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Verbal and visual memory performances of children with moderate-into-severe asthma

Abstract: Previous research reported about high comorbidity between asthma and neurodevelopmental disorders. Recently, asthma was associated also with executive functions poorness. The current study aimed to investigate the verbal and visual memory performances among fifteen asthmatic kindergarten children compared to the performances of other fifteen healthy kindergarten children. The results showed that the asthmatic group revealed poor performances in the immediate short term verbal memory and the verbal working memory tests but not in the verbal learning test as it was compared to the healthy group. In addition, the asthmatic group revealed poor performances in the visual memory tasks compared to the healthy group. The results were explained in light of the assumption that poor executive functions might be interfere the process of managing the attentional resources which are needed through the process of memory encoding and retrieval.

Keywords: asthma, executive functions, kindergarten, Verbal memory, Visual Memory

Introduction

Cognitive development can be considered as a case sensitive to genetic, environmental and even physiological factors (Pennington, 2009, p. 4–5). Different studies reported that in different cases of physiological illness, cognitive deficits in different cognitive functions were evident also.

For example, different researchers reported about frequent attention disorders among children with allergic diseases (Balzola, Cullen, Hoentjen, Ho, & Russell, 2013; Blackman & Gurka, 2007; Chen et al., 2013). Also, vitamin losses were related to poor cognitive and academic skills as will (Scott, D’Anci, & Rosenberg, 2015). Recently, different researchers reported about cognitive and learning poorness among children with asthma (Fryt, Pilecka, & Smolen, 2013; Taha, 2017; Yuksel et al., 2008).

In fact, the relationship between asthma and learning difficulties was reported in earlier screening studies. For example, data from the 1988 US National Health Interview Survey on Child Health, a nationally representative cross-sectional survey, was used to determine national estimates of school outcomes (Fowler, Davenport, & Garg, 1992). According to this survey, a modestly increased risk of academic problems among children with asthma com-

pared with typical children was suggested. In another recent survey conducted by Blackman and Gurka (2007), a sample of 102,353 randomly selected children ages 0–17 years was tested to explore the prevalence of developmental and behavioral comorbidities with asthma. According to this survey, children with asthma have higher rates of ADHD, diagnoses of depression, behavioral disorders, and learning disabilities. Accordingly, children with asthma might be in higher risks for emotional and cognitive disorders than typical children (Blackman & Gurka, 2007).

Moreover, Geschwind and Behan (1982) suggested the hypothesis of cerebral lateralization which postulates an association between immune disorders and learning disabilities. Even though, the empirical evidence for such a relationship was not consistent. However, in their study, Tønnessen, Høien, Lundberg, & Larsen, (1994) attempted to investigate the hypothesis of Geschwind and Behan in a population where all the individuals were affected by asthma. The results revealed that the proportion of students with reading problems – especially phonological problems – was much higher than would be expected in a normal population. In light of their results, Tønnessen et al., suggested that these findings leads to tentative and partial support of the Geschwind-Behan hypothesis.

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In recent research of Taha (2017), the cognitive flexibility of 27 asthmatic children with learning difficulties has been tested by using the Wisconsin Card Sorting Test (WCST) and was compared to the performances of 30 non-asthmatic children with learning difficulties. The results revealed that the asthmatic group has poor performance through all the WCST psychometric parameters and especially the perseverative errors suggesting that learning difficulties of asthmatic children could be attributed to poor executive functions (hereafter: EF). EF is defined as an umbrella term for the management, regulation and control of the cognitive processing (Lezak, 2004, p. 611).

According to the above-mentioned review it might be supposed that the impact of asthma on the efficiency of cognitive skills might be associated with executive functions and reading skills. Learning, as cognitive process, relays mainly upon verbal and visual memory skills and is thought to be associated with the EF (Banich et al., 2009). We assume also, that in light of the fact that poor executive functions are associated with asthma (Taha, 2017) this EF poorness might negatively affect the earlier process of memory encoding. Earlier process of encoding into memory are very sensitive to the quality of the attentional resources which enable the intact concentration on relevant stimulus and the inhibition of irrelevant stimulus (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Miyake et al., 2000), therefore the cognitive sequences of poor EF among asthmatic children might be reveal into on poor memory performances.

However, there is a small body of research that investigated the efficiency of the memory skills among asthmatic children. For example, Bender, Lerner, and Kollasch (1988), found that among 27 severely asthmatic 8- to 16-year-old children, which were evaluated at high (61.5 mg/day) and low (3.33 mg/day) steroid levels, at the high steroid level patients reported increased depressive and anxious symptoms and performed less proficiently on a test of long-term verbal memory. Therefore, the authors assumed that high levels of steroid medications may reveal in reduction of memory performances of children with asthma. In an earlier study of Sues, Stump, Chai, & Kalisker (1986), tests of visual retention and paired-associate learning (memory-tests) were given to asthmatic children receiving theophylline or steroid-theophylline combination therapy and normal non-asthmatics. The performance of children receiving combination therapy was significantly worse than that of the non-asthmatics 6–8 hours after receiving steroid medication, but not 22–24 or 46–48 hours after medication. Children receiving theophylline alone did not differ from non-asthmatics on these tasks. The authors postulated that these observations suggest that steroid-inclusive medication regiments can affect cognitive performance. This assumption of the steroid effect on psychological and cognitive performances among children with asthma is compatible with the postulations of other researchers in this field. For example, a common explanation behind the comorbidity between asthma and disorders in attention

among children with asthma (Annett & Bender, 1994; Fasmer et al., 2011; Mogensen, Larsson, Lundholm, & Almqvist, 2011; Pelsser, Buitelaar, & Savelkoul, 2009) assumes that asthma medication itself and specifically the inhaled corticosteroids (ICS) is responsible for this comorbidity, due to the reporting of behavioral disturbances, developmental disabilities and psychosis in children using inhaled ICS (Bonala et al., 2003). Contrary to the later explanation, different studies do not prove these correlations (see for example; De Vries, Van Roon, & Duiverman, 2008).

As it was mentioned-above, the cognitive sequences of poor EF among asthmatic children might be evident on poor memory performances; accordingly, the aim of the current study is to test the verbal and visual memory skills of kindergarten children with asthma and to compare their performances to typical kindergarten children. Anyway, it will be expected that verbal and visual memory performances of children with asthma will be worse than those of non-asthmatic children.

Method

Participants

Fifteen kindergarten children (6 boys and 9 girls) with severe asthma were recruited from different kindergartens in north of Israel (age = 4.68 ± 0.28). The performances of the asthmatic group in the different tasks were compared with those of fifteen typical children (10 boys and 5 girls with age average of 4.86 ± 0.24).

For each participant, the parents were asked to sign a consent form for the participation of their son in the current study. Both groups, the asthmatic and non-asthmatic, were not reported to have any sensory, physical or intellectual disability. Information about the health status of each participant was obtained by a short questionnaire which was sent to the parents through which they were also asked to report about the frequency of their son's asthma attacks and if their son had been hospitalized at least several times in the last year due to the asthma attacks. Children with asthma who were hospitalized at least three times in the last year preceding the study were included.

Procedure

Each participant was tested with different tasks for assessing the verbal and the visual memory performances. Each participant was tested in quiet room in the kindergarten that was devoted for the research purposes. The order of the tasks was changed between the participants in aim to control the stable order effect.

Tests and Stimulus

The tasks were used to assess the verbal and the visual memory performances among the participants as following.

Verbal memory tests

Immediate short term verbal memory (Digit span)

In this task, each participant was asked to recall immediately a series of heard number-words in the same

order as they were presented during the oral presentation. This task consisted from 8 items. Each item consisted from 6 series, while each series in the first item consisted from one number-word only; while the series in each following item was consisted from one number-word more than the series from the former one. The order of number-words in each series is different between the different items and between the series within each item also. The task conduction was stopped after two mistakes within the same item.

Verbal Working memory (backward digit span)

In this task the children were asked to recall immediately a series of heard number-words in backward order. This task consisted from 8 items. Each item consisted from 6 series, where each series in the first item consisted from two number-words; while the series in each following item was consisted from one number-word more than the series from the former one. The order of number-words in each series is different between the different items and series within each item. The task conduction was stopped after two mistakes within the same item.

s/he was asked to select the target one from the other distractors.

Recognition trail test from the Rey Complex Figure Test (RCFT) (Psychological Assessment Resources, 1995)

For the purposes of the current study each child was presented with the whole complex figure and was asked to draw all its subfigures. After the drawing stage, each subject was presented with 24 figures and s/he was asked to respond with “yes” if s/he supposes that the presented figure was part of the whole complex one or by “No” if s/he supposes otherwise. 12 from the 24 figures are distractors.

Results

One way analysis of variance (ANOVA) was used for comparing the performances between the two groups (asthmatic vs. non-asthmatic) regarding all above mentioned dependent variables (the performance in the different memory tests, see Table 1 for means and SDs of the both groups performances).

Table 1. Means and \pm SDs for the performances of both groups, (non-asthmatic and asthmatic), in the different verbal and visual memory tasks

Group	Digit span	Verbal working memory	Verbal learning test	Visual memory subtests of the MVPT-3	RCFT visual recognition test
Non-Asthmatic	23.47 (\pm 2.50)	3.87 (\pm 2.41)	1.40 (\pm 2.06)	8.60 (\pm 1.95)	17.8 (\pm 1.65)
Asthmatic	16.13 (\pm 1.45)	1.13 (\pm 1.40)	.93 (\pm 1.66)	4.27 (\pm 1.48)	13.2 (\pm 2.21)

Verbal Learning Test

This test was adapted according to the Rey Auditory Verbal Learning Test (RAVLT). The RAVLT is a commonly used as clinical, cognitive and educational measure of verbal learning and memory (Strauss, Sherman, & Spreen, 2006; Sullivan & Bowden, 1997). Each participant required to recall the fifteen words after hearing them from the examiner immediately and in any order after they were presented. Five trials of the recall task were conducted in which the order of words remains fixed and the instructions were repeated for each trial. The performance of the free recall (the learning accumulation induction) was scored by calculating the difference between the number of words which were recalled in the fifth and the first trails.

Visual memory tests

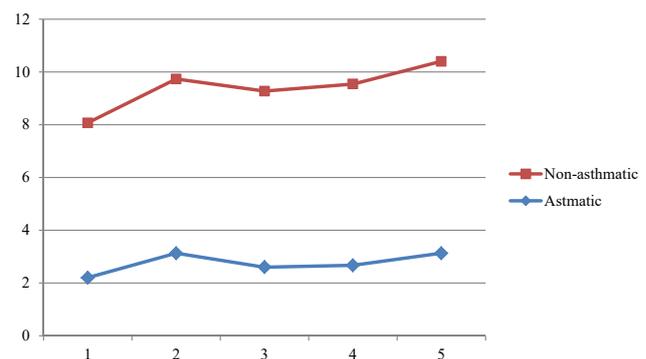
Visual memory test

The items for the current task were selected from the visual memory subtests of the Motor-Free Visual Perception Test (MVPT-3) (Colarusso & Hammill, 2003). In total, the current test consisted from 15 items (items 14–22 and 61–65 from the original MVPT-3 test). Each participant was presented with a drawn picture for five seconds. After the presentation of the target picture, the participant was presented with four pictures and

Verbal memory performances

The results revealed a significant differences between both groups considering the performances in the *Immediate short term verbal memory* and the verbal working memory tests, $F(1, 29) = 92.97, p < .001 (\eta^2 = .76)$ and $F(1, 29) = 46.64, p < .001 (\eta^2 = .62)$, respectively. In addition, any significant difference wasn't revealed between both groups in considering the performance on the Verbal Learning Test $F(1, 29) = .46, p = .5 (\eta^2 = .016)$.

Figure 1. The performance of the Asthmatic and the non-asthmatic groups in the verbal learning task (the five trials of the recall)



Visual memory tests

The results revealed a significant differences between both groups considering the performances in the visual memory subtests of the *MVPT-3* and the RCFT test, $F(1, 29) = 46.64, p < .001 (\eta^2 = .62)$ and $F(1, 29) = 41.6, p < .001 (\eta^2 = .59)$, respectively.

Discussion

In light of previous research findings, where children with asthma were reported to manifest difficulties in performing cognitive tests which aimed to assess executive functions and attention (Fryt et al., 2013; Taha, 2017; Yuksel et al., 2008), the current study aimed to assess the performances of kindergarten children with asthma, compared to healthy kindergarten children, in different memory tests. The assumption that lays in the basis of the current research postulates that encoding quality into memory is affected by the quality of attention which directed to such process. Difficulties in recruiting sufficient attention resources during such process may negatively affect the encoding quality, and therefore may result in poor later retrieval or recognition performances (Craik et al., 1996; Miyake et al., 2000).

The findings from the verbal memory tasks showed that significant differences were shown for the short and working memory tasks but not for the learning rate of the RAVLT task. This finding doesn't mean that the immediate verbal learning of the asthmatic children presents an equal learning quality like the non-asthmatic group. The difference between the both groups is distinguished while looking into each trail of retrieval (i.e. 1, 2, 3, 4 and 5) (see Figure 1). However, because this variable measures the difference between the fifth retrieval trail and the first one, It seems that both groups showed similar differences between the trails which mean that the total learning rate is similar between both groups. This finding can be attributed to the general assumption that verbal short memory but not learning rates is negatively associated with asthma.

Also the findings from the visual memory tests are similar to those of the verbal tasks and to those from previous studies (Suess et al., 1986). The gains of the asthmatic group in the different visual memory tasks were significantly below of those which were measured in the non-asthmatic group.

In light of previous findings where asthma was associated with poor EFs, it could be postulated that poor EFs might interrupt the intact process of managing the attention resources during the process of encoding or retrieval during the memory performances. Short term memory tasks and specially working memory and visual recognition tasks are affected by the quality of the continuous attentional resources which are recruited during these processes. This quality of attentional recruiting and monitoring is one of the essential executive functions (Lezak, 2004, p. 611). Therefore, if poor EFs are associated with asthma, accordingly difficulties in performing memory or general learning tasks might be associated also with

underlie difficulties in the domain of EFs among asthmatic children.

The study findings show that asthmatic children achieved relatively low standard deviations from healthy children in almost all memory tasks, although the healthy subjects performed better. We assume that the effects of asthma on the performance of the various tests are uniform among the asthmatic and indicate a uniform effect on the field of memory and its extent. Apparently, the lack of efficiency of the attention resource management processes during the coding processes leads to a similar decrease in performance among the asthmatic participants, a situation that does not exist among the healthy participants.

In sum, poor learning among children with asthma might be associated with difficulties in managing short term memory functions. It might be assumed that these difficulties are associated with more general difficulties in the EF. Further research is still need for deep and direct investigation of the relationship between EF and the memory and learning process among asthmatic children.

Compliance with Ethical Standards

The authors declare that have no conflict of interest.

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