

INTERNATIONAL MEETING: WORKING MEMORY AND ITS RELATIONSHIP WITH OTHER MEMORIES

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ABSTRACTS

Working memory and cognitive development

ARE WORKING MEMORY MEASURES FREE OF SOCIO-ECONOMIC AND CULTURAL INFLUENCES?

Engel PMJ*, Santos FH, Martin R, Gathercole SE

*University of York.

*e-mail: p.engel@psychology.york.ac.uk

This research investigated the hypothesis that working memory skills are independent of environmental factors such as socio-economic or cultural background. Study 1: Twenty Brazilian children aged 6 and 7 years from low socio-economic status families were evaluated on measures of working memory (verbal short-term memory and verbal complex span, taken from the AWMA: Automated Working Memory Assessment) and of vocabulary (expressive and receptive). They were compared with typically developing Brazilian children from the same region, matched on age, sex, and nonverbal ability from families of higher socio-economic status. Children from the low socioeconomic status group obtained significantly lower scores on the vocabulary tests but not on the verbal short-term memory measures, compared to their peers from a higher socio-economical background. Both groups differed on one of the two complex span measures – counting recall - but performed equally well on backwards digit recall. The results indicate that tests of verbal short-term memory and also backwards digit recall provide measures of cognitive abilities that are not biased by the quality of the child's socio-economical background.

Study 2: The Brazilian children were also compared to a population of Portuguese-speaking, immigrant children growing up in Luxembourg, evaluated on the same measures. Results will specify whether or not, in addition to being independent of socioeconomic background, verbal short-term memory and backwards digit recall are also free of cultural bias. As these measures are also highly sensitive to language ability, they may provide useful methods for diagnosing language disorder that are independent of environmental opportunity.

LINKS BETWEEN WORKING MEMORY, PHONOLOGICAL AWARENESS, AND LANGUAGE LEARNING: EVIDENCE FROM CHILDREN IN A MULTILINGUAL SOCIETY

Engel PMJ*, Gathercole SE

*University of York.

*e-mail: p.engel@psychology.york.ac.uk

The aim of the study was to investigate the relationship between working memory, phonological awareness and developing language skills in a population of children growing up in a multilingual context involving the three languages of Luxembourgish, German, and French. A sample of 122 children from Luxembourg aged 5 to 7 years participated in the study, completing assessments of phonological short-term memory, complex working memory, phonological awareness, native and foreign vocabulary knowledge, language comprehension and reading. The data were best

characterized by a model of working memory that consisted of two related but separable components – corresponding to phonological short-term memory and the central executive – that were distinct from phonological awareness. Language abilities in both the native and foreign languages were more strongly associated with phonological short-term memory than other factors in the model. The findings lend strong support to the proposal that vocabulary learning in particular is mediated, in part at least, by phonological short-term memory.

WORKING MEMORY, EPISODIC MEMORY AND MATHEMATICAL SKILLS IN CHILDREN

Santos FH

Universidade Estadual Paulista, UNESP/Assis.

e-mail: flaviahs@assis.unesp.br

We obtained normative data from 164 Brazilian children aged from 5 to 12 years of age for working memory, episodic memory and mathematical skills. The children were divided in two groups: rural (N=73) and urban (N=91). Group differences were not found for Corsi block tapping test, Brazilian children's test of pseudoword repetition, semantic and phonological verbal fluency, visual recognition of abstract patterns, free recall of words, copy and recall of complex figure. Age effect was observed in all tasks. Correlations between mathematical skills (Zareki-R) and memory tasks were found. The results suggest that these memory tasks are culture-free and both memory systems are related to mathematical skills.

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RELATIONSHIP BETWEEN WORKING MEMORY AND STUTTERING: REPORT ON A GROUP OF CHILDREN WHO STUTTERED

Barbosa LMG

Psicologia do Centro Universitário Nove de Julho.

e-mail: luciabarbosa@uninove.br

The verbal performance of 15 children who stutter (group S) was compared to that of 15 children who do not (group NS). Groups were matched in terms of age and gender. The mean scores obtained in the subtests which are part of the "Wechsler Intelligence Scale for Children. WISC-III" (Wechsler, 1994) Verbal Scale, the Verbal Intelligence Quotient (VIQ) and the Verbal Comprehension Factor (VC) were assessed. A t-test revealed significant differences between the two groups for the subtests Information, Similarities and Digit Span, for the VIQ and also for the VC Factor. It was suggested that the difficulties showed by the children who stutter were related to the pre-motor level of speech processing and that their verbal performance was not successful because of the inefficiency of working memory. Specifically, they faced problems to select and adopt effective cognitive strategies.

Working memory, stimulation and training

WORKING MEMORY AND THE ACQUISITION OF IMPLICIT MEMORIES

Helene AF, Xavier GF*

*Instituto de biociências, Universidade de São Paulo

*e-mail: gfxavier@usp.br

This study investigated acquisition of a mirror-reading skill via imagery training, without the actual performance of a mirror-reading task. In Experiment I, healthy volunteers simulated writing on an imaginary, transparent screen placed at eye level, which could be read by an experimenter facing the subject. Performance of this irrelevant motor task required the subject to imagine the letters inverted, as if seen in a mirror from their own point of view (imagery training). A second group performed the same imagery training interspersed with a complex, secondary spelling and counting task. A third, control, group simply wrote the words as they would normally appear from their own point of view. After training with 300 words, all subjects were tested in a mirror-reading task using 60 non-words, constructed according to acceptable letter combinations of the Portuguese language. Compared to control subjects, those exposed to imagery training, including those who switched between imagery and the complex task, exhibited shorter reading times in the mirror-reading task. Experiment II employed a 2 x 3 design, including two training conditions (imagery and actual mirror-reading) and three competing task conditions (a spelling and counting switching task, a visual working memory concurrent task, and no concurrent task). Training sessions were interspersed with mirror-reading testing sessions for non-words, allowing evaluation of the mirror-reading acquisition process during training. The subjects exposed to imagery training acquired the mirror-reading skill as quickly as those exposed to the actual mirror-reading task. Further, performance of concurrent tasks together with actual mirror-reading training severely disrupted mirror-reading skill acquisition; this interference effect was not seen in subjects exposed to imagery training and performance of the switching and the concurrent tasks. These results unequivocally show that acquisition of implicit skills by top-down imagery training is at least as efficient as bottom-up acquisition.

THE ROLE OF WORKING MEMORY IN IMPLICIT ACQUISITION BY IMAGERY TRAINING

Helene A F

Associação Alberto Santos Dumont para Apoio à Pesquisa.
e-mail: afh@ib.usp.br

The working memory model assumes that a controlling attentional system, the central executive, supervises and coordinates the activity of functions that require temporary storage and manipulation of information, also involved in visual imagery. In a group of experiments we investigated acquisition of visual and motor skills (mirror-reading task) via imagery training, without the actual performance of the task. The results unequivocally show that acquisition of implicit skills by top-down imagery training is at least as efficient as bottom-up acquisition and indicate that imagery could be an useful instrument either in practical and theoretical issues, such as evaluating new perspectives in understanding learning and memory process and systems, or in rehabilitating patients with either perceptual or motor skill disturbances produced by brain dysfunctions, neurodegeneration and cerebral damage.

NEURAL CORRELATES ASSOCIATED WITH STRATEGIC MEMORY TRAINING

Miotto EC

Serviço de Saúde da Divisão de Psicologia, Hospital das Clínicas, Faculdade de Medicina da Universidade de São Paulo.
e-mail: ecmiotto@usp.br

Background: the prefrontal cortex (PFC) has been implicated in the ability to apply semantic

organizational strategies in verbal encoding and episodic learning. However, there has been no direct evidence demonstrating an improvement in performance and its neural correlate after semantic strategic memory training. The aim of the present study was to investigate which specific areas in the PFC are engaged before and after a cognitive training using semantic strategies. Methods: We studied 15 right handed normal subjects using a block design fMRI acquisition (GRE EPI TR: 2s / TE: 40ms / 15 axial slices - AC-PC / 3.125 x 3.125 x 7.7 mm voxels) in a 1.5 T magnet. Subjects were studied during the encoding of word lists presented in 3 conditions: unrelated, related non-structured and related structured. All stimuli were visually presented on a screen, and synchronized with the scanner RF pulse. After each run, the volunteers were checked for word list recall. Results: There was a significant activation in the bilateral dorsolateral prefrontal (DLPF) and orbitofrontal (OFC) after cognitive training only in the related non-structured and unrelated conditions. These activations were correlated with an improvement in word list recall. Conclusions: The results demonstrated the engagement of the bilateral DLPF and OFC cortex during strategic memory processes. They also showed the participation of these areas only when mobilization and implementation of effective use of strategies were required.

EFFECTS OF TRANSCRANIAL DIRECT CURRENT STIMULATION ON WORKING MEMORY

Boggio PS

Centro de Ciências Biológicas e da Saúde, Universidade Presbiteriana Mackenzie.
e-mail:boggio@mackenzie.br

Transcranial direct current stimulation (tDCS) is a capable technique to modulate cortical excitability in a safe, painless and noninvasive manner. This technique of brain stimulation can be used as a research tool of neuropsychological functions. We aimed to investigate the effects promoted by tDCS on working memory (WM) in healthy volunteers and Parkinson's disease (PD) patients. Fifteen health volunteers and 18 PD patients underwent a 3-back letter WM paradigm during sham, anodal or cathodal tDCS applied over the left dorsolateral prefrontal cortex (DLPFC) and primary motor cortex. Results of both groups indicate that only anodal stimulation of the left DLPFC increases response accuracy when compared to sham stimulation. Results showed that the effect of tDCS depends on the stimulation polarity and is specific to the site of stimulation. The observed improvement might be explained by an increase in the local excitability of the DLPFC. In conclusion, tDCS can be used as an interesting tool in cognitive neuroscience studies and neuropsychological rehabilitation.

Working memory for visuospatial information

LORAZEPAM AFFECTS DEDUCTIVE REASONING

Pompéia S*, Manzano GM, Pradella-Hallinan M, Bueno OFA

*Departamento de Psicobiologia, Universidade Federal de São Paulo.

*e-mail: spompeia@gmail.com

Rationale: Benzodiazepines slow logical thinking when a verbal-based spatial relational reasoning task is used, but which phase of reasoning is affected, and whether this effect generalizes to other types of relations is unknown. Methods: This was a double-blind, cross-over design study of acute oral doses of lorazepam (2 mg) and placebo using young healthy volunteers. We focused on response delay of three temporally separable phases of deductive reasoning and matched working memory maintenance tasks: the premise processing phase, the premise integration phase, and the

validation phase, in which reasoners decide whether a conclusion logically follows from the premises (reasoning task) or is identical to one of the premises (maintenance task). Type of relations in the premises was also manipulated: difficult to envisage visually and visuospatially (“subconic”), and material easy to envisage visually or visuospatially. Results and Conclusion: Acute lorazepam administration affected reasoning processing in two ways: it slowed processing unspecifically when working memory demands increased in the premise integration phase, and increased validation time depending on the difficulty (subconic>visual>visuospatial) in generating and/or manipulating mental representations by the central executive.

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THE STORAGE CAPACITY IN WORKING MEMORY DERIVED FROM DEFINED STIMULUS THROUGH THE CONJUNCTION OF VISUAL AND AUDITORY CHARACTERISTICS

Caprio M, Galera CA*

* Faculdade de Filosofia Ciências e Letras de Ribeirão Preto, Universidade de São Paulo

*e-mail: cesar_galera@ffclrp.usp.br

This present study has the objective of investigating the working memory model proposed by Baddeley and Hitch (1974). At first, this proposed model, considered the existence of three subsystems: fonological storing; visual-spatial and the central executive. In 2000, after some revisions over the initial model, Baddeley proposes the existence of one more component for the model: one episodical storing which function is providing the interface among the systems (visual-spatial storing and fonological link) and the long-term memory and it is responsible for the integration of the multi-modal information. The objective of this study is discussing the revision of the model proposed by Baddeley, specifically in relation the episodic buffer. From the task of spatial localization, we have made four experiments using the visual information, face schemes, the fonological, people’s names, objects and pseudo words, and the conjunction of the two categories. Our results present the possible existence of this buffer, especially in relation to the conjunction of the multi modal information.

DOES THE VIVIDNESS OF MENTAL IMAGERY DEPEND ON VISUO-SPATIAL MEMORY CAPACITY?

Araújo M, Galera CA*, Marques SL

* Faculdade de Filosofia Ciências e Letras de Ribeirão Preto, Universidade de São Paulo

*e-mail: cesar_galera@ffclrp.usp.br

Experimental evidence suggests that vividness of visual mental imagery depends on short-term visual memory. Intervent tasks that disrupt visual memory also impair vividness of imagery. We investigated if the vividness of visual imagery could be correlated to the span of visual and spatial memory. The kind and vividness of imagery was established through the Object-Spatial Imagery Questionnaire (OSIQ, Blajenkova et al., 2006) and through the Visual Vividness Imagery Questionnaire (VVIQ, Marks, 1973). The spans of visual and spatial memory were estimated through a visual pattern span test (VPS), and Corsi Block Test (CBT). The results obtained with 75 healthy subjects (58 women) indicate significant correlation between VPS-CBT ($R = 0.30$; $p = 0.01$), VPS and Spatial-OSIQ ($R = 0.23$; $p < 0.05$), and between the Object and Spatial components of OSIQ ($R = -0.25$; $p < 0.05$). The results are discussed according to the working memory model.

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Using the working memory concept

FALSE MEMORIES PIT THE ADVANTAGE OF THE GENERATION EFFECT

Mojardín-Heráldez A

Laboratorio de Investigación sobre Memoria y Aprendizaje, Facultad de Psicología, Universidad Autónoma de Sinaloa

e-mail: amojardin@yahoo.com.mx

The Generation Effect (GE; memory advantage for learning materials that was generated by subjects, compared to learning material that was received from others) is a strong memory phenomenon that offers dangerous ways to create False Memories (FM; memories that differ from what was experienced). Recent studies have shown that when subjects generate new information, they obtain a memory advantage for that information, but also greater rates of FM. The present study reports on three experiments that evaluated the association between GE and FM, having associate words, sentences and pictures as learning materials. All results indicate that when subjects generate information, they obtain memory advantages for that information, but at the same time create conditions to improve the rates of FM. Implications of these results are discussed, having Fuzzy-trace theory as the theoretical framework.

FALSE MEMORIES ABOUT TRUE EMOTIONS: THE EFFECT OF EMOTIONAL LABELING ON MEMORY

Stein LM*, Rohenkohl G, Brainerd CJ

*Pontifícia Universidade Católica do Rio Grande do Sul.

*e-mail: Lilian@pucrs.br

Recently, some hypotheses have been tested regarding how emotion affects memory illusions. In most studies, emotion is assumed to involve two dimensions: valence and arousal. The present study investigated the effect of a new dimension: whether stimuli represent emotion concepts themselves (e.g., sorrow and satisfaction) as opposed to equally affectively arousing stimuli that do not represent emotions (e.g., spider and music). This new variable, called emotional labeling, may induce autobiographical elaboration that could differently affect false memory responses in the DRM paradigm. In a series of studies, we explored the effect of emotional labeling, using the Brazilian version of the DRM paradigm, which included positive and negative lists. Each of the lists was related to a critical distractor that was either an emotional label (e.g., sorrow) or not (e.g., spider). Semantic relatedness (BAS and FAS) and arousal were equated across the lists. Overall, results from recognition tests indicated that emotional labelling affected both false and true memory rates. Negative emotional label lists produced more false recognition as compare to negative non-label lists and positive lists. Results are discussed in light of fuzzy-trace theory.

WORKING MEMORY AS AN ESSENTIAL COMPONENT IN ADDICTION TO DRUGS OF ABUSE

Nakamura-Palacios, EM

Departamento de Ciências Fisiológicas, Universidade Federal do Espírito Santo.

e-mail: esma@terra.com.br

Cellular and molecular mechanisms involved in learning and memory processes seem to be very similar or even the same as those involved in the drug-induced reorganization of neural circuitry that occurs during addiction. Using a classic working memory task in animal learning, a radial maze, we demonstrated that different drugs of abuse administered directly in the mPFC disrupted working memory. We also demonstrated that this disruptive effect involves dopaminergic, glutamatergic and opioidergic mediation in the mPFC. The mPFC is part of a brain reward circuitry; therefore, the working memory dysfunction induced by drugs of abuse may be strongly related to addiction.

AN IMPLICIT WORKING MEMORY IN TIME AND TONALITY SENSE OF MUSIC LISTENING

FirminoEA*, Bueno JLO

*Departamento de Psicologia e Educação, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo

*e-mail: ericoaf@yahoo.com

This work investigated the underlying memory and expectation of time and tonality sense in music listening. One experiment described the effects on retrospective reproductions of sudden and gradual modulations to close and distant keys. The results showed that modulations elicit time underestimations as an inverse function of interkey distances, with a major impact from sudden modulations. A proposed expected development fraction model describes memory and expectation roles during the interkey crossing. The expected development (semantic memory) is longer than the perceived duration (implicit working memory, IWM). This disproportion is applied over IWM-duration, leading to underestimation. Tonality and its time have coherence and implicit expression. Since participant needs to recover the image of the stimulus or its duration to accomplish the task, and this image has to be retained only during the short period of the test, the data suggests the mediation of an implicit working memory.

WORKING MEMORY FOR TONES, WORDS AND PSEUDOWORDS IN SINGERS

Benassi-Werke ME*; Bueno, OFA, Queiroz MG, Araújo RS, Oliveira MGM

Departamento de Psicobiologia, Universidade Federal de São Paulo

e-mail: marianawerke@yahoo.com.br

In Baddeley's working memory model (2003), the phonological loop is a temporary acoustic-verbal storage system, necessary for short-term recall of verbal material. Some authors suggest that non-verbal melodic material can be processed by this same loop, but others suggest that musical material is processed by an independent loop. However, no studies were designed to test these hypotheses. **Objective:** To verify whether the same short-term loop of working memory can equally manage (numbers and pseudowords) and non-verbal (tones) sounds. **Method:** Forward (FS) and backward (BS) tests of digit, pseudowords and melodic spans were applied in two groups: amateur singers (n=15) and professional singers (n=14). For the analysis of the data we used a three-way ANOVA for repeated measures and a two-way ANOVA for repeated measures to analyze indexes (FS-BS/FS), and Newman-Keuls *post hoc* tests. **Results:** The two groups didn't differ in recall of digits and pseudowords, but the amateur group presented a smaller melodic span than the professional group (p<0,05). The indexes analysis showed that digit span and pseudoword span didn't differ from each other but the melodic span differed from the other two in both groups (p<0,05). **Conclusion:** Musical professional experience is important to the recall of tones, so much

in the FS as in the BS, but the present results suggest that melodic and verbal sounds do not share the same phonological loop of the working memory, as both professional and amateur singers presented a disproportionately higher decline of melodic BS span, compared to verbal material spans.

Working memory and cognitive disorders

THE ASSESSMENT OF EXECUTIVE FUNCTIONS IN ELDERLY PATIENTS WITH ALZHEIMER'S DISEASE: CLINICAL AND FUNCTIONAL CORRELATIONS

Diniz CMC, Carvalho FCR, Minett TSC, Bueno OFA, Bertolucci PHF*

*Departamento de Neurologia Clínica, Universidade Federal de São Paulo

*e-mail: paulohb@neuro.epm.br

Objective: To verify the presence of changes in executive functions (EF), by neuropsychological tests, in aged patients with early Alzheimer's disease (AD) and the intensity of the association between performance in tests, functional level and behavior. **Method:** Cross-sectional study, with examiner blind to the diagnosis of the individuals. **Sample:** 23 AD patients and 33 normal controls, 60 years or older and MMSE 24 points or higher. All had biochemical tests, cerebral image examination, clinical and neurological evaluation and underwent a battery of five executive functions tests. **Results:** The AD patients were impaired compared with controls in four of the EF tests: Brown-Peterson's Task, phonetic and semantic verbal fluency (VF), Trail Making Test and Wisconsin Card Sorting Test (WCST). Considering the analysis of logistic regression, VF - fruit was the test that better discriminated the groups independently of age and education. VF - fruit and digit span backwards had strong correlation with functional level. Brown-Peterson's Task and WCST had strong correlation with behavior. **Conclusions:** Since initial phases of AD, it is possible to identify important changes on the EF. VF - fruit was able to discriminate the groups and had a strong correlation with the functional level.

CORSI BLOCK TAPPING TEST IN ALZHEIMER'S DISEASE

Guariglia CC*, Nitrini R

*Grupo de Neurologia Cognitiva e do Comportamento, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo

*e-mail: carlaguariglia@yahoo.com

Corsi Block tapping test (CB) were developed in 1971 as a non-verbal task to measure spatial memory. The original apparatus consisted of a set nine cubes arranged irregularly on a board. The cubes are tapped by the examiner in novel sequences of increasing length. The participant are required to reproduce each sequence immediately.. The results are influenced by schooling, gender and age. Patients with Alzheimer disease (AD) have a decline in working memory because of central executive impairment. The goal of the study was to evaluate working memory in AD patients with the CB. Thirty subjects and 30 probable AD patients with 8 or more years of schooling were evaluated with the Mini Mental, digit span and CB. AD patients had impairment working memory but there were no differences between control subject and mild dementia patients, concluding that in this population working memory was not impaired in early stage of AD.

LACK OF IDENTIFICATION OF COGNITIVE IMPAIRMENT IN THE ELDERLY BY THE GENERAL PRACTITIONER IN BRAZIL – EVALUATION OF WORKING

MEMORY AS A SCREENING TOOL

Jacinto AF*, Porto CS, Brucki SMD, Nitrini R

*Grupo de Neurologia Cognitiva e do Comportamento, Departamento de Medicina Interna, Hospital das Clínicas da Universidade de São Paulo.

*e-mail: alessandrojacinto@uol.com.br

Objectives: To verify if elderly patients have their cognitive impairment diagnosed by general practitioners. Methods: A sample of elderly patients followed by general practitioners were randomly selected and submitted to a cognitive and functional evaluation by a geriatrician. Several tools were used and MMSE and/or IQCODE scores were initially chosen to classify these individuals into possibly cognitive impaired or not. Digit-span (backwards) was one of the tools used. General practitioners' files of the possibly cognitive impaired patients were checked. Results: 248 patients were screened and 52 (20%) were classified as possibly impaired. There was statistically significant difference on Digit-span (backwards) between possibly impaired and non-impaired patients. Almost no mention of cognitive impairment was found in the general practitioners' files. Conclusion: Our findings reinforce the knowledge that general practitioners usually do not diagnose cognitive impairment in their working sets. Working memory is thought to be impaired in early stages of dementia. Evaluation of working memory as a screening instrument was statistically significant in this study.

EFFECT OF CORTISOL LEVELS ON WORKING MEMORY PERFORMANCE

Souza-Talarico JN* Chaves EC, Caramelli P, Nitrini R

*Grupo de Neurologia Cognitiva e do Comportamento, Departamento de Medicina Interna, Hospital das Clínicas da Universidade de São Paulo.

*e-mail: juli3@bol.com.br

Background: Cortisol levels can interfere with declarative memory performance of the elderly with or without cognitive impairment. Objective: To investigate the correlation between cortisol levels and working memory performance of healthy cognitive elderly and patients with mild Alzheimer's disease. Methods: The cortisol levels was measured through the saliva of 40 patients with mild probable Alzheimer's disease (AD group) and 40 elderly without cognitive impairment (control group). Working memory was evaluated with Digit Span in direct (DO) and indirect (DI) order. Results: Both groups presented similar cortisol levels. No statistically significant correlation was found between cortisol levels and digit span scores in both groups. Conclusion: This results suggest that working memory performance of elderly is independent of cortisol levels.

EXECUTIVE FUNCTIONS IN ATTENTION-DEFICIT / HYPERACTIVITY DISORDER

Mattos PEL

Instituto de Psiquiatria, Universidade Federal do Rio de Janeiro.

e-mail: paulomattosmd@gmail.com

Attention-Deficit / Hyperactivity Disorder (ADHD) is accompanied by attentional deficits since childhood which may persist into adulthood. Memory problems are very frequent in the disorder and may be considered secondary to the attentional deficit and also executive dysfunction. However, many other disorders are also present with attentional and memory deficits, especially depression and anxiety which are highly prevalent in comorbidity with ADHD. Neuropsychological assessment of attention and executive functions may contribute to a better understanding of the

overlapping symptomatology and help differential diagnosis.

WORKING MEMORY IN DEPRESSED MULTIPLE SCLEROSIS PATIENTS

Haase VG*; Ferreira FO

*Departamento de Psicologia, FAFICH – UFMG;

Programa de Pós-graduação em Saúde da Criança e do Adolescente, Faculdade de Medicina, UFMG.

*e-mail: vghaase@gmail.com

We examined if the Working Memory (WM) Assessment Battery (BAMT-UFMG) discriminates between multiple sclerosis (MS) patients with and without depressive symptoms, and age-matched controls. Sample consisted of 31 non-depressed MS patients (mean age = 41.45 years, sd = 12.10 years, 67.7 % female), 36 depressed MS patients (Beck Depression Inventory scores higher than 15, mean age = 41.92 years, sd = 8.63 years, 77.8 % female), and 108 controls (mean age = 39.62 years, sd = 10.58 years, 73.5 % female). Participants absolved the BAMT-UFMG, assessing: a) processing efficacy (speed of resolving simple arithmetic/sentence comprehension tasks); b) storing capacity (digit/word spans); c) coordination effectiveness (calculation/listening spans). Storing capacity and coordination effectiveness correspond to the phonological loop and central executive of Baddeley's WM model. Group comparisons used paired t-tests with Bonferroni's correction. None of the differences between controls and non-depressed MS patients reached significance levels. Differences between depressed MS patients and controls reached significance on the coordination and processing efficacy subtests (t 's: 3.35 - 3.65, p 's < 0,001), but were nonsignificant on storing capacity subtests. Depressive symptoms may exacerbate MS-related deficits in executive function and processing speed tasks, surpassing an impairment threshold, below which cognitive impairment is not apparent.

COGNITIVE DEFICITS AND BRAIN VOLUME ABNORMALITIES IN SUBJECTS WITH FIRST-EPISEODE PSYCHOSIS

Busatto GF*, Minatogawa TM, Schaufelberger M, Ayres A, Duran FLS, Scazufca M, Menezes PR

*Departamento de Psiquiatria, Medicina Preventiva e Radiologia da Faculdade de Medicina da Universidade de São Paulo

*e-mail: geraldo.busatto@hcnet.usp.br

Introduction: Neuropsychological deficits have been frequently reported in association with first-episode psychosis (FEP). Many studies have documented the presence of brain structural alterations in groups of subjects with FEP compared to control samples, such as reductions in grey matter volumes preferentially in prefrontal and temporal lobe regions. Despite the large number of studies describing neuropsychological deficits and brain structural alterations in association with FEP, the possible interrelationship between the findings of those two research areas has not been widely investigated. Aims: We report herein the results of an investigation of the relationship between patterns of cognitive impairment (including working memory and word production deficits) and grey matter volume abnormalities, as assessed with morphometric magnetic resonance imaging (MRI), in a large sample of FEP subjects. Methods: FEP patients and control subjects were evaluated using verbal fluency, backward and forward digit span tasks. MRI data was analysed using voxel-based morphometry methods. Results: Significant direct correlations emerged between cognitive impairment and grey matter volumes in prefrontal-temporal networks in FEP patients (n=101) as well as in the schizophreniform psychosis subgroup (n=55) ($p < 0.005$, corrected for multiple comparisons); however no significant correlations were found in affective psychosis

subgroup (n=46). In the asymptomatic control group (n=94), cognitive performance was significantly correlated with gray matter volumes in the temporal neocortex but not in the prefrontal region ($p < 0.05$, corrected). Conclusion: Cognitive deficits in FEP are directly related to regional gray matter volume abnormalities in the prefrontal cortex, particularly in subjects with the diagnosis of schizophreniform disorder.

Edited by the scientific committee.