Original Article

Standardization of Tests of Attention and Inhibition

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ABSTRACT

Aim: The aim of the study was to standardize tests of attention and inhibition for adults in the age range of 16–30 years, who had 1–10 years of formal education. The objectives were to develop normative data for the tests of attention and inhibition, to establish the reliability of the tests of attention and inhibition, and to establish the validity of the tests of attention and inhibition. **Materials and Methods:** The tests studied were figural visual scanning test (FVST), auditory target detection test (ATDT), stop signal test, and go/no-go (GNG) test. The four tests were given to a normal sample of 60 subjects (30 males and 30 females). Reliability of the tests was determined by retesting 20 individuals, (10 subjects from each group) from the sample after an interval of 1 month. The tests were given to a matched clinical sample of patients with unilateral focal lesions, and the results were compared to test discriminant validity. Means, standard deviations, *t*-test, correlations, and percentiles were used to analyze the data. **Results and Conclusion:** Results indicated that FVST and ATDT were reliable and valid tests of attention and stop signal test and GNG test were reliable and valid measures of inhibition of motor processes.

Key words: *Attention, inhibition, norms, reliability, standardization, validity*

INTRODUCTION

Attention is the capacity to select behaviorally relevant elements of sensory experience for cognitive processing while simultaneously excluding others from consciousness.[1] Attention involves a variety of processes such as (i) a selective process, whereby some information coming from the internal or external environment is analyzed and perceived while other information is ignored; (ii) an intensive process, whereby the amount of attention devoted to a particular information source can be varied; and (iii) an alerting and sustaining process, whereby receptivity to input information can be heightened over the short- or long-term. Attention is neither a property of a single brain area nor the entire brain. It involves networks of anatomical areas that perform particular cognitive functions.

Inhibition involves the ability to inhibit processing off to be ignored stimuli.[2] A variety of paradigms have used the concept of inhibition, and in most of these paradigms, changes in inhibitory functioning were

Access this article online	
Website: www.ijpm.info	Quick Response Code
DOI: 10.4103/0253-7176.185959	

How to cite this article: Thomas S, Rao SL, Devi BI. Standardization of tests of attention and inhibition. Indian J Psychol Med 2016;38:320-5.

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inferred from variations in speed or errors in responding. These paradigms can be of two types depending on the role of the subjects being either active or passive. The stop signal paradigm and go/no-go (GNG) paradigm involve active inhibition of motor responding. In stop signal task, subjects are asked to respond to a visual stimulus in a choice reaction task and to abort their response when on a minority (usually 25%) of trials a tone is presented shortly after the imperative stimulus. In GNG paradigm, two equiprobable stimuli (e.g., letter X and Y) are presented to subjects in random order and subjects are asked to respond to one stimulus (e.g. X) with a button press and to withhold their response to the other stimulus (e.g., Y).[2] Four clinical tests of inhibition were developed in the Neuropsychology Unit at National Institute of Mental Health and Neurosciences (NIMHANS). These include stop signal, GNG, task switching, and interference susceptibility tests. Out of these, the stop signal and GNG tests were found to be reliable and valid.[3] Only a very few attempts have been made to standardize the tests.

Attention and inhibition are very important cognitive functions, and they are found to be impaired in neurological and psychiatric disorders, especially autism,[4,5] attention deficit hyperactivity disorder,[4-6] and bipolar disorder.[6] Different disorders have specific characteristics in the attention and inhibition dysfunctions,[4,6] and hence, specific tests that measure different aspects of attention and inhibition are needed.

There is a need for attention and inhibition tests which can be used on patients who are illiterates and/or with low levels of education. Such tests will require stimuli which do not require reading or writing skills. The figural visual scanning test (FVST),[7] auditory target detection test (ATDT),[8] stop signal test, and GNG test satisfy this criterion and were selected to be standardized. They have been adapted to the Indian context taking into consideration the cultural and sociodemographic factors. These tests do not require formal education as they do not require reading or writing abilities. In India, where educational level is low, these tests could be of use to aid in the detection of brain dysfunctions and formulating strategies for neuropsychological rehabilitation.

MATERIALS AND METHODS

Aims and objectives

The aim of the present study was to standardize tests of attention and inhibition for adults in the age range of 16–30 years, who had 1–10 years of formal education. The specific objectives were to develop normative data for the tests of attention and inhibition, to establish the reliability of the tests of attention and inhibition, and to establish the validity of the tests of attention.

Sample

The sample included two groups of subjects, normal subjects and patients with brain lesions in the age range of 16–30 years whose education ranged from 1 to 10 years.

Normal sample

The normal sample consisted of right-handed normal volunteers. The sample was divided into two groups on the basis of gender. The sample size was 60 with 30 subjects in each gender group. The subjects had no history of any psychiatric, neurological, or neurosurgical disorders and were with normal or corrected vision and hearing.

Clinical sample

The sample consisted of 20 adult patients with focal brain lesions who fulfilled the criteria of the study. Patients having unilateral lesions in the frontal, temporal, parietal, or occipital lobes, or a combination of these lobes, restricted to one hemisphere as identified by magnetic resonance imaging/computed tomography scans were selected for the study. There were 10 patients each with lesions restricted to the right and left hemisphere. The patients with no history of any psychiatric, neurological, or neurosurgical disorder with normal or corrected vision and hearing were taken Patients with raised intracranial pressure and exposure to cranial irradiation were excluded from the study.

Tools

Sociodemographic data sheet

Sociodemographic data sheet was prepared by the researcher to collect sociodemographic details of each subject included in the sample, i.e., name, age, sex, occupation, address, and education level for both the normal and patient groups. For the patient group, further information on the diagnosis, type of lesion, and area of lesion were obtained.

Screening tools

Edinburgh handedness inventory[9]

Edinburgh handedness inventory was used to determine handedness as only right-handed subjects were included in the sample. The inventory has 10 items and it takes 5–10 min for administration.

Tests to measure attention

The tests selected were FVST and ATDT.

Figural visual scanning test[7]

FVST measures focused attention. The test included 20 sets of meaningful and nonmeaningful figures, 5 each on each sheet of paper. The target is given on the left and the 5 choices on the right. The subject had to choose the target from the 5 choices given on the right. The total time was recorded. The number of correct answers and errors was also calculated.

Auditory target detection test[8]

ATDT is a measure of attention. A list of 120 concrete nouns was presented to the subject auditorily. The stimuli were words which are in common use and not pertaining to any category. All the words were of the same size. The target word is randomly repeated 20 times in the list. The test was available in English, Kannada, Tamil, and Malayalam. Scoring was in terms of hits, omissions, and commissions.

Tests to measure inhibition

The tests selected to measure inhibition were stop signal and GNG tests.

Stop signal test[3]

The stop signal task focused on the stop signal paradigm, in which subjects were given a primary task to perform and on occasions, a stop signal was presented that told them not respond on that trial. The stimulus was a list of double digits between 10 and 99. The digit 10 was the target and these targets were randomly inserted into the list. There were 48 targets, and out of these, 24 targets were coupled with the stop signal; they were predesigned targets to which the subject was not required to respond. The final score was the total of omission and commissions combined.

Go/no-go test[3]

In this task, two equiprobable stimuli were presented to the subject in random order, and subjects were asked to respond to one stimulus only and to withhold their response to the other stimulus. The list of names (50 trials with the name Ram and 50 trials with the name Mohan) was recorded in an audiocassette at the rate of one name per second. The score was the total errors or omissions and commissions combined.

Procedure

Normal subjects as per the inclusion and exclusion criteria were selected from the population. Informed consent was obtained after explaining about the study. The option to withdraw at any point of time without affecting treatment was given to the patients. The subjects were screened using the screening tool. Those who were not eligible to participate in the study were explained the reason for rejecting them. The subjects were seated comfortably in a quiet room and the tests were administered. The four tests were given in the same session with intervals of a few minutes duration in between the tests. Effect of fatigue was not seen in normal subjects. The order of presentation was randomized across subjects. Reliability of the tests was determined by retesting a part of the sample after an interval of 1 month. The tests were given to the clinical sample selected as per the inclusion and exclusion criteria from the inpatients and outpatients of the Department of Neurosurgery. For the patients, longer rest pauses were given to minimize the effect of fatigue. For patients with parietal and occipital lobe lesions, visual and perceptual deficits were ruled out before administering the tests.

Statistical analysis

The results obtained were tabulated and analyzed using statistical techniques such as means, standard deviations, *t*-tests, correlations, and percentiles.

RESULTS

Sociodemographic data

Normal subjects

The sample consisted of 60 individuals who were between 16 and 30 years of age and whose education varied between 1 and 10 years of formal education. The sample was divided into two groups based on the gender. The mean age of the sample was 21.07 years, and the mean education was 8.42 years.

Clinical subjects

The clinical sample included a matched group of 20 individuals with focal brain lesions, consisting of 10 individuals with lesions in the left hemisphere and 10 with lesions in the right hemisphere, 10 males and 10 females. The age range was 16–30 years and education range was 1–10 years of education. The mean age of the sample was 24.1 years, and the mean education was 7.15 years. The patients were recruited from the inpatient and outpatient departments of the Department of Neurosurgery, NIMHANS. The sociodemographic characteristics are given in Table 1.

Table 1: Sociodemographic characteristics of the sample

	n		Mean±SD	
	Normal	Clinical	Normal	Clinical
Sociodemographic characteristic				
Males	30	10		
Females	30	10		
Age	60	20	21.07±4.95	24.1±4.64
Education	60	20	8.42±2.61	7.15±2.99
Occupation				
Daily wage laborers	26	3		
Self-employed	1	4		
Agriculture	1	2		
Student	24	2		
Unemployed	8	9		

SD – Standard deviation

The effect of gender was calculated for all the test variables using *t*-test. It was found that females performed significantly poorer than males only on FVST ($t = 2.77$; $P < 0.05$). Males and females did not differ on the other tests. Pearson's correlation was used to examine the association between age, education, and test performance. Age had a significant effect on the performance of females on FVST ($r = 0.59$ for time and 0.66 for errors). It is seen that performance decreases significantly as education decreases. In males, there is a significant effect of education on figural visual scanning error ($r = -0.38$), auditory target detection commissions ($r = -0.37$), and GNG errors ($r = -0.63$). In females, there is a significant effect of education on figural visual scanning time and errors ($r = -0.71$), stop signal errors ($r = -0.48$), and GNG errors ($r = -0.41$).

Norms

Patients those who scored below the 15^{th} percentile on the scores of accuracy were considered to have a deficit. A score above the 85^{th} percentile was considered a deficit for time and error scores. In figural visual scanning errors and auditory target detection misses and commissions, majority of the subjects had the same score. For these measures, mode was taken as the measure of central tendency and the cutoff. A score above the mode was considered a deficit. The cutoff scores for the variables are presented in Table 2.

Reliability

Reliability of the test measures was established by retesting 20 subjects, 10 males and 10 females after 1 month and comparing the results obtained on the two occasions, i.e., test and retest were correlated.

The tests were found to have moderate to good reliability ranging from 0.94 to 0.32. ATDT commissions were not found reliable in the current study.

Validity

The validity of the different variables was determined by testing 20 patients with focal brain lesions and the results compared with the scores of normals on the different tests using *t*-test. It was found that all the variables had discriminant validity, i.e., they could differentiate between patients and normals. The tests had adequate face validity also.

Sensitivity and specificity of the tests

The sensitivity of a test variable can be defined as the probability that a patient with a brain lesion will have a deficit on a neuropsychological test, i.e., the true-positive rate.[10] The sensitivity of each test variable was studied by calculating the proportion of patients who had deficits according to the norm.

The specificity of a test can be defined as the probability that an individual without a clinical diagnosis will obtain a score indicating absence of deficits.[10] This is the true-negative rate. The specificity of the test variables was examined by calculating the proportion of the normal sample who had deficits in comparison with the norm. The sensitivity and specificity of each variable are presented in Table 3.

FVST errors and SS errors had high sensitivity and specificity. ATDT misses and commissions had moderate sensitivity and specificity. FVST time, ATDT hits, and GNG had adequate specificity but not sensitivity.

DISCUSSION

The main findings of the study are that FVST and ATDT are reliable and valid tests of attention and stop signal and GNG tests are reliable and valid measures of inhibition of motor processes. The norms of these tests could also be established.

FVST was affected by gender difference. This was the only test that had visuospatial aspects to it. It is seen from earlier research that males can perform significantly better on visuospatial tasks. Males have higher levels of testosterone. The testosterone level is hypothesized to increase visuospatial functions.[11] The reason for better visuospatial abilities in males is also hypothesized to be a result of evolutionary need arising from the need for more navigational abilities.[12] Since FVST had visuospatial aspects to it, apart from

Table 2: Cutoff scores of the variables

Measure	Cut-off for males	Cut-off for females
FVST time (s)	122	223
FVST errors	0	0
ATDT hits	18	18
ATDT misses	1	0
ATDT commissions	0	0
SS errors	9	10
GNG errors	5	5

FVST – Figural visual scanning test; ATDT – Auditory target detection test; SS – Stop signal test; GNG – Go/no-go test

Table 3: Sensitivity and specificity of the variables

Variable	Sensitivity	Specificity
FVST time	0.45	0.93
FVST errors	0.85	0.60
ATDT hits	0.30	0.93
ATDT misses	0.60	0.57
ATDT commissions	0.55	0.77
SS errors	0.65	0.93
GNG errors	0.35	0.90

FVST – Figural visual scanning test; ATDT – Auditory target detection test; SS – Stop signal test; GNG – Go/no-go test attentional aspects, females could have performed poorer on this test.

Age had influence only in the performance of FVST in female subjects. The age range of the subjects in the current study is too narrow (16–30 years) to manifest developmental changes. Ostrosky-Solis *et al*. found that the effect of aging is more pronounced in visual detection tasks.[13] The effect of age must have magnified on the test which was more difficult for females. None of the other tests are affected by age.

It is seen that performance decreases significantly as education decreases. Ostrosky-Solis *et al*. found the consequences of learning to read and write changes visual perception, logical reasoning, and remembering strategies.[13] Education improves the strategies to limit errors, and lesser education is associated with poorer error monitoring strategies.

All the tests were found to have moderate to good reliability ranging from 0.32 to 0.94. These indices of reliability indicate that the tests give similar results if given at different points of time. Since the individuals were tested after a time gap of only 1 month, there could have been effects of learning, practice, and familiarity which could influence the retest performance. The items on the different tests were such that there would be minimum effects of practice. In FVST, the stimuli and distractors were simple figures and on the other tests, the stimuli were numbers or common words, for which familiarity would not have any influence. Devender had determined the reliability of the tests of inhibition in a different population;[3] the age range was 20–30 years, and it was a heterogeneous sample of school educated, graduate, and postgraduate individuals. The current study is done with only school educated individuals with a wider age range of 16–30 years. In both the studies, it was found that the GNG and stop signal tests were reliable measures of inhibition. Auditory target detection commissions were not found reliable in the current study ($r = 0.32$). This might be because on retesting, the individuals were more familiar with the test and less anxious and were more careful about making unnecessary errors.

It was found that all the variables could discriminate between normal subjects and patients with brain lesion and had discriminant validity. Construct validity was present as the tests of attention required sustained, focused attention. The tests had targets and distractors. The tests of inhibition involved active inhibition of motor processes to irrelevant stimuli. The tests had adequate face validity also.

The sensitivity and specificity of the different variables were found. It is found that figural visual scanning and stop signal errors had high sensitivity and specificity. This must be because these tests were high on task difficulty as the distractors were similar to the targets. It may be hypothesized that the patients with brain damage had greater difficulty when the stimuli were similar as these tasks needed more attentional and inhibitory capacities. Auditory target detection misses and commissions had moderate sensitivity and specificity. For these scores, the cutoff scores could have been more stringent than the auditory target detection hits, and so it could discriminate between patients and normals. The sensitivity was less for figural visual scanning time, auditory target detection hits, and GNG errors, but these tests had adequate specificity. Figural visual scanning time cutoff might be influenced by the high scores that a few individuals in the normal sample had. Hence, it is possible that the patients also could perform adequately on the test. Auditory target detection hits were found less sensitive. This might be because the lesser number of targets made the task easy. The cutoff score was easy to pass. GNG test was a relatively simpler test with only two kinds of stimuli. Thus, the patients also could perform well on these tests.

The study reveals that sociodemographic variables can have a significant influence on the basic processes of attention and inhibition. The tests developed can be used effectively on clinical populations of lesser education also as the tests did not require reading or writing skills.

The study was limited by constraints of time. Norms are limited to the age group of 16–30 years and only individuals with 1–10 years of education. A more representative sample should have been taken for the male group as most of the individuals in the male group had more than 5 years of education. There should have been a greater number of individuals with lesser education. The patient sample should have been more representative to increase the generalizability of results. Sensitivity of the tests to lesion localization could not be studied as the patient sample was less. The clinical group should have consisted of a greater number of patients with lesions in the frontal lobe so that the sensitivity of the tests could be assessed more adequately.

Norms could be collected for other groups of the population also, with different age range and educational levels. Studies on validation and reliability can be done for other patient populations. Further studies can include more patients with lesions in the frontal lobe and compared with lesions in other lobes to study the effects of lesion localization on attention and inhibition.

CONCLUSION

The present study has established norms for two tests of attention, FVST and ATDT, and two tests of inhibition, stop signal and GNG tests. All four tests selected in the study were found to be reliable and valid.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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