

Assessment of Executive Function for Schizophrenia in Hong Kong

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Abstract

Patients with schizophrenia have been found to exhibit a cluster of symptoms collectively known as dysexecutive syndrome. However, neuropsychological studies of dysexecutive syndrome and their corresponding assessments are inherently difficult. Published studies of dysexecutive syndrome have predominantly considered English-speaking populations and, almost invariably, western cultural groups. As a consequence, the majority of assessment measures and checklists are standardised in English. The purpose of this paper is to discuss the current issues in the assessment of executive functions for schizophrenia in clinical practice in Hong Kong.

Key words: Hong Kong, Needs assessment, Schizophrenia

Introduction

Schizophrenia is associated with a wide range of cognitive impairments, including attention, memory, and executive functions, as well as a general decline in intellectual functioning.^{1,2} In particular, patients with schizophrenia have been found to exhibit a cluster of symptoms collectively known as dysexecutive syndrome.³ Dysexecutive syndrome may have a range of effects on activities of daily life, including the ability to work or attend school, function responsibly in the home, or have appropriate social relationships.⁴⁻⁶ Green et al found that deficits in executive functions in patients with schizophrenia ultimately determine the functional outcomes in terms of poor community living skills, self-care activities, social problem-solving skills, and psychosocial skills.^{7,8}

Neuropsychological studies of dysexecutive syndrome and its rehabilitation face inherent difficulties. One of the main critiques is the assessment of executive functions. Executive functions are thought to comprise a series of abilities to achieve a goal.^{9,10} Therefore, failure to accomplish executive function tests may be due to several reasons because damage may occur to any component of the process following the onset of schizophrenia or a brain lesion.

A further difficulty lies in the apparent fractionation of dysexecutive syndrome,^{11,12} meaning that a patient's performance in 1 frontal lobe test may have little or no predictive value for how they may perform in another test, let alone in a complex real-world situation. To address this problem, there is an increasing emphasis on incorporating more complex multifaceted life-like challenges within performance measures; in other words tasks that will tap a number of executive domains at the same time.¹³⁻¹⁵ However, behaviour in real-life must always remain the ultimate test for the clinician.

Published studies of dysexecutive syndrome have predominantly considered English-speaking populations and, almost invariably, western cultural groups. As a consequence, the majority of assessment measures and checklists are standardised in English. The purpose of this paper is to discuss the issues relating to the assessment of executive functions in local clinical practice. In particular, the focus will be on the Supervisory Attentional System.^{9,16} This theory assumes that the processes involved in the cognitive control of action and thought can be divided into 2 systems: contention scheduling and a supervisory attentional system. Contention scheduling is responsible for routine learned behaviour and performance of everyday tasks. Contention scheduling enables prioritisation of the order of simultaneously competing tasks or routine activities such as making a cup of coffee when a telephone rings. The supervisory attention system is responsible for regulating non-routine and novel tasks. There are 5 types of situations where routine automatic activation of behaviour would not be sufficient for optimal performance: situations involving planning or decision-making; situations involving error correction or troubleshooting; situations where responses are not well-learned or contain novel sequences of actions; dangerous or technically difficult situations; and situations that require a strong habitual response to be

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overcome or a temptation to be resisted. Impairment of this system would be expected to result in the inability to formulate a goal, to plan, and to choose between alternative sequences of behaviour to reach a particular goal.

The Supervisory Attentional System theory outweighs other theories by having a detailed subclassification or fractionation of specific components.^{10,17,18} The abnormalities associated with schizophrenia could be explained by such a theory. Frith has incorporated this construct in a cognitive neuropsychological theory of schizophrenia.¹⁹ This author proposed that 3 principal cognitive abnormalities found in schizophrenia can be plausibly understood as a failure at the level of the supervisory attentional system model. For this reason, only tests specifically developed within the framework of a supervisory attentional system model are reviewed. Three approaches of assessment will be addressed — namely, the neuropsychological and psychometric approach, the experimental approach, and the ecological approach.

The Neuropsychological and Psychometric Approach

The psychometric approach is commonly adopted in clinical practice and is primarily based on statistical concepts such as normalisation, factor analysis, validity, and reliability of different neuropsychological tests. However, one of the main critiques of neuropsychological testing is the validity of the construct being measured, particularly the assessment of executive functions. The most recent and significant advance in the past decade has been the attempt to isolate the specific component processes of executive functions — namely, initiation, planning, mental set shifting, strategy allocation, monitoring, and inhibition.^{10,14} However, in clinical practice, there is no pure task specifically designed to capture all the components of executive functions. It was only after the mid-1990s that researchers and rehabilitation professionals began to incorporate these components of executive functions into the development of neuropsychological testing.

The Six Elements Test (SET)¹⁴ was originally designed to assess strategy allocation and has been shown to exhibit both impressive validity and sensitivity for patients with schizophrenia,²⁰ as well as for patients with other neurological disorders.¹² The SET consists of 3 types of tests (simple arithmetic, written picture-naming, and dictation), each of which has 2 tasks (thus constituting a total of 6 tasks). Participants are required to attempt at least part of each of the 6 tasks within 10 minutes, but are not allowed to switch directly from a task of one type to its counterpart of the same type. To achieve a good performance in the test, participants are required to mobilise the most appropriate schemata across the different tasks consistently and optimally. Explicit monitoring of task performance can be used to check against any mismatch of representations or incorrect operations throughout the testing session. This test shows the ability to maintain an optimal performance

across different tasks. Chan et al have adapted this test to patients with post-concussion symptoms, schizophrenia, and healthy adults in Hong Kong and have shown that this test is sensitive for patients with deficits in attention allocation strategy and monitoring.^{21,22}

Semantic initiation and inhibition function may be assessed using the Hayling Sentence Completion (HSC) Test.¹⁷ In this test, participants are presented with sentences in which the last word is missing but is strongly cued by the rest of the sentence. The test is divided into 2 parts. The first part of the test requires the participants to give words that appropriately complete the sentence. In the second part of the test, words that make no sense in the context of the sentence are required. The participants are required to suppress the most salient responses. Salient responses are those that are rapidly and strongly triggered by intensity, categorical, or semantically related words. The first and second parts of the test therefore capture the construct of semantic initiation and inhibition, respectively. Recent studies using the Chinese versions of the HSC Test have demonstrated that patients with cognitive disorders such as schizophrenia perform significantly worse than healthy controls in inhibiting their semantic responses to related cued words.²²

The Brixton Spatial Anticipation Test measures rule detection ability within a format that is easy to administer and is designed to be pleasant for the participant.¹⁸ The test usually takes between 5 and 10 minutes to complete, and yields an easily understood scaled score of between 1 and 10. As this test is perceptually simple and does not require a verbal response, it is universally appropriate for people with a wide range of associated deficits, including those involving speech production or reading. This test has been demonstrated to have good sensitivity to problems with rule detection and tendencies towards impulsive and bizarre behaviour.

For switching and flexibility, the Stroop Test²³ and the Colour Trails Test²⁴ are frequently used for verbal and non-verbal aspects, respectively. For the Stroop Test, participants are requested to perform 2 tasks. The first 'colour task' requires participants to read the words of colour names, which are printed in colours different from the meaning of the words. The second colour task requires participants to read the printed colour of the words. The difference in time to complete the 2 parts indicates switching ability and flexibility. The advantage of the Colour Trails Test is the elimination of literacy. In part 1, participants are instructed to join the digits within the circles in ascending order. For part 2, participants are asked to join the digits within the circles with alternate colours. The response time to complete parts 1 and 2 reflects switching ability and flexibility.

The Tower of Hanoi^{25,26} and its derivative, the Tower of London,²⁷ have been used extensively for patients with neurological disorders²⁷ and schizophrenia^{22,28} to assess strategy allocation and planning. Each of these tests is a disk transfer task that involves a board with 3 equal-length

pegs spaced equidistantly and 4 wooden disks graduating in size. The version of Humes et al appears to have better psychometric properties than other variants.²⁶ In this version, participants are requested to solve a series of 12 tasks. They are given 6 trials to solve each problem correctly. A problem has to be solved correctly in 2 consecutive trials for the participants to receive points and move onto the next problem. A profile score for the 12 tasks is then computed. Chan et al have adapted this test for patients with post-concussion symptoms and those with schizophrenia, and have demonstrated that the planning time to initiate the first move of the disk is loaded on a factor of initiation, whereas the total profile score is loaded on a factor of attention allocation and planning.^{21,22,29}

The Experimental Approach

Unlike the neuropsychological and psychometric approach, the experimental approach does not concern the normative data of the corresponding tests. On the contrary, this approach focuses on the underlying cognitive process or component by controlling potential confounding variables as much as possible. This approach commonly involves computing programming augmented by different paradigms such as neurophysiological parameters, imaging and neuroimaging techniques, and eye-tracking equipment to examine specific components of executive functions.

Robertson et al³⁰ and Manly et al³¹ have successfully incorporated the construct of the supervisory attentional system in their test of sustained attention — the Sustained Attention to Response Task (SART). In this test, regularly presented non-target visual responses should be withheld for a rare target digit of '3'. Owing to the regular rhythmic pacing and the rarity of the targets, the task encourages a strategy of a fast anticipatory automatic response. Within a supervisory attention framework, while the non-target response is frequently exogenously activated and elicited by the task, the activation level of the target response must be endogenously maintained close to threshold if it is to compete successfully when appropriate. SART is therefore, in the supervisory attentional framework, designed to tap the ability to maintain sustained attention, which requires the higher cognitive control function of the supervisory attentional system. Chan et al have demonstrated that the correct response and commission error of the SART capture sustained attention and action inhibition, respectively.²²

The Ecological Approach

The ecological approach emphasises performance in an unstructured and unconstrained environment to simulate real-life situations as much as possible. The performance in these scenarios represents the real-life performance of patients. It has been noted that most laboratory tasks or neuropsychological measures of attention impairments are conducted in highly constrained environments over a short period of time, in contrast to daily life tasks that typically

occur in more complex and distracting environments over relatively prolonged periods of time.³²⁻³⁴ Data obtained from laboratory tasks may not represent real-life situations and may not be able to detect the true nature of attention problems among healthy people or represent executive dysfunctions among patients. Although many patients with frontal lobe lesions perform well in traditional tests of neuropsychological functions, they still experience difficulty in everyday activities.¹⁴

More complex multistep tasks in an unstructured environment or daily life scenario may require a complicated series of responses, including goal and subgoal setting, prioritisation of subgoals, triggering prospective memory to initiate tasks when the conditions are appropriate, and inhibition of irrelevant and inappropriate actions to different tasks. Therefore, most of the conventional experimental tasks tackle issues only at the impairment level, but cannot reflect a true picture beyond the levels of disability and handicap. Psychiatrists and psychologists need to pay equal attention to these purposes. This may be achieved through the use of more ecologically valid tests of executive function performance in real-life situations.

The development of the Behavioural Assessment of the Dysexecutive Syndrome (BADs)¹⁵ covers many aspects of performance in daily life. The tests in BADs require patients to impose structure on the tasks and to engage in forward planning. One potential danger of using unstructured tasks is that inter-rater reliability will be low. However, the inter-rater reliability coefficients for all BADs subtests are more than adequate. Another impressive feature of BADs, shared with other tests from the same group, is the demonstrated convergence with observational ratings of everyday problems in the same domain.

Other related ecologically valid assessment tools that map real-life behaviours and are relevant to the Chinese context include the Naturalistic Action Task³⁵ and the Test of Everyday Attention (TEA).³⁶ TEA has been adapted to the Hong Kong population³⁷ and has been shown to be useful for discriminating patients with attentional and executive function deficits from healthy people.^{21,29,37}

An alternative method is the use of a checklist or questionnaire asking patients or relatives to rate the frequency of occurrence of certain dysexecutive characteristics — for example, impulsivity and planning problems in abstract thinking. The 2 most commonly used questionnaires in clinical practice are the Dysexecutive Questionnaire¹⁵ and the Cognitive Failures Questionnaire.³⁸ These questionnaires have been validated among the healthy Chinese population and among patients in Hong Kong.^{21,39,40}

These tools might prove to be useful for neuropsychological and psychiatric rehabilitation. As they provide a method for picking up subtle difficulties in planning and organisation, particularly for people who appear to have well-preserved cognition and who function well in structured situations, they may prove to be particularly useful for assessing and preparing patients for the move from hospital care into more independent living situations.

Neurological Signs as an Alternative Method of Assessing Executive Functions

For neuropsychological assessment, the Lurian fist-edge-palm test of motor function is often used as a quick and easy-to-administer test that is sensitive to brain dysfunction such as that which occurs in schizophrenia^{22,41} and traumatic brain injury.⁴² In this task, participants are requested to successively place a hand in each of 3 postures of fist, edge, and palm. However, Luria later commented that this task was not specific and could be a general sign for diffused brain dysfunction collectively known as ‘soft signs’ or ‘neurological soft signs’.⁴³ The boundary between neuropsychological assessment and neurological signs is therefore contentious. Modifications of this task and other similar movements involving rhythm and repetitive action such as simple finger tapping, alternate finger tapping, and diadochokinesia have been incorporated as tests for frontal-executive functions⁴⁴⁻⁴⁶ and soft signs tests.^{41,47} More recently, Chan et al demonstrated that soft signs such as motor coordination, sensory integration, and disinhibition are strongly correlated with executive functions in patients with schizophrenia.²² The nature and characteristics of neurological soft signs testing (shorter testing time, the language-free component, and the portable nature) suggest that this test can be treated as an alternative for screening executive dysfunctions in clinical settings.

Conclusions

These 3 different approaches for assessing executive functions each have strengths and weakness. Although the reliability and validity of the different tests for the neuropsychological and psychometric approaches are commonly reported, a comprehensive assessment of the complete set of tests capturing specific components of executive

functions is time-consuming. The norms specific to the Chinese population are an issue for making an accurate clinical judgement on any deficits of executive functions. Nevertheless, finding the norms for the Chinese population in Hong Kong will be beneficial for this process. For the experimental approach, the stringent experimental conditions enable specification of the component of the executive functions that is impaired, if any, in patients with different neurological disorders. However, not all clinics may be equipped with full facilities for event-related potential testing or functional magnetic resonance imaging. The highly restrictive environment may also induce anxiety in patients, which may affect the final performance. The ecological approach enables study of executive functions in a relatively unstructured environment and therefore may be more valid for daily life situations. The use of self- and relative-reported data from questionnaires is a convenient and feasible approach both for clinicians and patients. However, more complex multistep tasks performed in an unstructured environment or daily life scenario may necessitate a more complicated and impure test for identifying specific executive component deficits.

It is clear that these 3 approaches require different methods and tests of executive functions, which may exist within a hierarchy of levels of analysis encompassing the continuum of disability. Figure 1 illustrates the relationships between different levels of the disease process of psychiatric disorders and the corresponding types of assessments adopted by these 3 approaches. The disease process potentially proceeds from pathology (abnormal electrical brain potentials) through impairment (failures in sustained attention) to disability (poor performance in real-world tasks), and finally to handicap of social participation (social roles dysfunction). Conventional neuropsychological and experimental tasks demand relatively simple responses to single events and tackle issues at the impairment level, whereas naturalistic

Figure 1. Relationship between different levels of the disease process and types of assessments.

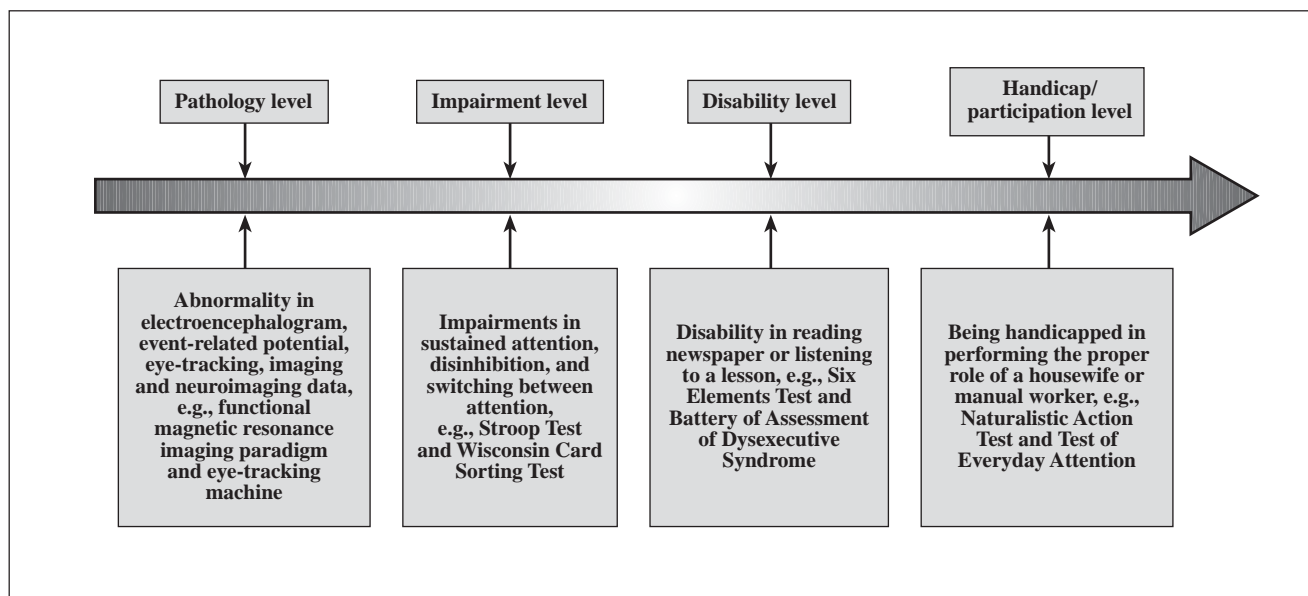


Table 1. Summary of tests of executive functions.

Test	Components	Language component	Format
Hayling Sentence Completion Test ^{17*} Chinese version ²²	Verbal inhibition	Yes	Laboratory-based test
Brixton Spatial Anticipation Test ^{18*}	Rule-detection and impulsivity	No	Laboratory-based test
Stroop Test Chinese version ²³	Verbal inhibition	Yes	Laboratory-based test
Colour Trails Test ²⁴	Switching and psychomotor speed	No	Laboratory-based test
Wisconsin Card Sorting Test (48 Modified version) ⁴⁸	Switching and preservation	No	Laboratory-based test
Tower of London ^{27*} Tower of Hanoi ^{26*}	Planning and strategy allocation	No	Laboratory-based test
Sustained Attention to Response Task ^{30*}	Sustained attention and inhibition	No	Laboratory-based test
Six Elements Test ^{15*}	Planning and strategy allocation	Yes	Semi-laboratory-based test
Naturalistic Action Test ^{35*}	Strategy allocation and planning	No	Real-life test
Battery of Assessment of Dysexecutive Syndrome ^{15*}	Different components of executive functions	Yes	Real-life test
Test of Everyday Attention ³⁶ Cantonese version ²¹	Sustained attention	Yes	Real-life test
Cognitive Failures Questionnaires ³⁸ Chinese version ³⁹	General everyday life cognitive failures	Yes	Real-life test (self- and relative-rated)
Dysexecutive Questionnaires ^{15*} Chinese version ³⁷	Intentionality, inhibition, executive memory, positive and negative affect	Yes	Real-life test (self- and relative-rated)

* Theory-based on the Supervisory Attentional System.

tasks capture a relatively true picture of performance at the levels of disability and handicap.

In clinical practice, it is more feasible to integrate these 3 approaches according to the needs of the patients and the characteristics of the settings. The significant correlations between neurological soft signs and executive dysfunctions, the shorter testing time, the language-free component, and the portable nature of neurological soft signs tests suggest that neurological soft signs can be treated as an alternative for screening executive dysfunctions in clinical settings.

Clinicians may use neurological soft signs and other bedside cognitive assessments to screen out potential executive function deficits. Patients may then be referred to neuropsychologists for further evaluation. As a quick reference, Table 1 lists some of the tests of executive functions, many of which have been validated among the Hong Kong Chinese population for clinical comparisons.^{15,17,18,21-24,26,27,30,35-39,48} Most importantly, the tests involving language components have been validated among the Hong Kong Chinese population for local psychiatric practice.

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