



Neuropsychological correlates of the bicycle drawing test

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Abstract

Objective: There is a need for psychological tools to assess cognitive functioning in illiterate or partly illiterate patients.

Method: We examined neuropsychological correlates of scores on Luria's bicycle drawing test on a sample of 30 psychiatric patients (mean age =33.2, SD=15.3, 11 females, 19 males) referred for psychological testing. The test battery included the bicycle drawing test, the Millon Clinical Multi-axial Inventory – III (MCMI3), Raven's Standard Progressive Matrices, WAIS Vocabulary Test, and Logical Memory subtests from Wechsler Memory Scale-Revised. We have developed our scoring system to separately rate 12 aspects of bicycle drawings, on a scale from 0 (= missing or unrecognizable) to 5 (= adequate, distinct): wheels, frame, handlebar, seat, pedals, chain, tires, brakes, fenders, bell, headlight, back reflector, and the connection of the wheel axis to the frame. A global rating of the distortion of the frame (from 0 = adequate to 25 = unrecognizable) was also included.

Results: The bicycle test scores were not significantly correlated ($p > .05$, 1-tailed) with MCMI3 psychopathology, however, they correlated with nonverbal reasoning skills (correlations ranging from .57 to .74) and with measures of verbal skills (correlations ranging from .41 to .62 to scope of vocabulary).

Conclusions: The correlational patterns support concurrent validity of our scoring system.

The bicycle drawing test may be a useful screening procedure for cognitive impairment.

As the digital display clocks enjoy an increasing popularity, the bicycle test may become a convenient substitute for the Draw a Clock Test in studies of dementia.

Keywords: bicycle drawing, nonverbal reasoning, memory, vocabulary

1. Introduction

The increasing popularity of digital watches sets new limitations on the use of the clock drawing test ^[1] in neuropsychiatric assessments. Furthermore, as even some obviously organic patients might still score perfectly on the clock test ^[2], more complex and arduous drawing tests such as the bicycle drawing test ^[3] are needed. In the bicycle test, the patient is provided with a pencil and a sheet of white paper (usually 21.6 cm x 27.9 cm, i.e., 9.5" x 11") and is asked to sketch a bicycle. Usually only patients with dementia or severely psychotic patients are unable to produce a recognizable drawing of a bicycle.

Several scoring systems are available ^[3], some of which are based on Piagetian perspectives ^[4]. The test was validated in comparisons of normal children with those with organic impairments and those with other psychiatric diagnosis ^[4] and was also used in neuropsychological investigations of adults with aphasia or Parkinson's ^[5,6].

Our study evaluated statistical correlations of scores on the bicycle drawing test (as based on our own scoring system that focused on omissions of bicycle parts as well as on their distortion/functionality) to psychological measures of psychopathology and to measures of cognitive skills in the area of verbal and nonverbal intelligence and of verbal memory.

2. Method

A retrospective review was carried out on psychological test files of 30 psychiatric patients (age 16 to 75 years,

mean=33.2, SD=15.3, 11 females, 19 males) who completed the bicycle drawing test, Millon Clinical Multi-axial Inventory – III ^[7], Raven's Standard Progressive Matrices ^[8], and the Logical Memory subtest from Wechsler Memory Scale-Revised ^[9]. The measures also included the vocabulary subtest from the *Wechsler Adult Intelligence Scale – Revised* ^[10]. The vocabulary subtest was administered in a multiple choice version developed by Paitich and Crawford ^[11] for the former Clarke Institute of Psychiatry, Toronto, Canada: the multiple choice version was used in group testing sessions by several psychiatric hospitals in Ontario, Canada.

We have developed our own scoring system to separately rate 12 aspects of bicycle drawings, on a scale from 0 (missing or unrecognizable) to 5 (adequate, distinct) for the following parts of the bicycle: wheels, frame, handlebar, seat, pedals, chain, tires, brakes, fenders, bell, headlight, back reflector, and the connection of the wheel axis to the frame.

An overall rating of the distortion/functionality of the frame (from 0 = adequate to 25 = unrecognizable) was also included.

3. Results

The total scores on bicycle drawings were uncorrelated ($p > .05$, 1-tailed) with age, gender, and MCMI3 psychopathology, however, they significantly correlated with nonverbal reasoning skills, measures of verbal skills, and with some measures of logical memory. The significant correlations are listed in Table 1.

Table 1: Pearson correlations (2-tailed) with measures of nonverbal reasoning skills, of verbal skills, and of logical memory

	Total Score on Bicycle Test	Distortions / Functionality
<i>Raven's Matrices: IQ equivalent</i> (age corrected measure of nonverbal visuo-spatial reasoning)	.57 p=.003	.74 p<.001
<i>Raven's Matrices: raw scores</i> (measure of nonverbal visuo-spatial reasoning, without corrections for age)	.58 p=.003	.73 p<.001
<i>WAIS Vocabulary Test: IQ equivalent</i> (age corrected measure of the scope of vocabulary)	.41 p=.032	.59 p=.001
<i>WAIS Vocabulary Test: raw scores</i> (scope of vocabulary, without age corrections)	.41 p=.036	.62 p=.001
<i>Logical Memory I: equivalent of the memory quotient</i> (immediate recall of complex logically structured verbal information, corrected for age)	.40 p=.046	.25 p=.240, n.s.
<i>Logical Memory I: raw score</i> (immediate recall of complex logically structured verbal information, uncorrected for age)	.42 p=.038	.26 p=.212, n.s.
<i>Logical Memory II: equivalent of the memory quotient</i> (delayed recall of complex logically structured verbal information, corrected for age)	.37 p=.072, n.s.	.23 p=.274, n.s.
<i>Logical Memory II: raw score</i> (delayed recall of complex logically structured verbal information, uncorrected for age)	.39 p=.051, n.s.	.24 p=.263, n.s.

Note: n.s. denotes "not significant"

The highest correlations were to measures of nonverbal reasoning with visuospatial elements: these correlations are moderate for the total bicycle drawing scores and high for the "functionality/distortion scores," but their square roots indicate that they may explain only between 7.5% to 8.6% of the variance in the bicycle drawing scores. Other factors such as technical interests, personal experiences with riding or repairing bicycles, visual memory, and interest in drawing could also be important determinants of scores on the bicycle drawing test.

It is noteworthy that correlations of bicycle drawing scores to Raven's matrices are of similar magnitude whether or not the scores on Raven's were corrected for age.

As shown in Table 1, the correlations of bicycle drawing scores to knowledge of less common verbal concepts (WAIS Vocabulary subtest) and also some correlations to logical memory (immediate recall of complex logically structured information presented to the patient verbally in the form of stories) are also significant: most of these significant coefficients involving memory or verbal skills are within the moderate category.

4. Discussion

The results support concurrent validity of our scoring system in adult psychiatric patients. It is noteworthy that the presence versus absence of distortion (lack of bicycle functionality) is strongly correlated to more time-consuming psychological measures of nonverbal intelligence in the area of nonverbal visuo-spatial reasoning skills (tasks on Raven's Matrices) and is also significantly correlated to the person's overall scope of comprehension of complex verbal concepts (see Table 1).

In comparison, only a few correlations involving verbal memory were statistically significant: they seem less well suited for clinical predictions in individual cases.

It is of interest that, in this sample of psychiatric patients, no significant correlations were found to measures of anxiety, depression, schizoid or compulsive personality, and to other scales of psychopathology of the MCMI3. However, all of these patients were already adequately stabilized on psychiatric medication, they were no longer hospitalized, and were able to travel: they were tested on an outpatient basis in an urban medical clinic. The correlational patterns might be different in samples of hospitalized psychiatric inpatients with acute psychotic symptoms.

It appears from the correlational data that the performance on bicycle drawing tests by psychiatric outpatients indicates an overall level of cognitive processing rather than

psychopathology such as anxiety, depression, or schizoid personality traits.

Our results are consistent with findings by Schmitt, Livingston, Galusha, and Davis in their 2009 study [12] of correlates of the bicycle drawing test in elderly patients evaluated for dementia. Schmitt's team concluded that "the Bicycle Drawing Task may be a useful screening procedure for cognitive impairment."

5. Conclusions

Low scores on the bicycle drawing test indicate cognitive difficulties in the area of nonverbal visuo-spatial reasoning and also suggest potential problems with cognitive processing in the area of verbal concepts.

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7. References

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