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Similarities and differences between learning abilities, "Pure" learning disabilities, "Pure" ADHD and comorbid ADHD with learning disabilities

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ABSTRACT

This research pursues the crucial question of the differentiation of preadolescents with "Pure" ADHD, comorbid ADHD with learning disabilities, "Pure" learning disabilities and age-matched normal controls. For this purpose, Topographic Mapping of Event-Related Brain Potentials (ERPs) to a Memory Workload Paradigm with visually presented words, Bilateral Electrodermal Activity during cognitive workload and Mangina-Test performance were used.

The analysis of Topographic distribution of amplitudes revealed that normal preadolescents were significantly different from "Pure" ADHD ($P<0.0001$), "Pure" learning disabilities ($P<0.0001$), and comorbid ADHD with learning disabilities ($P<0.0009$), by displaying enhanced prefrontal and frontal negativities (N450). In contrast, preadolescents with "Pure" ADHD and comorbid ADHD with learning disabilities have shown a marked reduction of prefrontal and frontal negativities (N450). As for the "Pure" Learning Disabled preadolescents, very small positivities (P450) in prefrontal and frontal regions were obtained as compared to the other pathological groups.

Bilateral Electrodermal Activity during cognitive workload revealed a significant main effect for groups ($P<0.00001$), Left versus Right ($P=0.0029$) and sessions ($P=0.0136$).

A significant main effect for the Mangina-Test performance which separated the four groups was found ($P<0.000001$).

Overall, these data support the existence of clear differences and similarities between the pathological preadolescent groups as opposed to age-matched normal controls. The psychophysiological differentiation of these groups, provides distinct biological markers which integrate central, autonomic and neuropsychometric variables by targeting the key features of these pathologies for diagnosis and intervention strategies and by providing knowledge for the understanding of normal neurocognitive processes and functions.

1. Introduction

School/academic learning abilities reflect increasing degrees of neurocognitive skills necessary for the acquisition of new and more complex knowledge. In contrast, learning disabilities are composed of persisting specific impairments in the complete acquisition of age — appropriate mathematics, reading/comprehension, written expression, or any other subject of cognitive endeavor despite "normal" or "quasi-normal" intelligence. Moreover, very subtle learning disabilities, which may go undetected, are very frequent in the general population. In recent years however, another equally serious problem, namely Attention Deficit Hyperactivity Disorder (ADHD) attracted most emphasis. Although learning disabilities and ADHD are two distinct pathologies, they may coexist in the same person. As such, the understanding and differentiation of a "Pure" learning problem from a "Pure" ADHD is of paramount importance as is the detection of these two pathologies when both are present. Hence, a methodological framework taking into account the complexity of the differences and similarities of symptoms, is pivotal in helping those suffering from either one of the two or from both of these conditions.

Over the years, research with the Mangina Diagnostic Tool of Visual Perception (Mangina-Test) has shown that increasing degrees of "analytical-specific perceptual skills" are fundamental for learning new and more complex tasks (Mangina, 1981a,b,c, 1986, 1989, 1991, 1994a,b,c, 1998; Mangina and Beuzeron-Mangina, 1988, 1992a,b, 2004a,b, 2006; Mangina et al., 1998, 2000; Mangina and Sokolov, 2006). Research using the Mangina-Test has also revealed a relationship between performance in this test, Topographic Mapping of Event-Related Brain Potentials (ERPs) and Bilateral Electrodermal Activity in normal preadolescents as opposed to Learning Disabled/ADHD subjects with severe behavioral disorders (Mangina et al., 1998, 2000). Improvements both in the Mangina-Test performance, schoolmarks and in neurophysiology were reported in post-treatment condition after the administration of a psychophysiological treatment methodology for learning disabilities (Mangina and Beuzeron-

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Mangina, 1988, 1992b; 2004a,b). Furthermore, Mangina-Test performance differences and ERP topographic indicants were found to delineate normal subjects, "Pure" learning disabled, "Pure" ADHD and comorbid ADHD with learning disabilities (Mangina and Beuzeron-Mangina, 2006, 2008). Impaired Mangina-Test performance was found along with ERP irregularities in Early Alzheimer's Disease as compared to age-matched normal controls (Mangina and Beuzeron-Mangina, 1998, 2000). Functional Magnetic Resonance Imaging (fMRI) investigations were undertaken in young healthy adults and revealed the neural correlates underlying "analytical-specific visual perception" as measured by the Mangina-Test in terms of task difficulty and specificity of the stimuli (Mangina et al., 2008a,b; Mangina et al., 2009a,b-this issue). Additional research showing the clinical usefulness and diagnostic value of the Mangina-Test includes children and adolescents with neuropsychiatric pathologies and language impairments (Chiarenza and Benvenuti, 2002; Chiarenza et al., 2006), the neuropsychometric evaluation of ADHD and the differentiation between ADHD and learning disabilities (Karakaş et al., 2006, 2008).

With large samples of children and adolescents, we had also *identified* and *standardized* the bilateral electrodermal parameters of learning disabled subjects and those with normal neurocognitive abilities (Mangina and Beuzeron-Mangina, 1992a). The intracerebral representation of neural modulators of *human* electrodermal phenomena was investigated for the first time with the *direct* electrical stimulation of the brain and the concomitant recording of Bilateral Electrodermal Activity (Mangina and Beuzeron-Mangina, 1994, 1996). It was found that, among the 32 sites investigated, the anterior cingulate gyri, the amygdalae and the anterior and posterior hippocampi are potent ipsilateral modulators of bilateral electrodermal responses as opposed to neocortical sites such as the mid-regions of the second temporal gyri (Mangina and Beuzeron-Mangina, 1996). Systematic manipulations of Bilateral Electrodermal Activity coupled with stimulation using "analytical-specific perceptual tasks" (derived from the Mangina-Test), has been applied within a complex psychophysiological treatment methodology for learning disabilities and the improvement of neurocognitive abilities (Mangina, 1986, 1989, 1991, 1993, 1997; Mangina and Beuzeron-Mangina, 1988, 1992a,b, 1998, 2004a,b). During this psychophysiological treatment procedure, manipulation and maintenance of bilateral electrodermal activation within the identified and standardized range of 6.5–8.5 μmhos simultaneously combined with "analytical-specific perceptual stimulation" contribute to the enhancement of prefrontal and frontal N450 Event-Related Brain Potentials (ERPs) in treated learning disabled/ADHD subjects after eight consecutive months of treatment (Mangina and Beuzeron-Mangina, 2004a,b). In contrast, learning disabled/ADHD subjects who were *not* treated, exhibited the same ERP irregularities at baseline and eight months later *in spite of having received special education interventions within the same time interval* (Mangina and Beuzeron-Mangina, 2004a,b). Thus, those results suggested that *time and/or maturation per se* did *not* play a role in improving ERP topography and neurocognitive abilities. Rather, brain plasticity as expressed in ERP Topographic Mapping was involved in the improvement of treated learning disabled/ADHD subjects *due* to the direct *impact* of specific methodological intervention which *alters* the functional neuroanatomy and electrophysiology of the human brain (Mangina and Beuzeron-Mangina, 2004a,b; Mangina and Sokolov, 2006). Of particular interest to this psychophysiological treatment methodology, is the fact that the amygdala, the hippocampus and the anterior cingulate gyrus are important limbic modulators of Bilateral Electrodermal Activity (Mangina and Beuzeron-Mangina, 1994, 1996). Moreover, the anterior cingulate, richly interconnected with the prefrontal cortex, has a fundamental role in regulating cognition, behavioral adjustment and memory functions (Goldman-Rakic, 1987a,b, 1994, 1995; Goldman-Rakic et al., 1984, 1992, 1993; Fox and Bell, 1990; Fuster, 1997, 2000; Pribram, 2003; Mangina and Sokolov, 2006).

Our present research pursues the crucial question of the differentiation of preadolescents with normal learning abilities, "Pure" learning disabilities, "Pure" ADHD and comorbid ADHD with learning disabilities (Mangina and Beuzeron-Mangina, 2006, 2008). Our previous studies focused on comorbid populations suffering from learning disabilities with ADHD, and we had drawn attention to the fact that these independent pathologies may often coexist (Mangina et al., 2000; Mangina and Beuzeron-Mangina, 2004a,b). In recent years however, the need for differentiating groups with different pathologies as well as comorbid conditions as compared to normal subjects without any pathologies became imperative (Mangina and Beuzeron-Mangina, 2006, 2008). Other investigators have also warned that comorbid pathologies in boys and girls are frequent, independently transmitted in families and that both are etiologically distinct (Monuteaux et al., 2005; Seidman et al., 2001, 2006; Doyle et al., 2001). Those studies, along with our findings had indicated that comorbid ADHD with learning disorders in mathematics and/or reading comprehension should receive adequate professional attention for both pathologies.

Following the above rationale, our present research examined the following aspects in four distinct preadolescent groups: 1) normal learning abilities; 2) "Pure" learning disabilities; 3) "Pure" ADHD; 4) comorbid ADHD with learning disabilities and to establish markers distinguishing similarities and differences among groups as follows:

1) The extent to which varying degrees of "analytical-specific visual perception" as measured by the Mangina-Test performance would differentiate the four groups;
2) The extent to which Bilateral Electrodermal Activity (EDA) during cognitive workload would differentiate the four groups;
3) The extent to which Topographic Mapping of ERPs to our Memory Workload Paradigm would differentiate the four groups.

2. Method

2.1. Participants

For this research, 80 male preadolescents were selected. Of these, 20 were normal controls (16 right-handed and four left-handed), 20 with "Pure" learning disabilities (18 right-handed and two left-handed), 20 with "Pure" ADHD, (17 right-handed and three left-handed) and 20 had comorbid ADHD with learning disabilities (18 right-handed and two left-handed).

The age range of all preadolescent participants was 10.5–11.8 years (mean age 11.4). In addition, the following selection criteria were rigorously applied for each group.

2.1.1. Selection criteria for the normal control preadolescents

1. Absence of any learning disabilities and/or ADHD.
2. School-marks *higher* than 65%.
3. WISC-R IQ ≥ 85.
4. No psychiatric disorders.
5. No sensory impairments.
6. No evidence of neurological impairments.
7. No medication.

2.1.2. Selection criteria for "Pure" learning disabled preadolescents

1. DSM-IV criteria for learning disorders (both Mathematics Disorder and Reading/comprehension Disorder) (American Psychiatric Association, 1994).
2. School-marks *lower* than 51%.
3. WISC-R IQ ≥ 85.
4. No other psychiatric disorders.
5. No sensory impairments.
6. No evidence of neurological impairments.
7. No medication.