Behaviour planning and problem solving deficiencies in children with symptoms of attention deficit hyperactivity disorder from the Balobedu culture, Limpopo province, South Africa

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Objective: To compare planning behaviour (frontal lobe functioning) in children with and without symptoms of attention deficit hyperactivity disorder (ADHD).

Method: A total of 90 children (45 with symptoms of ADHD and 45 matched controls without ADHD symptoms) of both genders, who were medication naïve, from the Balobedu culture (Limpopo province, South Africa), aged 7–13 years, participated in the study. The performance of the two groups was compared on a test of planning and problem solving, the Tower of London (ToL) task. The results were analysed as a function of gender and ADHD subtype. The Finger Tapping test (testing fine motor skills) was used as a control test to verify that the expected differences were not due to poor motor skills.

Results: The children with ADHD symptoms scored significantly lower than the non-ADHD comparison group which indicated deficiency in frontal lobe functioning ($p = 0.00$). The difference in performance was not due to poor motor control ($p = 0.70$).

Conclusion: Children with ADHD symptoms show deficits in behavioural planning which indicates impairment of functions of the frontal areas supplied by the mesocortical dopamine branch. More so than others, the ADHD Inattentive and Combined subtypes showed poor performance in the Tower of London task, indicating poor organisational and planning skills in these groups. The results also did show that the difference was not due to problems with motor control and that the ToL task is a culture-fair instrument for testing planning behaviour.

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common psychiatric disorders of young people, affecting 3% to 6% of primary school children (Arruda, Querido, Bigal, & Polanczyk, 2015; Biederman, 2005; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007; Sagvolden, Johansen, Aase, & Russell, 2005; Taylor et al., 2004). The disorder consists of a persistent pattern of inattentiveness, impulsiveness and/or hyperactivity that is inconsistent with the child’s developmental level.

In the 1940s the brain was associated with ADHD-like symptoms which were described as minimal brain damage; this later changed to minimal brain dysfunction. In 1980 DSM-III provided the first reliable diagnostic criteria for the disorder (American Psychiatric Association, 1987). These criteria, and their revisions (American Psychiatric Association, 1994, 2013) prompted many research projects that eventually led scientists to view ADHD as a seriously impairing, often persistent
neurobiological disorder of high prevalence that is caused by a complex interaction between genetic and environmental risk factors (Faraone et al., 2015).

In children and adolescents ADHD predominantly affects males and shows a male-female ratio of 4:1 in clinical studies and 2.4:1 in population studies (Polanczyk et al., 2007). The disorder runs in families and leads to educational underachievement. Parents and siblings of children with ADHD show between a fivefold and tenfold increased risk of developing the disorder compared with the general population (Biederman, Faraone, Keenan, Knee, & Tsuang, 1990; Biederman et al., 1986).

The prevalence of ADHD does not significantly differ between countries in Europe, Asia, America and Africa (Polanczyk et al., 2007). Evidence also exists that ADHD is as prevalent on the African continent as in Western countries (Bakare, 2012; Kashala, Tylleskar, Elgen, Kayembe, & Sommerfelt, 2005; Meyer, 1998; Meyer, Eilertsen, Sundet, Tshifularo, & Sagvolden, 2004; Ofovwe, Ofovwe, & Meyer, 2006; Polanczyk, 2007). In our study the focus was mainly on children in the Limpopo province of the Republic of South Africa, where the Balobedu tribe falls under the reign of the now deceased Rain Queen Modjadji, who was believed to have rain-making powers. The Balobedu number about one million people, distributed among about 150 villages around the Modjadji area. They speak Khelebodu which is not recognised as one of South Africa’s 11 official languages (Meyer, 2005; Nxumalo, 2000; Rammala, 2003).

ADHD places children at risk of school failure and drop out, juvenile delinquency, criminality, substance abuse, sexual promiscuity and many other problems later on (Aase, Meyer, & Sagvolden, 2006). This finding is supported by a study by Rasmussen and Gillberg (2000), which revealed that 58% of the study’s sample with ADHD/developmental coordination disorder (DCD) had a poor outcome and that antisocial personality disorder, alcohol abuse, criminal offending, reading disorders and low educational level were overrepresented in this group.

Behavioural planning and problem solving skills are considered executive functions (Lezak, Howieson, & Loring, 2004). Holmes et al. (2010) reported that deficits in executive functions are considered high level cognitive processes involved in goal-directed behaviour. Executive functions are being regarded as an umbrella term with a wide range of cognitive processes and behavioural competencies including verbal reasoning, problem solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilisation of feedback, multitasking, cognitive flexibility and the ability to deal with novelty (Chan, Shum, Touloupoulou, & Chen, 2008).

Barkley (1997a), agrees that ADHD is founded on prior theories of neuropsychological functions of the brain’s prefrontal lobes. Executive functioning deficits are seen in visuospatial and verbal working memory, inhibitory control, vigilance and planning (Faraone et al., 2015; Willcutt, Doyle, Nigg, Faraone, and Pennington, 2005).

Dysfunction of several brain regions and neural pathways has been implicated in underpinning the symptoms of ADHD, especially deficits in executive functioning (Cortese et al., 2012). The frontal lobes seem to be involved most (Biederman et al., 2008; Doyle, 2006; Seidman, Biederman, Monuteaux, Doyle, & Faraone, 2001; Shue & Douglas, 1992). The dorsolateral prefrontal cortex is linked to working memory, the ventromedial prefrontal cortex to complex decision making and strategic planning (Faraone et al., 2015). The essence of planning is the attainment of a goal through a series of intermediate steps. Neuropsychological evidence has established the central role of the frontal lobes, especially the prefrontal cortex in this process (Baker et al., 1996; Geurts, Verte, Oosterlaan, Roevers, & Sergeant, 2005; Tripp, Ryan, & Peace, 2002).

Neurotransmitter circuits in the brain are associated with the symptomatology of ADHD. The dopamine system plays an important part in planning and initiation of motor response activation, switching reaction to novelty and in reinforcement mechanisms (Faraone et al., 2015; Johansen, Aase, Meyer, & Sagvolden, 2002; Sagvolden et al., 2005; Tripp & Wickens, 2008; Williams & Taylor, 2004).

The Dynamic Developmental Theory of Sagvolden et al. (2005) postulate that ADHD symptoms could be a result of altered dopamine functioning which fails to appropriately modulate non-dopaminergic (primarily glutamate and GABA) signal transmission. This theory further indicates that the hypofunctioning dopamine branches give rise to the main individual predispositions as they predict that behaviour and symptoms in ADHD result from the interplay between individual
predispositions and the surroundings. This model assumes that ADHD is in a position of a behavioural continuum. There are three branches involved, the hypofunctioning mesolimbic dopamine branch (said to produce altered reinforcement of behaviour and deficient extinction of previously learned behaviour), the hypofunctioning mesocortical branch (causing attention response deficiencies and poor behavioural planning), and the hypofunctioning nigrostriatal dopamine branch (resulting in modulation of motor functions and deficient non-declarative habit learning and memory). The mesocortical branch connects the ventral tegmentum to the cerebral cortex, in particular the frontal lobes. It is crucial to the normal cognitive function of the dorsolateral prefrontal cortex, which is associated with behaviour planning (Gendle, Young, & Romano, 2013; Oades et al., 2005; Sagvolden et al., 2005).

Generally, children diagnosed with ADHD are said to have a tendency of blurting out answers before a question is completed, difficulty awaiting turn, and frequent interruption and intrusion in other people’s activities. These tendencies point to impulsiveness which could mean acting without reflecting and failure to plan ahead. These difficulties — directing behaviour and directing actions towards long-term accomplishments — are what the authors (Johansen, Sagvolden, Aase, & Russell, 2005; Sagvolden et al., 2005) regard as being the result of a hypofunctioning mesocortical dopamine branch which supplies the prefrontal cortex, and therefore causes deficits in executive functioning, which includes the planning of behaviour.

The widely used form of diagnosis of ADHD is based mostly on questionnaires such as the Conners rating scale (Conners, Sitarenios, Parker, & Epstein, 1998) or the Disruptive Behaviour Disorders (DBD) scale (Meyer, Eilertsen, Sundet, Tshifularo, & Sagvolden, 2004; Pelham, Jr., Gnagy, Greenslade, & Milich, 1992; Pillow, Pelham, Jr., Hoza, Molina, & Stultz, 1998). Since it is generally agreed (Barkley, 1997a; Barkley, 2015; Geurts et al., 2005; Lambek et al., 2011; Mattison & Mayes, 2012; Sagvolden et al., 2005) that executive functions deficits underlie ADHD symptoms, this further highlights the need for psychometric assessments that could help in aiding the clinical diagnostic process.

The Tower of London (ToL) task is a measure of executive control, and successful performance on the ToL is associated with activation of the prefrontal cortex (Culbertson & Zillmer, 1998). Optimal prefrontal function and ToL performance both depend on the availability of dopamine (Gendle et al., 2013; Robbins & Arnsten, 2009). Performance on the ToL correlates highly with performance on other strategy tasks that involve information processing in spatial working memory (Baker et al., 1996; Morris, Ahmed, Syed, & Toone, 1993). Using the ToL in one of the many cultures in South Africa may shed some light on both discriminating between children with and without problems with planning behaviour as a result of ADHD and consequently, prefrontal lobe dysfunction caused by insufficient dopamine supply by the mesocortical branch. It would also establish whether the ToL is a culture-fair instrument for assessing planning behaviour.

Gender differences in the presentation of ADHD symptoms (more boys than girls), clinical presentation (boys mostly diagnosed with the combined (ADHD-C) or hyperactive/impulsive (ADHD-HI) presentation while girls are mostly diagnosed with the predominantly inattentive presentation (ADHD-PI)), and both genders showing impairments in executive functions also points to a need to distinguish these differences. Dirlikov et al. (2015) reported sex-based differences in cortical morphology of functions subdivisions in the frontal lobe which may relate to the difference in the expression of the symptoms between the genders.

The purpose of the study therefore, was twofold: (1) to investigate whether children with ADHD have deficits in behaviour planning and problem solving as measured by the ToL, caused by insufficient dopamine supply to the ventromedial prefrontal cortex; and (2) to establish whether the ToL can be regarded as a culture-fair instrument, tapping the same deficiencies and sensitive to measure behaviour planning and problem solving in an African culture as it is in Western cultures. The Finger Tapping test (Lezak et al., 2004; Reitan & Wolfson, 1993; Spreen & Strauss, 1998) was used as a control test to verify that the expected differences were not due to problems of motor control, often observed in children with ADHD (Fliers et al., 2010; Meyer & Sagvolden, 2006).
Method

Sample
Children from the Balobedu culture were recruited from a school-based population in the rural area around the Modjadji Royal Kraal in the Limpopo province of South Africa. The children (68 boys and 22 girls), aged 7–13 years, were selected following screening for ADHD of the general population of primary school children. A total of 1,286 children were screened for symptoms of ADHD. In all, 45 children from the Balobedu culture (34 boys and 11 girls) were screened positive for ADHD symptoms. They were matched for age and gender with children without symptoms of ADHD. The group without ADHD symptoms formed the comparison group (N = 45). Written permission was obtained from the Department of Education, Limpopo province, and from the principals of the selected schools. The study was approved by the Ethics Committee of the University of Limpopo.

The DBD rating scale (Pelham, Jr., Gnagy, Greenslade, & Milich, 1992; Pillow, Pelham, Jr., Hoza, Molina, & Stultz, 1998) was standardised for the population of the Limpopo province (Meyer et al., 2004) and was used as a screening instrument. Teachers were given the rating scale to complete for the children in their grades. Only teachers’ ratings were used for the screening, since the return of the parents’ rating scale was below 50%, probably because many children either did not live with their parents and/or the parents were illiterate. Teachers’ ratings are usually regarded as an accurate measure of assessment and are regarded as reliable as information obtained from parents (Crystal, Ostrander, Chen, & August, 2001; Meyer et al., 2004; Wolraich et al., 2003). The return of the teachers’ rating scale was close to 100%. Participation was voluntary. Informed consent was attained from the children’s parents or legal guardians for the procedure to take place and for the data to be used for research purposes. Children were divided into a group classified as ADHD group (with symptoms of ADHD) and a comparison group without ADHD symptoms (Table 1), based on teachers’ ratings on the DBD rating scale. The children meeting the criteria for inclusion into the groups with ADHD symptoms (about 7%) were selected for further testing. They were matched for gender and age with children without ADHD symptoms based on their scores obtained by the screening process.

Cut-off points for the group with ADHD symptoms (95th percentile or above) and comparison group (85th percentile or below) were based on the results on a prevalence study (Meyer et al., 2004) in which more than 6,000 children were rated on the DBD. According to these norms, scores recorded as higher than 18 on the hyperactive/impulsive (H/I) items were classified as having symptoms of ADHD-HI (hyperactive/impulsive presentation) and having higher than 21 on the inattention (Inatt) items were classified as having symptoms of ADHD (inattentive presentation) and formed the ADHD-PI group. If the criteria were met on both types of items they were classified as having symptoms of ADHD (combined presentation, ADHD-C). The cut-off point for the comparison group was set at the 85th percentile or below to decrease the risk of false negatives in this group, as the DBD was the only measure used. Thus, children with scores on the H/I items less than 15 and Inatt less than 17 were regarded as comparisons.

The final sample comprised 90 children from the Balobedu culture (see Table 1). Children with an IQ lower than 80 and/or with a history of neurological problems (e.g., epilepsy, head injuries,

Table 1: Sample characteristics

| Group               | Gender | Presentation | N   | Age in years |
|---------------------|--------|--------------|-----|--------------|
| ADHD                | Male   | ADHD-HI      | 7   | 10.83 ± 1.33 |
|                     | Male   | ADHD-PI      | 11  | 10.83 ± 1.27 |
|                     | Male   | ADHD-C       | 16  | 10.69 ± 1.08 |
|                     | Female | ADHD-HI      | 5   | 10.56 ± 1.48 |
|                     | Female | ADHD-PI      | 2   | 10.70 ± 1.49 |
|                     | Female | ADHD-C       | 4   | 10.86 ± 0.82 |
| Non-ADHD control    | Male   |              | 34  | 10.62 ± 1.64 |
|                     | Female |              | 11  | 10.80 ± 1.40 |
cerebral palsy or cerebral malaria) or severe psychiatric disorders were excluded from the study. There are no standardised IQ tests for the indigenous African populations (Balobedu) therefore Raven’s progressive matrices were used to estimate IQ. This test is considered to be “culture-fair” (Raven, 2000; Wilkes & Weigel, 1998). None of the children was on psychostimulant medication at the time of testing.

The differences in age between the groups (ADHD and Control) were not statistically significant (males: \( p = 0.86 \); females: \( p = 0.19 \)). There were statistically significant differences on the Inattention scores (\( p = 0.00 \)) and the H/I scores (\( p = 0.00 \)) of the DBD rating scale between the ADHD and the non-ADHD control groups.

**Instruments**

The main assessment tool used was the ToL. The Finger Tapping test was used as a control test to make sure that the expected differences in performance were not due to poor motor control, as children with ADHD often have problems with motor control (Fliers et al., 2010; Meyer & Sagvolden, 2006; Pitcher, Piek, & Hay, 2003). The ToL-Drexel Version developed by Krikorian, Bartok and Gay (1994) and Shallice (1982) is a planning task and measures spatial planning, problem solving and cognitive impulsiveness (Albert & Steinberg, 2011; Gau & Shang, 2010; Phillips, Wynn, McPherson, & Gilhooly, 2001) The subject must look ahead to determine the order of moves necessary to rearrange three coloured beads from their initial position on two or three upright sticks to a new set of pre-determined positions on one or more of the sticks (Lezak et al., 2004). The child is also informed to find the solution using a minimum number of moves. The test is presented in 12 different patterns, and the solution varies from 2 to 5 moves. The ToL is a “frontal lobe test” which is considered to measure the part of the executive functions connected to strategic planning (Alvarez & Emory, 2006; Beauchamp, Dagher, Aston, and Doyon, 2003; Goel & Grafman, 1995). It is sensitive in relation to children with ADHD difficulties (Barkley, 1997b).

Motor skills (finger movement and speed) were measured using the Finger Tapping test (Reitan & Wolfson, 1985; Schatz, 2011). The test apparatus is a micro-switch operated by a key consisting of a metal arm and a round disk (20 mm in diameter). The key is placed at the short end of a 223 mm × 151 mm plastic box where the operating hand is to be rested. The length of the metal arm from the micro-switch to the centre of the disk is 60 mm. The switch needs 65 g dead weight to close. An electronic counter records the number of micro-switch closings (taps). The child has to press the switch 15 mm to activate the counter. The hand must be rested in a constant position in contact with the surface of the plastic box to ensure that only the index finger is moving. A stopwatch is used to time each 10-second trial. The child may rest at any time between the trials, but is told to take a break at least after every third trial. For each hand, the test is terminated after 10 trials or when 5 consecutive trials do not vary by more than 5 taps. The means of five trials with the highest number of taps are computed for each hand and used as the final scores.

**Procedure**

The children were tested by a tester fluent in the child’s own language (Khelobedu). The assessments were conducted in the mornings and the children were asked not to be on any medication 24 hours before testing. The children were assessed individually in a quiet room during school hours so as to lessen interferences or any disturbances. The total number of correct responses for the ToL and the number of taps per 10 seconds for Finger Tapping were recorded (total score). The actual testing time for each child (ToL and Finger Tapping) lasted about 30 minutes.

**Statistical analysis**

Analysis of variance (ANOVA) was used to investigate possible between-group differences in raw scores for both the ToL and the Finger Tapping test, using the Statistica 10 programme (StatSoft, 2011). The results were analysed with a 4 x 2 (ADHD-type x gender) ANOVA for independent samples. Post-hoc tests consisted of multiple comparisons using the Bonferroni correction (Weinfurt, 1998).
Results

Planning behaviour — Tower of London
Children with high scores on the DBD rating scale, and consequently classified as having ADHD symptoms, performed more poorly on the ToL task than the control group without ADHD symptomatology. All three ADHD presentations, ADHD-HI ($M = 21.62 \pm 4.02$), ADHD-PI ($M = 19.82 \pm 3.86$) and ADHD-C ($M = 19.94 \pm 4.07$) performed worse than the non-ADHD control group ($25.32 \pm 3.71$). Figure 1 presents the performance on the ToL for the three ADHD presentations and the non-ADHD control group.

Control test — Finger Tapping test
There were few differences in taps per 10 seconds for the ADHD presentations, ADHD-HI ($M = 34.14 \pm 9.13$), ADHD-PI ($M = 28.61 \pm 6.44$) and ADHD-C ($M = 29.56 \pm 6.14$) and the non-ADHD control group ($M = 31.01 \pm 4.84$).

As there was no effect of gender, neither main, nor interacting, for the results on the ToL, the gender groups were not analysed separately. The ANOVA results indicated a statistically significant result between the ADHD groups ($p = 0.00$). The post-hoc analysis (Bonferroni correction) indicated that the differences were between the ADHD-PI presentation and the non-ADHD control group ($p = 0.00$) and the ADHD-C presentation and the non-ADHD control group ($p = 0.05$). Although nearing significance ($p = 0.07$), the difference in performance between the ADHD-HI presentation and the non-ADHD was not statistically significant (Table 2).

The ANOVA results of the Finger Tapping showed no differences in performance between the non-ADHD controls and the ADHD presentations. There was, however, a significant result of gender ($p = 0.00$) which was not relevant for this study (Table 2).

![Figure 1: Graphic representation of the results of the ToL according to ADHD presentation](image-url)

Note: The graph represents the means and ± SEM of the scores on the ToL of the three ADHD presentations and the non-ADHD control group as a function of gender.
Discussion

The study aimed to compare the performance of children with symptoms of ADHD and a non-ADHD comparison group on measures of behaviour planning and problem solving, functions of the prefrontal lobe, supplied by the mesocortical dopamine branch. Children with ADHD obtained significantly lower scores on the ToL. This was especially the case for the ADHD-Inattentive and ADHD-Combined subtypes/presentations, which indicates poor prefrontal lobe functioning. No effect of gender was found when the results were analysed.

The poorer performance of the two ADHD presentations was not unexpected. Several studies have reported that children with ADHD scored significantly lower on tests that measure frontal lobe functioning, especially planning, problem solving, mental flexibility and spatial working memory than their matched peers (Chiang, Huang, Shur-Fen Gau, & Shang, 2013; Culbertson & Zillmer, 1998; Hughes, 1998; Klorman et al., 1999; Larochette, Benn, & Harrison, 2009; Macallister et al., 2012; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Solanto et al., 2007; Tripp et al., 2002). However, Houghton et al. (1999) did not find that the ToL discriminated between children with and without ADHD. This was also the conclusion of a Mexican study. Yanez-Tellez et al. (2012) found a great variety of cognitive deficiencies in children aged 7–12 years with ADHD, but the ToL could not differentiate between them and a control group without ADHD. Sonuga-Barke et al. (2002) found no significant differences in planning behaviour between pre-schoolers with and without ADHD, using the ToL. This finding may indicate that planning behaviour in children depends on the development of the frontal lobes in the child.

The subtypes/presentations differed on the scores of the ToL and consequently on their prefrontal lobe dysfunction. The ADHD combined and the ADHD inattentive presentations seemed to have more difficulty in planning ahead than the ADHD-HI and the non-ADHD comparison group. This was also observed in a study conducted by Nigg, Blaskey, Huang-Pollock and Rappley (2002) and Solanto et al. (2007), who also found that ADHD-C had larger deficits and the ADHD-PI deficits of frontal lobe functioning were less pronounced. Geurts, Verte, Oosterlaan, Roeyers and Sergeant (2005) found conflicting results: children with ADHD-C and ADHD-PI did not differ from the controls on any of the planning measures with increasing planning load. In our study the ADHD-HI, although performing poorer on the task, did not differ statistically from the typically developing comparisons, which indicates that inattention contributes more to planning and problem solving than hyperactivity/impulsiveness. This indicates that parietal areas are also involved, as they are associated with attention (Behrmann, Geng, & Shomstein, 2004). The dorsolateral prefrontal cortex and posterior parietal cortex are two parts of a broader brain network involved in the control of cognitive functions such as working memory, spatial attention and decision making (Katsuki & Constantinidis, 2012). The posterior parietal cortex, is connected with the prefrontal cortex and has been shown to represent neural correlates of decision making and planning (Faraone et al., 2015).

According to Oosterlaan, Scheres and Sergeant (2005), poor performance on the ToL is indicative of ADHD children making the first move before they had successfully generated an appropriate solution to the problem. Therefore, the fast planning times in ADHD children could be interpreted as impulsiveness which does not arise from a tendency towards fast motor response. However, the

| Table 2: ANOVA results for the ToL and Finger Tapping |
|-------------------------------------------------------|
|                                                      |
| **DF**  | **F**  | **p**  |
| Tower of London | Gender  | 1, 82  | 1.311  | 0.25  |
|                | ADHD presentation | 3, 82  | 6.454  | 0.00* |
|                | Gender × ADHD presentation | 3, 82  | 1.454  | 0.23  |
| Finger Tapping  | Gender  | 1, 82  | 8.615  | 0.00* |
|                | ADHD presentation | 3, 82  | 1.954  | 0.13  |
|                | Gender × ADHD presentation | 3, 82  | 1.454  | 0.16  |

DF: degrees of freedom; *p = 0.00
findings of our study found that inattention contributed more to the poor performance on the ToL task and therefore dysfunction of the prefrontal areas, than impulsiveness/hyperactivity.

The Finger Tapping test did not discriminate between children with symptoms of ADHD and the control group; therefore the obtained results could be attributed to deficiencies in planning and problem solving and not to poor motor control, which also may be experienced by children with symptoms of ADHD.

Gendle et al. (2013) supplied evidence that problems with planning and problem solving were not caused by structural abnormalities in the prefrontal areas, but by a hypofunctioning mesocortical dopaminergic pathway as postulated by Johansen et al. (2002) and Sagvolden et al. (2005). Gendle et al. (2013) administered the exogenous serotonin precursor 5-hydroxytryptophan (5-HP) which results in the production of serotonin in dopaminergic neurons and an associated reduction in dopamine release. The researchers also used the ToL because of its sensitivity to changes in frontal dopamine activity, but insensitivity to alterations in serotonin (Cools, Stefanova, Barker, Robbins, & Owen, 2002). Gendle et al. (2013) found that 5-HTP significantly lengthened the average time needed to complete the ToL task. They concluded that disruption of the dopaminergic function in the prefrontal cortex affected planning and problem solving.

**Culture-fairness of the Tower of London**

A variety of factors are taken into account when psychometric instruments are used. Cultural and ethnic differences can influence the results. Therefore the diagnostic instrument should be preferably non-verbal and proven to be culture-fair. When a diagnostic instrument is culture-fair, the results can be subjected to analysis in children of different ethnic and cultural groups in South Africa and in other countries. Besides its extensive use in the USA (Gendle et al., 2013; Solanto et al., 2007) and Europe (Baker et al., 1996; Cazalis et al., 2003; Roussos, Giakoumaki, Pavlakis, and Bitsios, 2008; Rowe, Owen, Johnsrude, & Passingham, 2001), it also has been used successfully in Eastern, Middle Eastern and South American countries (Chang et al., 2011; Tenjin et al., 2012; Yanez-Tellez et al., 2012) and many more. No studies using the ToL could be found for populations on the African continent. Our results clearly indicated that the ToL could successfully be used with children from the Balobedu culture in South Africa, as the obtained results were in line with those obtained in Western cultures. The test can therefore be considered as culture-fair.

**Limitations**

The sample size was small, especially when the ADHD group was subdivided into the three subtypes/presentations. This may have influenced the statistical outcome. Co-varying for IQ should ideally have been done. However, as there are no standardised IQ tests for the Balobedu children, and Raven’s Progressive Matrices can only estimate IQ, when a child had no scholastic problems or history of repeating grades a normal IQ was presumed. The Raven Progressive Matrices was administered only when there was doubt. The children were only screened by teachers for ADHD symptoms, a diagnosis involving the parents could not be done, as the schools were in a remote rural area, and most parents could not be reached while some were illiterate, or the children did not live with their parents. However, a previous study showed that teachers’ ratings, especially if the teachers are from the same culture as the children, turn out to be very accurate (Meyer et al., 2004).

**Clinical implications**

Problems with planning and problem solving affect the educational performance and outcome of the child. General cognitive impairment may be the result of frontal lobe dysfunction caused by a hypofunctioning dopaminergic mesocortical branch as is the case in ADHD. Children with ADHD need to be neuropsychologically assessed and followed up. They should be monitored and assisted by clinical psychologists and remedial teachers. If needed, pharmacological treatment should be supplied. Given the remoteness and being situated in areas with limited infrastructure, these options are not always feasible. Furthermore, the ToL could be deemed a useful tool in the assessments in both research and clinical practice especially in relation the diverse cultures found in South Africa.
Conclusion

The goal of this study was to assess the behaviour planning deficits in children with ADHD from the Balobedu culture. The study showed that especially the inattentive and combined ADHD presentations have problems with planning, problem solving, goal-oriented behaviour and the ability to form a mental representation of a task. It also shows that they find it problematic to follow rules. The findings support the sensitivity and usefulness of the ToL to measure behaviour planning and problem solving even in a non-Western culture.

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