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## ORIGINAL ARTICLE

**Attention and executive function in people with schizophrenia:  
Relationship with social skills and quality of life**PHILIP J. TYSON<sup>1</sup>, KEITH R. LAWS<sup>2</sup>, KENNETH A. FLOWERS<sup>3</sup>, ANN M. MORTIMER<sup>4</sup>  
& JOERG SCHULZ<sup>2</sup><sup>1</sup>School of Natural and Social Sciences, University of Gloucestershire, Francis Close Hall Campus, Cheltenham, Gloucestershire, UK, <sup>2</sup>School of Psychology, University of Hertfordshire, Hatfield, UK, <sup>3</sup>Department of Psychology, University of Hull, Hull, UK, <sup>4</sup>Department of Psychiatry, University of Hull, Hull, UK**Abstract**

Executive function and attention are highly complex cognitive constructs that typically reveal evidence of impairment in people with schizophrenia. Studies in this area have traditionally utilised abstract tests of cognitive function and the importance of using more ecologically valid tests has not been extensively recognised. In addition, there has been little previous examination of the relationship between these key cognitive abilities and social functioning and quality of life in this population. Thirty-six schizophrenic patients and 15 controls were assessed on the Behavioural Assessment of the Dysexecutive Syndrome (BADs) test, three subtests from the Test of Everyday Attention (TEA), a measure of social functioning and a quality of life measure. Analysis of subtest scores revealed that patients were impaired on all attentional measures, but only one BADs subtest score in addition to the BADs profile score. However, 23 patients demonstrated no impairment in their BADs profile scores whilst being impaired on at least one attentional measure. Only the BADs profile score predicted social functioning and quality of life in schizophrenic patients. We conclude that ecologically valid tests of attention and executive function can play an important role in defining the cognitive deficits in schizophrenia and how such deficits relate to social function and quality of life.

**Key Words:** Schizophrenia, cognition, attention, executive function, social function, quality of life**Introduction**

Both executive function and attention are multi-dimensional and highly complex cognitive constructs. The high-level guiding and organizing nature of these processes means that both are often required for the successful operation of other cognitive domains, e.g., memory; and although they are regarded as being intimately related to each other, executive deficits are thought to affect the ability to co-ordinate and guide processes that might otherwise be regarded as attentional. For example, when defining executive processes, some refer to the fact that they guide attention as well as other processes (e.g., memory), are involved in the planning, sequencing and initiation of behaviour, self-monitoring, and the inhibition of behaviour that is inconsistent with a specific goal [1,2]. In some research, the two constructs are used almost interchangeably (e.g., [3]). Indeed, both processes are considered to be mediated by a supervisory *attentional* system (SAS [4]) which

plays an important role in the modulation of behaviour when tasks are novel, difficult and require a degree of planning and forethought (see [5]).

The notion that deficits of both executive and attentional function occur in schizophrenia can be traced back to the seminal works of Bleuler [6] and Kraepelin [7]. Indeed, cognitive fragmentation, lack of co-ordination and integration of higher mental functions figured prominently in their work; as did references to “a certain unsteadiness of attention” [7], or that “acute attention was lacking” [6]. More recently, poor performance on cognitive tasks have been widely documented in people with schizophrenia where mean effect sizes for both executive function and attention have been large (for meta-analytic reviews, see [8–10]; and even the relatives of people with schizophrenia show small to medium effect sizes [11]). Executive function (like attention), of course, comprises a variety of abilities and has been examined using a large number of tasks as varied as the Wisconsin Card Sorting Test (WCST)

through to verbal fluency and the Stroop (see [8] for a review); some of which also (implicitly) seem to be identified as tests of attention or minimally, as demanding significant aspects of attention (e.g., the Stroop and selective attention; the WCST and attentional switching). Therefore, like attention, executive function may be measured in a variety of ways and like attention, no single test can cover the manifold character of executive function. For example, tests of switching or set-shifting attention are typically regarded as tests of executive rather than attentional function (e.g., [12]). Indeed, deficits in this executive ability have been widely reported in schizophrenia using a variety of experimental paradigms that tap attentional function, including; cross-modal switching [13], the Wisconsin Card Sorting Test [14–16], the symbol digit modalities test (SDMT [17]) and the Intra/Extra dimensional shift test (ID/ED [18,19]).

On a cognitive level, contemporary definitions of attention suggest that this is a multifaceted concept incorporating selective, sustained and divided components [1]. *Selective attention* refers to the ability to maintain focus on relevant stimuli or ideas in the presence of other distracting stimuli and has commonly been found to be impaired in schizophrenic patients on tasks such as the Stroop (e.g., [14,17,20,21]), Go/NoGo tasks (e.g., [22]) or in paradigms where patients have to selectively respond to auditory or visual stimuli (e.g., [23]). *Sustained attention* (or vigilance) describes the ability to maintain attention and has been found to be impaired in people with schizophrenia in a variety of paradigms, including the Continuous Performance Test (CPT [14,24,25]); the Digit Vigilance Test (DVT [17]), and the Rapid Visual Information Processing Test (RVP [18,26]). *Divided attention* refers to the ability to attend simultaneously to more than one task or to several elements within a task. Performance decrements between individual and simultaneous task trials provide an indication of the divided attention abilities of patients. This aspect of attention has not been extensively investigated in schizophrenia, although the few studies that have been conducted have reported impaired performance in schizophrenic patients relative to controls on tasks of counting backwards whilst performing a visual digit cancellation task [27] and on binary (auditory and visual) choice reaction time tests [28].

Although many studies over several decades have examined executive and attentional functioning in people with schizophrenia, it should be noted that many executive and attention tasks are quite abstract in character (the paradigmatic case being the WCST). Although both Card Sorting and measures of vigilance relate to functional outcome [29], it is important to examine these cognitive domains using tasks that have some ecological validity. Ecological

validity has been described as the “functional and predictive relationship between the patient’s performance on a set of neuropsychological tests and the patient’s behavior in a variety of real world settings” (Ref. [30] p. 16). Tasks that tap everyday experiences (e.g., shopping, following a map, reading a telephone directory) are more likely to overcome any inherent motivational problems in schizophrenic patients, especially on complex and demanding executive and attentional tasks. Additionally, one must consider the fact that traditional executive tasks (in particular) are highly demanding and often correlate strongly with measures of general intellectual functioning (e.g., [8]). People with schizophrenia often present with an apparent IQ decline from estimated premorbid levels and in many cases, their schooling is severely interrupted. These factors mean that highly complex and demanding tasks may simply be pitched at too high a level to engage schizophrenic patients. Fortunately, suitable ecologically valid batteries of attentional and executive processes do exist in the form of the Everyday Test of Attention (TEA [31]) and the Behavioural Assessment of the Dysexecutive Syndrome (BADS [32]), respectively; and these are used in the current study. Although the TEA and the BADS have been well validated in groups of brain-impaired patients, these tests differ from traditional tests of attention and executive function insofar as their focus is on identifying individuals with limited functional abilities rather than the discrimination of brain injured and intact subjects; or in determining the etiology of possible brain dysfunction [33]. Chaytor and Schmitter-Edgecombe [33] have proposed that ecological validity is established through verisimilitude and veridicality. The former is the degree to which a test appears similar to situations in daily life, while the latter refers to the empirical relationship between test performance and functioning in daily life. In this context, the TEA and the BADS have high verisimilitude. The importance of using ecologically valid tests is stressed by studies which fail to find consistent associations between social abilities and performance on traditional, experimentally based tests of cognitive function (e.g., [29,34,35]). The current study examines the extent to which people with schizophrenia are impaired on batteries assessing ecologically valid (or everyday) attentional (TEA) and executive (BADS) abilities. Furthermore, in studies such as this it is important to incorporate an ecologically relevant criterion variable to explore the extent that performance on the TEA and BADS predicts social functioning in the community. Therefore patients will also be assessed with a measure of social ability and community based quality of life.

## Method

### Patients

Thirty-six patients (31 males; five females) were recruited from inpatient ( $N=5$ ) and outpatient ( $N=31$ ) units in East Yorkshire, UK. These patients all had a DSM-IV diagnosis of schizophrenia and no history of neurological disease, head injury, substance or alcohol abuse. The patient sample had an average age of 38 years ( $SD=8$ ; range 22–52), and had been ill for an average of 13 years ( $SD=7$  years; range 2 months to 31 years). The Brief Psychiatric Scale (BPRS) was used to assess symptom type and severity [36] and the mean total score on this scale was 10.6 ( $SD=4.9$ ; range 3–22). In addition, the BPRS score was broken down according to the four symptom dimensions identified by Overall et al. [37] and subsequent ratings were: thinking disturbance ( $M=4.1$ ,  $SD=2.9$ , range 0–11); withdrawal/retardation ( $M=2.0$ ,  $SD=2.0$ , range 0–8); hostility/suspiciousness ( $M=1.8$ ,  $SD=1.4$ , range 0–5), and anxiety/depression ( $M=4.6$ ,  $SD=3.0$ , range 0–12).

To investigate associations between medication levels and performance on the test battery, antipsychotic dosages were converted to the Percentage of Maximum Dose (PMD) in line with the British National Formulary (BNF [38]). This method of comparing antipsychotic potency circumvents some of the problems of using chlorpromazine equivalents as a method of assessing dose equivalence [39].

### Controls

Fifteen non-psychiatric controls were drawn from non-academic staff at the University of Hull and nursing staff from local NHS services. They were matched with the patient group for age (40.6 vs. 38.7:  $t_{49} = -0.72$ ,  $P=0.47$ ) and estimated premorbid IQ (103.2 vs. 98.2:  $t_{49} = -1.22$ ,  $P=0.22$ ) as measured by the National Adult Reading test (NART [40]).

## Tests and procedure

### Measures of attention and executive function

*The Test of Everyday Attention (TEA [31]).* Three subtests were chosen from this battery in order to investigate the key components of attention in an ecologically valid paradigm:

1. *Sustained attention.* This refers to the ability to sustain attention to repetitive stimuli. The TEA sub-test is based on a scenario where subjects are asked to imagine they are in an elevator with no visual means of indicating which floor they are on. Instead, the elevator “bleeps” whenever it passes a floor and the subjects simply have to count the bleeps in order to determine which

floor they have reached. Performance is judged on how many sequences of bleeps the subject counts correctly (up to 7).

2. *Selective attention.* This refers to the ability to attend to target stimuli in the presence of powerful distracters. This is similar to the sustained attention task, although the subject has to count bleeps of a certain pitch whilst ignoring those of a different pitch. Performance is judged on the number of sequences of bleeps counted correctly (up to 10).
3. *Divided attention.* This concerns the ability to respond to more than one task at the same time. This TEA sub-test involves an auditory counting task as detailed in the sustained attention test and at the same time, the subject has to search through a page from a telephone directory for specific entries. Performance is in terms of the decrement in performance between doing each task individually and both tasks simultaneously.

The Behavioural Assessment of the Dysexecutive Syndrome (BADs [32]). This battery contains six subtests:

1. *The Rule Shifts Cards Test* in which a previously established response set (responding “yes” to red cards, “no” to black) has to be inhibited in favour of responding in terms of whether or not a card matches the colour of the card immediately preceding it. Time taken and errors made constitute the performance indicators.
2. *The Action Program Test* is a planning task in which the solution requires the client to utilize various everyday materials (e.g., plastic, cork, and wire) in order to solve a problem. Scoring is based on the number of steps completed without prompting.
3. *The Key Search task* requires subjects to imagine they had lost their keys in a large field and are required to draw the route they would use to search for the keys. Scoring is based on the search strategy and time taken.
4. *The Temporal Judgement task* requires subjects to estimate the length of time it takes to perform an everyday activity. Performance is judged in terms of reasonable estimations according to BADs norms.
5. *The Zoo Map test* requires subjects to plan a route around a zoo in order to visit specific animals whilst not breaking certain rules (e.g., not using some paths more than once). Key performance indicators are the number of errors made, the number of places visited in the correct sequence, the time taken to plan the route and the time taken to execute the plan.
6. *The Modified Six Elements Test* (see [41]) assesses scheduling and time management by requiring clients to tackle three different tasks

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within the time limit; there are two versions of each task and the rules prohibit tackling these contiguously. Scoring is in terms of the number of tasks attempted, the number of times a rule is broken and the time spent on each activity

*Measures of social function and quality of life*

*The Multinomial Community Ability Scale [42].* The purpose of this Likert scale is to provide an indication of the level of social functioning of chronically mentally ill patients living in the community. It is designed to be completed by someone with a detailed knowledge of the patient and poses questions about a number of different domains of social function. An abridged version of the scale was used in the current study, including the modules *adjustment to living* and *social competence*.

*The Quality of Life Self Assessment Inventory [43].* This is a self report scale which provides patients with an opportunity to indicate areas of their life which they deem as unsatisfactory. It contains a 100-item inventory which is divided into 11 domains: housing, environment, knowledge and education, contacts, dependence, inner experiences, mental health; physical health, leisure, work and religion. The more items that are deemed unsatisfactory, the lower the quality of life.

*Statistical analysis*

Analysis of the frequency distributions of the TEA and BADS scales in the control group, using the D'Agostino–Pearson omnibus test for normality [44], revealed for three scales (i.e. TEA sustained attention, BADS Action program, BADS Rule shift card) non-normal distributions ( $K^2 = 16.48, 38.41$  and  $17.71$ , respectively; all  $P < 0.001$ ). The patient group also showed distributions that were non-normal on exactly the same tests ( $K^2 = 22.6, 19.79$  and  $10.21$ , respectively; all  $P < 0.001$ ). Because of the distribution problems on these three tests, we compared the groups using bootstrapping techniques. Bootstrap methods require far fewer assumptions than traditional parametric tests regarding data distributions and are advisable in circumstances where controls score very highly or patients very lowly [45]. With bootstrap techniques, a relevant test statistic ( $t, F, r$ , etc.) is chosen and then computed for the  $n$  bootstrap samples, i.e.  $n$  permutations of the original group data. When this occurs *with replacement*, a data point goes back into the sampling pool and may be redrawn numerous times. After many permutations, this results in a distribution of test statistics (rather than data points). The value of the original statistic is then compared to this new distribution to determine whether it is abnormal, e.g., if it is among the most extreme 5% of cases.

Hence bootstrap methods may be applied to data collected using traditional stimuli (even when ceiling effects are present). We created 1000 bootstrap samples, each equal in size to the original sample, by randomly resampling with replacement from the original patient data. Initially we examined the 1000 resamples using independent  $t$ -tests to compare patients and controls. The tests were performed one-tailed, and power calculations showed that the power for the  $t$ -test to detect a mean difference between controls and patients amounting to a medium effect size (Cohen's  $d = 0.5$ ) was  $\beta = 0.48$  with an  $\alpha$  error of 5% (one-tailed), and for a large effect size (Cohen's  $d = 0.8$ ) the power was  $\beta = 0.82$ . We also used bootstrap techniques to create 1000 Spearman's rank correlation samples to investigate the relation between TEA and BADS performance scores and symptom ratings (BPRS), medication (percent of maximum dose) and length of illness. Finally, we created 1000 multiple regressions to examine which measures of attention and executive function predicted social functioning and quality of life in the patients.

**Results***Group comparison*

The results of the between-group comparisons are displayed in Table I. As expected, controls performed significantly better on the selective, sustained and divided attention tests, with moderate-large effects size. Significant differences were only obtained for one of five BADS tests (Rule Shift,) all of which corresponded to medium effects sizes. However, a highly significant mean difference amounting to a strong effect size was revealed for the BADS total score (see Table I).

Finally, as Chapman and Chapman [44] have pointed out, a differential deficit in performance does not necessarily indicate a differential deficit in ability. To measure differential deficit in ability, tests must be matched on psychometric characteristics of test reliability and test difficulty. In addition, differential discriminating power of the various tasks may obscure any differential deficits in ability. One problem with executive tests is that their reliability is potentially invalid (largely because the tests constitute an all or nothing process, i.e. the tests measure executive function until their basis is understood and then essentially become measures of memory). Therefore, methods based on reliability are not appropriate; however Chapman and Chapman [45] presented an alternative using standardized residual scores. In the current study, we used the BADS Profile score as a predictor for performance on the three attentional tasks using the control data to derive a regression equation. This was used to predict patient performance; and then

Table I. Performance of schizophrenic patients and healthy controls on everyday measures of attention and executive function.

Test	Schizophrenic patients $n=36$	Healthy controls $n=15$	Mean $P$ value*	Effect size Cohen's $d$ (95% CI)*
<b>Attention tests (TEA)</b> (Scaled scores)	$M$ (SD)	$M$ (SD)		
Sustained attention (Elevator counting)	5.9 (1.6)	6.9 (0.3)	.011	.59 (.90 to .35)
Selective attention (Elevator counting with distraction)	5.2 (3.0)	7.9 (3.9)	.048	.71 (1.5 to .10)
Divided attention (Telephone search whilst counting)	4.9 (3.9)	9.7 (5.1)	.010	1.1 (1.7 to .44)
<b>Executive Tests (BADs)</b> (Profile scores)				
BADS Rule shift cards	3.2 (0.8)	3.7 (0.5)	.028	.66 (1.2 to .21)
BADS Action program	3.4 (1.0)	3.9 (0.5)	.070	.46 (.79 to .05)
BADS Key Search	2.3 (1.2)	2.6 (1.2)	.210	.23 (.79 to -.32)
BADS Temporal judgment	1.9 (0.9)	2.4 (1.1)	.110	.51 (1.2 to -.08)
BADS Zoo map	1.6 (1.1)	1.9 (1.2)	.190	.28 (.89 to -.31)
BADS Modified six elements	3.0 (1.1)	3.5 (0.8)	.090	.49 (.98 to -.04)
BADS total score	15.4 (3.4)	18.0 (2.4)	.013	.79 (1.4 to .33)

\*Derived from 1000 bootstrap independent  $t$ -tests.

the standardized residual were calculated for each of the three attention variables. We then compared patients and controls on the standardized residual measures. This revealed a significantly poorer performance in the patients for: sustained ( $F=4.9$ ,  $P=0.031$ ) and divided attention ( $F=11.78$ ,  $P<0.001$ ), but selective attention failed to reach significance ( $F=3.6$ ,  $p=0.070$ ). Hence the degree of impairment on sustained and divided attention tasks was differentially greater than for the BADS task.

#### *Relationship between medication, symptoms and test performance in patients*

For patients, we examined the relationship of attention and executive test performance with symptom ratings (BPRS), medication (percent of maximum dose) and length of illness. All correlations were weak ( $r_s < 0.30$ ) and non-significant. Quality of Life was significantly positively correlated with BPRS scores and the percentage of maximum dose of antipsychotics. By contrast, the social functioning scores (Multinmah) correlated significantly with

the three attentional measures and the BADS profile score (Table II).

#### *Relationship between social function, quality of life and test performance in patients*

We ran hierarchical regression analyses on the patient data blocking the three attentional variables (sustained attention, selective attention, divided attention), followed by the BADS profile score as predictors of scores for social functioning (Multinmah) and Quality of Life. For the Multinmah questionnaire (social functioning) the multiple  $r^2$  was 0.33,  $P=0.01$ . The attentional measures were nonsignificant ( $F=1.67$ ,  $P=0.19$ ); however, the inclusion of BADS profile score in block two approached significance ( $F=3.65$ ,  $P=0.06$ ). The  $r^2$  change for the BADS was showed that it accounted for 8% of the variance in the social functioning measure. For the Quality of Life questionnaire the multiple  $r^2$  was 0.20,  $P=0.13$ . The attentional measures were nonsignificant ( $F=1.02$ ,  $P=0.40$ ); however, again, the inclusion of BADS profile score in block two approached significance ( $F=3.75$ ,

Table II. Correlation matrix for background, cognitive and outcome measures.

	% max	BPRS	Sus	Sel	Div	BADS	Multin	Quality
Length of illness	0.08	0.22	-0.01	-0.07	0.10	-0.18	-0.05	-0.20
Percent Max dose		0.16	0.13	-0.12	-0.05	0.28	0.07	<b>0.36*</b>
BPRS total			-0.29	0.06	0.15	0.05	-0.16	<b>0.42*</b>
Sustained				<b>0.36*</b>	0.31	<b>0.44**</b>	<b>0.34*</b>	0.02
Selective					<b>0.69**</b>	0.31	<b>0.34*</b>	0.03
Divided						<b>0.33*</b>	<b>0.45**</b>	0.21
BADS							<b>0.47**</b>	0.32
Multin								0.21

\* $P < 0.05$ , \*\* $P < 0.01$ .

$P=0.06$ ). The  $r^2$  change for the BADS showed that it accounted for 10% of the variance in the Quality of Life measure.

#### Incidence of impaired patients according to test norms

Using the norms for each test, we determined the proportion of patients scoring below the 5th percentile (according to age based comparisons). The normative sample for each battery is large: for the BADS, the normative sample comes from 216 healthy subjects and for the TEA, 154 healthy subjects.

Patient scores were compared against the age-based norms and divided into those above and below the 5th percentile score for the normative sample. This revealed that far more patients were intact than impaired on the BADS total score (32 vs. 4) and the sustained attention test (22 vs. 14); however, for the selective (16 vs. 20) and divided attention measures (12 vs. 24), the majority of patients were impaired (see Figure 1). All four patients with impaired BADS performance have at least one attentional impairment; by contrast, 23 patients showed impairment on at least one attention task and no overall BADS impairment.

## Discussion

The three TEA scores revealed evidence of attentional impairment, with moderate to large effect sizes in schizophrenic patients. By contrast, only the overall BADS total profile and the rule shift subscale scores revealed evidence of executive impairment (with moderate effect sizes). The incidence and degree of impairment differed across the executive and attentional domains, with the latter revealing a greater incidence and severity of impairment. The standardised residual analysis shows that the differential deficits in performance are not due to psycho-

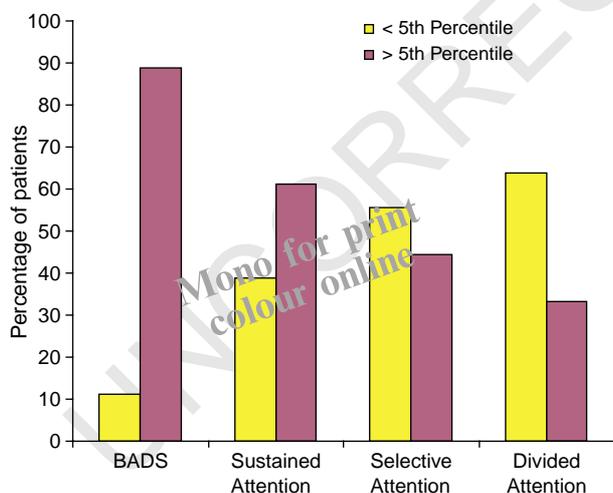


Figure 1. Percentage of patients performing above and below the 5th percentile level on each test (when compared with normative test data).

metric characteristics of the tests (e.g., test difficulty). Indeed, the majority of patients displayed some form of attentional deficit in the absence of any executive dysfunction; and the small number of patients with executive deficits all had attentional deficits. Neither executive nor attentional performance was related to the background variables of symptom ratings, medication (percentage of maximum dose) or duration of illness. This suggests that the presence of these cognitive deficits may be stable parts of the profile of schizophrenia rather than related to transient factors (relating, for example, to symptoms, medication, or length of illness); and in particular, that the severe and widespread attentional problem cannot be attributed to such factors.

Our findings show that, unlike the attentional measures, the BADS profile score predicts some variance in the outcome measures (social functioning and quality of life: 8 and 10%, respectively) in this patient group. These findings are consistent with the wider literature of associations between neurocognitive ability and social function [29] and a recent study has found that the BADS in particular was a significant predictor of functional outcome in this patient group [46], although the association has not been clearly shown in all studies [47]. Furthermore, Ritsner [48] found that cognitive deficits predicted impairments in quality of life in chronic schizophrenics, consistent with our results. Certainly, a wealth of evidence now exists to emphasise the importance of cognitive function to the social well-being of people with schizophrenia.

Although executive dysfunction has been pervasively documented in studies, the BADS identified only a minority of impaired patients in the current study, i.e. scoring below the 5th percentile. Given claims for the presence and pervasiveness of executive dysfunction or even frontal lobe disorder in schizophrenia, our data indicate that such impairments are perhaps neither as severe nor as widespread as previously thought. The largest executive deficit emerged for the overall profile score and this is consistent with two recent studies that used the full battery [49,50]. The profile score does, of course, compound the six subtest differences; and the patients performed significantly worse than controls only on the rule shift task. Even on the overall BADS profile measure, approximately only 10% of the patients scored within the impaired range. There are several possible interpretations of this finding. One is that the BADS battery is not sensitive to executive dysfunction or the kinds of executive dysfunction that are more commonly demonstrated using other (more abstract) tests such as the WCST, the Tower of London and so on. Although, as noted earlier, such tests may be too demanding for schizophrenic patients. Another possible interpretation is that the everyday character of the battery in some way makes it easier for the

patients to complete. Indeed, as hoped, patients may be able to draw on their life experience when attempting the BADS tasks and this might compensate for even moderate executive dysfunction. This notion is consistent with BADS having high verisimilitude, and our findings that this battery predicts social functioning also supports this assertion. Nevertheless, some authors propose that the BADS may be sensitive to subtle executive deficits that are not identified by some more traditional test of executive function [51]. It is also worth noting that ecologically valid tests of executive function rely on multiple cognitive domains and may not purely index the hypothesized cognitive constructs, e.g., the Action Program test of the BADS requires planning, self monitoring and inhibition.

The low level of executive impairment reported here, and the fact that many patients with attentional deficit showed no executive problems, suggests that attentional problems are not only more common and more severe, but may occur independently of executive dysfunction in schizophrenia. This accords with evidence from longitudinal high-risk studies in offspring of parents with schizophrenia, which suggest that abnormalities in attention are present far before the onset of the illness [52,53]. It is important to note that we did not find that patients performance on the attentional tasks to be predictors of social function or quality of life. This finding is not consistent with the wider literature, e.g., [29,48]. Perhaps the ecological validity (and verisimilitude) of the attentional tasks chosen can be questioned (indeed the authors do not consider "counting bleeps" to be a very common pastime in everyday life). It is also plausible that the cognitive concept of attention is not as closely related to social function as executive function. Furthermore, it has been suggested in the literature that cognitive abilities have to be at a certain criterion level in order to demonstrate an association with social abilities [54]. Therefore patient's performance on the attentional tasks did not meet this criterion threshold, yet performance on the executive tasks did.

The deficit of attention identified here affected all three aspects of attention that were measured. Nonetheless, our data indicate that not all aspects of attention were comparably impaired in schizophrenic patients, but that divided attention seemed most sensitive, while sustained was the least impaired and selective fell between the two. As detailed in the introduction, deficits in these aspects of attention have been previously reported in the literature, although as far as we are aware, this study is the first to document such deficits using a purportedly ecologically valid measure i.e. the TEA; and, moreover, to indicate that attentional deficits may occur independently of executive dysfunction in people with schizophrenia.

## Statement of Interest

There were no conflicts of interest with this work.

## References

- [1] Lezak MD. Neuropsychological assessment, 3rd ed. New York: Oxford University Press; 1995.
- [2] Frith CD. The cognitive neuropsychology of schizophrenia. Erlbaum: East Sussex, UK; 1992.
- [3] Chan RCK, Chen EYH, Cheung EFC, Chen RYL, Cheung HK. The components of executive functioning in a cohort of patients with chronic schizophrenia: A multiple single-case study design. *Schizophr Res* 2006;81:173–89.
- [4] Norman DA, Shallice T. Attention to action. Willed and automatic control of behaviour. University of California, San Diego, CA. CHIP Report 99; 1980.
- [5] Nebel K, Wiese H, Stude P, de Greiff A, Diener HC, Keidel M. On the neural basis of focused and divided attention. *Cogn Brain Res* 2005;25:760–76.
- [6] Bleuler E. Dementia praecox or the group of schizophrenias. New York: International University Press; 1911. (English edn 1950).
- [7] Kraepelin E. Manic depressive insanity and paranoia (translated by RM Barclay, from the 8th ed. of *Lehrbuch der psychiatrie*, vols III and IV). Edinburgh: Livingstone; 1921.
- [8] Laws KR. A meta-analytic review of Wisconsin Card Sorting Studies in schizophrenia: A general intellectual deficit in disguise? *Cogn Neuropsychiatry* 1999;4:1–35.
- [9] Heinrichs RW, Zakzanis KK. Neurocognitive deficit in schizophrenia: A quantitative review of the evidence. *Neuropsychology* 1998;12:426–45.
- [10] Henry JD, Crawford JR. A meta-analytic review of verbal fluency deficits in schizophrenia relative to other neurocognitive deficits. *Cogn Neuropsychiatry* 2005;10:1–33.
- [11] Sitskoorn MM, Aleman A, Ebisch SJH, Appels MCM, Kahn RS. Cognitive deficits in relatives of patients with schizophrenia: a meta-analysis. *Schizophr Res* 2004;71:285–95.
- [12] Silverstein ML, Mavroleftos G, Turnbull A. Premorbid factors in relation to motor, memory, and executive functions deficits in adult schizophrenia. *Schizophr Res* 2003;61:271–80.
- [13] Sutton S, Zubin J. Effect of sequence on reaction time in schizophrenia. In: Welford AT, Birren JE, editors. *Behavior, aging and the nervous system*. Springfield, IL: Charles C Thomas; 1965. p 562–97.
- [14] Hagh-Shenas H, Toobai S, Makeremi A. Selective, sustained and shift in attention in patients with diagnoses of schizophrenia. *Percept Mot Skills* 2002;95:1087–95.
- [15] Green MF, Satz P, Ganzell S, Vaclav JF. Wisconsin Card Sorting Test performance in schizophrenia: Remediation of stubborn deficit. *Am J Psychiatry* 1992;149:62–7.
- [16] Braff DL, Heaton R, Kuck J, et al. The generalized pattern of neuropsychological deficits in outpatients with schizophrenia with heterogenous Wisconsin Card Sorting Test Results. *Arch Gen Psychiatry* 1991;48:891–8.
- [17] Chan MWC, Yip JTH, Lee TMC. Differential impairment on measures of attention in patients with paranoid and nonparanoid schizophrenia. *J Psychiatr Res* 2004;38:145–52.
- [18] Morris RG, Evenden JL, Sahakian BJ, Robbins TW. Computer-aided assessment of dementia: Comparative studies of neuropsychological deficits in Alzheimer-type dementia and Parkinson's disease. In: Stahl S, Iverson S, Goodman E, editors. *Cognitive neurochemistry*. Oxford: Oxford University Press; 1987. p 21–36.
- [19] Tyson PJ, Laws KR, Roberts KH, Mortimer AM. Stability of set-shifting and planning abilities in patients with schizophrenia. *Psychiatr Res* 2004;129:229–39.
- [20] Weiss EM, Golaszewski S, Mottaghy FM, et al. Brain activation patterns during a selective attention test – a

- functional MRI study in healthy volunteers and patients with schizophrenia. *Psychiatr Res Neuroimaging* 2003;123:1–15.
- [21] Lopes-Machado EZ, Crippa JA, Hallak JE, Guimaraes FS, Zuardi AW. Electrodermally nonresponsive schizophrenia patients make more errors in the Stroop Color Word Test, indicating a selective attention deficit. *Schizophr Bull* 2002; 28:459–66.
- [22] Erkwow R, Sabri O, Schreckenberger M, et al. Cerebral correlates of selective attention in schizophrenic patients with formal thought disorder: a controlled H<sub>2</sub><sup>15</sup>O-PET study. *Psychiatr Res Neuroimaging* 2002;115:137–53.
- [23] Wood SM, Potts GF, Hall JF, Ulanday JB, Netsiri C. Event-related potentials to auditory and visual selective attention in schizophrenia. *Int J Psychophysiol* 2006;60:67–75.
- [24] Cosway R, Byrne M, Clafferty R, et al. Sustained attention in young people at high risk for schizophrenia. *Psychol Med* 2002;32:277–86.
- [25] Liu SK, Chiu CH, Chang CJ, Hwang TJ, Hwu HG, Chen WJ. Deficits in sustained attention in schizophrenia and affective disorders: stable versus state-dependent markers. *Am J Psychiatry* 2002;159:975–82.
- [26] Prouteau A, Verdoux H, Briand C, et al. Cognitive predictors of psychosocial functioning outcome in schizophrenia: A follow-up study of subjects participating in a rehabilitation program. *Schizophr Res* 2005;77:343–53.
- [27] Cannon TD, Huttunen MO, Lonnqvist J, et al. The inheritance of neuropsychological dysfunction in twins discordant for schizophrenia. *Am J Hum Genet* 2000;67: 369–82.
- [28] Daban C, Amado I, Bourdel M, et al. Cognitive dysfunctions in medicated and unmedicated patients with recent-onset schizophrenia. *J Psychiatr Res* 2005;39:391–8.
- [29] Green MF, Kern RS, Braff DL, Mint J. Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the “right stuff”? *Schizophr Bull* 2000;26:119–36.
- [30] Sbordone RJ. Ecological validity: Some critical issues for the neuropsychologist. In: Sbordone RJ, Long CJ, editors. *Ecological validity of neuropsychological testing*. Boca Raton, FL: St Lucie Press; 1996. p 15–41.
- [31] Robertson IH, Ward T, Ridgeway V, Nimmo-Smith I. *The test of everyday attention*. Bury St. Edmunds, UK: Thames Valley Test Company; 1994.
- [32] Wilson BA, Alderman N, Burgess PW, Emslie H, Evans JJ. *Behavioural assessment of the dysexecutive syndrome*. Bury St Edmunds, UK: Thames Valley Test Company; 1996.
- [33] Chaytor N, Schmitter-Edgecombe M. The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. *Neuropsychol Rev* 2003;13:181–97.
- [34] Prouteau A, Verdoux H, Briand C, et al. The crucial role of sustained attention in community functioning in outpatients with schizophrenia. *Psychiatr Res* 2004;129:171–7.
- [35] Semkowska M, Bedard M, Godbout L, Limoge F, Stip E. Assessment of executive dysfunction during activities of daily living in schizophrenia. *Schizophr Res* 2004;69:289–300.
- [36] Hedlund JL, Vieweg BW. The Brief Psychiatric Rating Scale (BPRS): A comprehensive review. *J Oper Psychiatry* 1980; 11:48–65.
- [37] Overall JE. The Brief Psychiatric Rating Scale in psychopharmacologic research. In: Rockville GW, editor. *ECDEU assessment manual for psychopharmacology* (DHEW Publication No (ADM) 76-338). Bethesda, MD: National Institute of Mental Health; 1976. p 166–9.
- [38] British National Formulary. *The British Medical Association: London*; 2004.
- [39] Yorston G, Pinney A. Chlorpromazine equivalents and percentage of British National Formulary maximum recommended dose in patients receiving high-dose antipsychotics. *Psychiatr Bull* 2000;24:130–2.
- [40] Nelson HE. *National Adult Reading Test (NART): Test Manual*. Windsor: NFER-Nelson; 1982.
- [41] Shallice T, Burgess P. Deficits in strategy application following frontal lobe damage in man. *Brain* 1991;114: 727–41.
- [42] Barker S, Barron N, McFarland BH, Bigelow DA. A community ability scale for chronically mentally ill consumers: Part 1. Reliability and validity. *Community Ment Health J* 1994;39:363–83.
- [43] Skantze K, Malm U. A new approach to facilitation of working alliances based on patients’ quality of life goals. *Nordic J Psychiatry* 1994;48:37–49.
- [44] Chapman LJ, Chapman JP. The measurement of differential deficit. *J Psychiatr Res* 1978;14:303–11.
- [45] Chapman LJ, Chapman JP. Strategies for resolving the heterogeneity of schizophrenics and their relatives using cognitive measures. *J Abnorm Psychol* 1989;98:357–66.
- [46] Katz N, Tadmor I, Felzen B, Hartman-Maeir A. The Behavioural Assessment of the Dysexecutive Syndrome (BADS) in schizophrenia and its relation to functional outcomes. *Neuropsychol Rehabil* 2007;17:192–205.
- [47] Evans J, Chua S, McKenna P, Wilson B. Assessment of the dysexecutive syndrome in schizophrenia. *Psychol Med* 1997; 27:635–46.
- [48] Ritsner MS. Predicting quality of life impairment in chronic schizophrenia from cognitive variables. *Qual Life Res* 2007;3:Epub.
- [49] D’Agostino RB, Belanger A, D’Agostino RB. A suggestion for using powerful and informative tests of normality. *Am Statistician* 1990;44:316–21.
- [50] Deluchhi KL, Bostrom A. Methods for analysis of skewed data distributions in psychiatric clinical studies: working with many zero values. *Am J Psychiatry* 2004;161:1159–68.
- [51] Krabbendam L, De Vugt ME, Derix MMA, Jolles J. The Behavioural Assessment of the Dysexecutive Syndrome as a tool to assess executive functions in schizophrenia. *Clin Neuropsychol* 1999;13:370–5.
- [52] Niemi LT, Suvisaari JM, Tuulio-Henriksson A, Lonnqvist JK. Childhood developmental abnormalities in schizophrenia: evidence from high-risk studies. *Schizophr Res* 2003;60: 239–58.
- [53] Gschwandtner U, Aston J, Borgwardt S, et al. Neuropsychological and neurophysiological findings in individuals suspected to be at risk for schizophrenia: preliminary results from the Basel Early Detection of Psychosis Study – Fruherkennung von Psychosen (FEPSY). *Acta Psychiatr Scand* 2003;108:152–5.
- [54] Wykes T, Reeder C, Williams C, Corner J, Rice C, Everitt B. Are the effects of cognitive remediation therapy (CRT) durable? Results from an exploratory trial in schizophrenia. *Schizophr Res* 2003;61:163–74.