovas followed by post-hoc pair-wise comparison tests revealed that PRMT and PAVT scores significantly increased with school-grade level. PRMT was validated internally (RM decreased as sequence size increased and exposure duration diminished) and externally (regression of PRMT scores upon PAVT scores revealed positive significant correlation: Covariant Analysis of PRMT scores as function of PAVT score level, having controlled the effect of school-grade level as covariant, revealed that RM increased strongly with vocabulary level). Such findings suggest that internal speech promotes picture RM, supporting the notion that internal speech fosters picture RM, and that interventions to increase phonological lexicon (vocabulary size) may benefit RM in children.

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STRONG EVIDENCE OF SUB-VOCAL SPEECH INVOLVEMENT IN IMAGE (PICTURE X NON-PICTURE) RECOGNITION MEMORY BY COLLEGE STUDENTS

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Because pictures can be sub-vocally named, they allow double processing (primary visual, secondary phonological), whereas non-pictures allow only visual processing. Because secondary processing demands time, short exposure time hinders sub-vocal naming, especially during long image sequences. This study tested whether picture recognition memory (RM) is higher than non-picture RM, and whether such picture RM advantage decreases as exposure time is diminished, especially in long sequences of pictures to be memorized. Participated 103 college students who were exposed to IRMT (Image Recognition Memory Test) and had to memorize 620 images (310 pictures and 310 non-pictures) presented with different exposure duration (.5, 1, 1.5, 2, 2.5 sec) and sequence size (4, 8, 16, 32, 64 images per sequence). RM scores were computed as function of image type, exposure time, and sequence size. Results revealed that: 1) picture RM is greater than non-picture RM, 2) image RM increases with the increase in exposure duration, 3) exposure duration benefits more picture RM than it does non-picture RM, 4) image RM decreases with the increase in the sequence size, 5) increase in sequence size hinders non-picture RM more than it does picture RM. Such findings fully support the notion that internal speech fosters picture RM.

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AUTHORING TOOL FOR CREATING COMPUTERIZED IMAGE (PICTURE X NON-PICTURE) RECOGNITION MEMORY TESTS

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The authoring tool FaberMemo permits developing computerized image recognition memory tests in psychology for clinical, educational and scientific purposes. FaberMemo permits controlling the effects several variables, such as the type of the images to be shown (pictures versus non-pictures), the time during which each image is to be shown (image exposure time: from .5 sec to 4 seconds per image), and the number of images to be presented at each sequence (sequence size from 4 to 64 images per sequence). It was developed in the platform Access 2005, and permits recording recognition scores and recognition time as function of image type, image exposure time, and number of images in sequence. Pictures are line-drawings that depict well-known referents; non-pictures contain the same line segments but arranged in random order so as to prevent recognition and naming. FaberMemo contains an image bank of 630 pictures, and their corresponding 630 non-pictures to be used in memory tests. In the bank, each picture has a precisely determined degree of name agreement (standardized for 3-18 year old students) and its corresponding picture-name has a precisely determined degree of orthographic familiarity standardized for 4-10 year old students. FaberMemo is being published and will be fully demonstrated.

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PRELIMINARY EVIDENCE OF VISEMIC-LALEMIC REVERBERATION INVOLVEMENT IN PICTURE RECOGNITION MEMORY SKILL IN PRESCHOOLERS

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Phonological lexicon (as assessed via Auditory Vocabulary Test: AVT) enables understanding spoken words. Visemic lexicon (as assessed via Orofacial Reading Vocabulary Test: ORT) enables understanding spoken words in the absence of sound. Both lexicons permit coverting a sequence of pictures into a sequence of names thus enabling subvocal rehearsal of those names. Phonologically-formed words are rehearsed in the phonemic-lalemic loop. Visemically-formed words are rehearsed in the visemic-lalemic loop. Theoretically, the greater the lexicons, the greater the memory (as assessed via Picture Recognition Memory Test: PRT). This study investigated the relationship between phonological lexicon (AVT scores), visemic lexicon (ORT scores), and visual recognition memory skill (PRT scores), as well as their development, in 43 hearing preschoolers aged 4-6 years old. Results showed significant positive correlation between AVT-PRT and ORT-PRT scores (the greater the phonological lexicon or visemic lexicon, the greater the recognition memory). Results also showed that orofacial reading skill (ORT scores) increased significantly above chance level only when children acquired literacy at 6 years of age. Results suggest that, when children become literate, they can begin to lipread, and use their recently-acquired visemic-lalemic loop to rehearse picture names so as to better recognize those pictures when they see them again.

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