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Psychometric Validation of the Dysexecutive Questionnaire (DEX)

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Psychometric Validation of the Dysexecutive Questionnaire (DEX)

Abstract

This study reported on the validation of the psychometric properties, the factorability, validity, and sensitivity of the Dysexecutive Questionnaire (DEX) in three clinical and nonclinical samples. A mixed sample of 997 participants—community (n = 663), psychiatric (depressed [n = 92] and anxious [n = 122]), and neurologically impaired (n = 120)—completed self-report questionnaires assessing executive dysfunction, depression, anxiety, stress, general self-efficacy, and satisfaction with life. Prior to analyses the data were randomly split into two subsets (A and B). Exploratory factor analysis performed on Subset A produced a three-factor model (Factor 1: Inhibition, Factor 2: Volition, and Factor 3: Social Regulation) in which 15 of the original 20 items provided a revised factor structure that was superior to all other structures. A series of confirmatory factor analyses performed on Subset B confirmed that this revised factor structure was valid and reliable. The revised structure, labeled the DEX-R, was found to be a reliable and valid tool for assessing behavioral symptoms of dysexecutive functioning in mixed community, psychiatric, and neurological samples.

Keywords: DEX-R, psychometric, validation, dysexecutive syndrome, mood and anxiety disorders

Introduction

Executive functioning is typically measured using clinical interviews, neuroimaging techniques, neuropsychological assessment, or standardized questionnaires. Each measurement approach has its strengths and limitations, and all are associated with a certain degree of error. Clinical interviews provide subjective, verbal accounts of deficits in executive functioning in a person's life. However, one of the major limitations associated with clinical interviews is that they can be time consuming, which, in the context of the present research, is not conducive to ease of data collection. Furthermore, due to their subjective nature it can be laborious to compare data across large samples. While neuroimaging is the most accurate way to measure neuroanatomical structures its ability to measure the severity and nature of hypothetical cognitive constructs, such as executive functioning, is arguable. Some of the most commonly used batteries of executive functioning include the Behavioral Assessment of the Dysexecutive Syndrome (Alderman, Burgess, Emslie, Evans, & Wilson, 2003), the Delis-Kaplan Executive Function System (Delis, Kaplan, & Kramer, 2001), the modified Six Elements Test (Burgess et al., 1996), the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996), and the Multiple Errands Test (Shallice & Burgess, 1991). While all the above assessment scales have been used in the literature the Dysexecutive Questionnaire (DEX) is the focus of this study.

The Dysexecutive Questionnaire

The frontal lobes are the higher cortical center for executive functioning. Due to the intricate networking of the brain the frontal lobes do not act in isolation when performing executive function tasks. Functions such as planning, attentional control, self-monitoring, and evaluation (i.e., considering consequences for one's actions) appear to be driven by separate mechanisms that share underlying neural circuitry (Weingartner, 2000). The term "Frontal

Lobe Syndrome" (The Dysexecutive Syndrome) was originally used to describe the collective dysexecutive symptoms observed in neurological patients. It was specifically defined as "an amorphous varied group of deficits resulting from diverse aetiologies, different locations and variable extents of abnormalities" (Stuss & Benson, 1984, p. 3). The DEX (Burgess et al., 1996) is a qualitative and quantitative self-report measure designed to fractionate daily functioning into sub-scales of dysexecutive functioning. Although the DEX was initially developed to assess impairment in frontal lobe patients the measure potentially allows for fairly specific comparisons of executive dysfunction across different clinical populations.

The DEX was developed to supplement and provide ecological validity for the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996). However, despite widespread use of the DEX in the literature there are a number of limitations relating to its use. First, no study has conducted a Confirmatory Factor Analysis (CFA) to confirm the psychometric properties of the questionnaire. Second, all previous factor analytic studies have used relatively restricted sample sizes and types. Third, despite some similarities in factor structures across studies the factor structure of the DEX remains ambiguous. Fourth, previous reliability and validity analyses are scant. For example, only one previous study (Bennett, Ong, & Ponsford, 2005) has reported on the internal consistency of the DEX. Finally, although prior research has validated its use in a variety of neurological samples (Bennett et al., 2005; Bogod, Mateer, & MacDonald, 2003; Burgess, 1997; Wilson et al., 1996) and in an opiate-dependent sample (Mooney, Walmsley, & McFarland, 2006), no study has examined the extent to which the scale can effectively measure executive dysfunction in psychiatric populations.

Despite these limitations the DEX remains widely used in the research literature (Bajo & Nathaniel-James, 2001; Bennett et al., 2005; Bogod et al., 2003; Chaytor, Schmitter-Edgecombe, & Burr, 2006; Norris & Tate, 2000), and is a promising measure of executive functioning across a variety of samples. Therefore, further research is warranted to ascertain the psychometric properties and factor structure of the DEX across community samples and psychiatric outpatients.

Four studies have explored the factor structure of the DEX using exploratory factor analysis (EFA) in a variety of samples (e.g., neurological, opiate-dependent, and normative); however, these studies have used limited sample sizes and types (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Chan, 2001; Mooney et al., 2006; Wilson et al., 1996). Furthermore, whilst these studies provide evidence of some consistency between factor structures there remains a lack of consensus regarding a robust and parsimonious factor structure. We reviewed each of these factor analytic studies, the results of which are presented in Table 1.

Insert Table 1 about here

A preliminary standardization study of the DEX examined a sample of 78 neurological patients (*M* = 38.8 years) of various aetiologies and 216 control participants (*M* = 46.6 years) recruited from a variety of sources in the United Kingdom (UK) and United States of America (USA) (Wilson et al., 1996). Initial EFA of the DEX for the neurological sample only showed that the symptoms associated with dysexecutive syndrome could be behaviorally fractionated into three general factors: (1) behavioral; (2) cognitive; and (3) emotional symptoms. These three factors account for approximately 50% of the variance (see Table 1).

In 1998 Burgess et al. conducted a more comprehensive EFA of the DEX using the same UK/USA sample as Wilson et al. (1996), with an additional 14 participants in the neurological cohort. Results revealed that a five-factor model was adequate in explaining the correlations among the 20 items. Varimax rotations revealed a five-factor solution, with these explaining 67.2% of the variance. Burgess et al. labeled Factor 1 as *"Disinhibition"* or the inability to inhibit a pre-potent response. Factor 2 included items that related to the patients' inability to formulate appropriate goal-oriented plans and follow complex behavioral sequences and was labeled *"Intentionality"*. Factor 3 described the memory disturbances associated with dysexecutive syndrome and was coined *"Executive Memory"*. Factors 4 and 5 related to the positive and negative emotions associated with dysexecutive syndrome and were consequently categorized as *"Positive Affect"* and *"Negative Affect"* respectively (see Table 1).

In another study Mooney et al. (2006) found a four-factor solution was the most parsimonious, in contrast to the factor solutions of the DEX found by Burgess et al. (1998) and Chan (2001). Mooney et al. argued that the five-factor solutions were theoretically uninterpretable and contained multiple ambiguous items. Given this, Mooney et al. concluded that their four-factor solution was the most favorable, with 54% of the variance being accounted for by the solution. The four factors are "*Inhibition"*, "*Intention"*, *"Social Regulation"*, and *"Abstract Problem Solving"*. This solution also contained two ambiguous items (i.e., item 5: euphoria, and item 16: inability to inhibit responses); however, item ambiguity was present in all three factor solutions described above (Burgess et al., 1998; Chan, 2001; Mooney et al., 2006). Item 10 (variable motivation) was also left out of the final factor structure.

There is currently a paucity of studies examining the factor structure of the DEX. All previous (EFA) studies yielded varying structures of between three and five factors (Burgess et al., 1998; Chan, 2001; Mooney et al., 2006; Wilson et al., 1996). However, no CFA research has been reported to date. CFA provides a stringent test of the latent structure of a measure, since it allows for the testing of specific hypotheses about data (Tabachnick & Fidell, 2007). Further, CFA explicitly identifies whether items are adequate measures of the underlying construct that the questionnaire is designed to measure (Chou & Bentler, 1995). CFA also allows alternative factor models to be compared for best fit to the data. As CFA is a more stringent statistical technique than EFA it should be an essential step in validating the DEX.

Results from previous DEX factor analytic studies are somewhat promising in that there appears to be some overlap between factor structures, despite the fact that there are some fundamental methodological differences between the studies. First, previous research used different versions of the questionnaire to measure symptoms of executive dysfunction; specifically, the DEX-O was used in two studies (Burgess et al., 1998; Chan, 2001), while the DEX-S was used in one study (Mooney et al., 2006). Second, these studies used restricted sample sizes, ranging from 49 to 78 participants for populations of interest.

Although previous EFA research of the DEX has provided some similarity across factor structures the factor structures remain ambiguous. Moreover, despite its widespread use the DEX has never been subjected to CFA. Thus, it is evident that further examination of the psychometric properties of this questionnaire is clearly warranted to evaluate the consistency and stability of the factor structure of the DEX across a variety of populations, in particular in psychiatric outpatients.

The current research aimed to address the limitations and gaps in the existing literature by further investigating the factor structure of the DEX-S in a diverse sample. Our study aimed to answer the question "Can DEX be generalized across community, psychiatric, and neurological samples?" Given that the findings of previous research were ambiguous in relation to a specific factor structure of the DEX, and that there was no a priori basis for a specific factor structure for the psychiatric group, no specific hypotheses were given; however, it was expected that a three-factor structure would most likely emerge based on previous findings. In addition, different previous models were also compared using CFA.

Method

Participants

Nine hundred and ninety-seven individuals across three settings participated (51% male), comprising a community sample (*n* = 663), psychiatric sample (depressed patients, *n* = 92; anxiety patients, *n* = 122), and neurologically impaired sample (*n* = 120). Psychiatric outpatients were recruited from a cognitive behavioral therapy (CBT) unit at a psychiatric hospital and, similarly, neurological patients were recruited from the head injuries unit of a large public general hospital. The community sample comprised a mix of university students and other individuals. The majority of participants were born in Australia (81.8%) and spoke English at home[1] (88.0%). We also collected participants' actual education level and created dummy variables for simplicity of descriptive reporting: participants had completed either year 10 or below (15%), year 11-12 (50%), or higher education (35.0%). Reported occupations included students (75.0%), professionals (15.0%), and casual or house-oriented workers (10.0%). We chose different samples in order to create a more rigorous and diverse DEX testing so that we could then directly compare the groups. This design added strength to our study. Ages ranged from 15 to 72 years (*M* = 29.7; *SD* = 13.8) with a median age of 23 years. The rejection rate for the clinical sample was less than 5%, while the rejection rate for the community sample was 20%. Thus, the total sample had a participant rate of about 80% to 95%, which was more than adequate. All patients admitted to the relevant hospital units during the recruitment period were approached and less than 5 % decided not to participate. This rate of refusal in a hospital setting is expected. However, in the community group, the rate of refusal from university students was less than 10% but the rate of refusal from other individuals was about 25%. Thus, overall, the community group refusal rate was about 20%.

[1] Australia is a very multicultural society and non-English-speaking households are common. It is important to note that while participants may not have spoken English as their first language at home this did not necessarily mean that they did not speak or understand English at all. Some patients in this category were given time and/or help to fill out the questionnaires.

Measures

Dysexecutive functioning was assessed using the DEX (Wilson et al., 1996). To examine the parsimony of the DEX models we employed the Zung Self-Rating Depression Scale (SDS) (Zung, 1965), the Beck Anxiety Inventory (BAI) (Beck, Epstein, Brown, & Steer, 1988), the Depression, Anxiety and Stress Scale (DASS), the General Self-efficacy Scale (GSES) and the Satisfaction with Life Scale (SWLS). These tests are well established and are the most commonly used tests for both anxiety and mood disorders for clinical outcome studies (See also Oei & Boschen, 2009).

Dysexecutive functioning. The DEX is a 20-item scale that measures a range of dysexecutive symptoms. It is structured on a five-point Likert scale ranging from 0 *(never)* to 4 *(very often)*, with higher scores indicating a greater severity of executive functioning problems. The DEX was designed to sample the four broad areas of change associated with dysexecutive functioning in brain-injured patients: (1) emotional or personality, (2) motivational, (3) behavioral, and (4) cognitive changes (Picton & Stuss, 1994). It was developed to supplement and provide ecological validity for the Behavioral Assessment of the Dysexecutive Syndrome (Wilson et al., 1996).

There are two versions of the DEX, one that is completed by the participant (DEX-S) and the other which is completed by a significant other who knows the participant well and has frequent contact with them (DEX-O); this is typically a caregiver, relative, or friend. In the present study the DEX-S was used for ease of administration and to allow for comparisons with previous research. In addition, the DEX-S is favored over the DEX-O given the importance of obtaining a large sample size to conduct EFA (*N* = 300, Tabacknick & Fidell, 2007), coupled with the convenience of obtaining self-report data which would allow for ease of data collection in terms of time and effort. Furthermore, as a relative or significant other has an intimate knowledge of a participant's functional ability their personal involvement and vested interest may significantly bias the accuracy of their ratings (Gans, 1983).

The DEX requires less than five minutes to complete when it is self-administered and approximately 10 minutes when orally administered. The DEX has been shown to have good internal consistency, with a Cronbach's coefficient reported to be in excess of 0.91 for a group of brain-injured patients (Bennett et al., 2005). In the current study the Cronbach's alpha was 0.90 for the community sample, 0.91 for the psychiatric sample, and 0.91 for the neurologically impaired sample.

Depression symptomatology. The SDS (Zung, 1965) was used to measure depression symptomatology. This 20-item self-report questionnaire is widely used as a screening tool because it assesses the common characteristics of depression, including pervasive affective disturbances, physiological/somatic symptoms, and psychological symptoms. Questions are anchored on a four-point Likert scale, ranging from 1 *(a little of the time)* to 4 *(most of the time)*. The SDS is a well-established scale with good reliability (Chronbach's alpha = 0.88).

Anxiety symptomatology. Anxiety symptomatology was measured using the BAI (Beck et al., 1988), a 21-item self-report measure designed to assess levels of anxious symptomatology experienced by the individual during the past week. The BAI is a widely-used and validated measure for anxiety symptomatology with response options for each item ranging from 0 (*not at all*) to 3 (*severe – I could barely stand it*) (Beck et al., 1988). A total score is computed by summing individual item scores, ranging from 0 to 63, with higher scores indicating greater levels of anxious symptomatology. Internal consistency reliability was 0.94.

Stress symptomatology. The DASS stress (DASS-S) scale (Lovibond & Lovibond, 1995) was used to measure stress symptomatology. The DASS-S is anchored on a four-point

Likert scale of 0 *(did not apply to me at all)* to 3 *(applied to me very much, or most of the time)*. The seven items measuring the subscale of "*stress*" (DASS-S) were used in the current study. A Cronbach's alpha of 0.81 and 0.90 has been previously reported for a normative sample that completed the 7- and 14-item "*stress*" scales respectively (Lovibond & Lovibond, 1995).

Self-efficacy. Self-efficacy was measured using the GSES (Sherer et al., 1982), a 17-item self-report questionnaire that assesses an individual's general sense of perceived self-efficacy. The GSES was anchored on a five-point Likert scale ranging from 1 *(strongly agree)* to 5 *(strongly disagree)*, and thus the five-point version was administered to participants. Cronbach's reliability coefficient for a normative sample has been reported as ranging from 0.86 (Sherer et al., 1982) to 0.92 (Endler, Speer, Johnson, & Flett, 2001).

Global life satisfaction. The SWLS (Diener, Emmons, Larsen, & Griffin, 1985) was used, which is a five-item self-report questionnaire that measures global levels of satisfaction with life according to idiosyncratic criteria (Shin & Johnson, 1978). The SWLS is anchored on a seven-point Likert scale, with 1 *(strongly disagree)* to 7 *(strongly agree)*. It has favorable psychometric properties, with the scale's internal consistency estimates ranging from 0.79 (Blais, Vallerand, Pelletier, & Briere, 1989) to 0.89 (Alfonso & Allison, 1992).

Procedure

Prior to the research commencing ethical clearance was received in accordance with the ethical review processes of the universities and hospitals and within the guidelines of the Australian Government's National Health and Medical Research Council. Data were collected from individuals across three sites, encompassing community, psychiatric (depressed and anxiety patients), and neurologically impaired samples. Prior to engaging in the research written informed consent was obtained from participants and they were informed that their participation was voluntary and that all responses would remain confidential. Participants were not paid for their participation; however, first-year psychology students participated in the study for partial course credit. Participants[2] completed the questionnaires in the same order, with participation time ranging from 15 to 45 minutes.

Results

Preliminary Analyses

Prior to undertaking various descriptive and inferential analyses variables were examined for accuracy of data entry, missing values, and the extent to which distributions satisfied the assumptions of parametric analysis. Missing values were scattered randomly throughout the data and equated to less than 5% of responses for each variable; as such, they did not pose any methodological problems (Cohen & Cohen, 1983). As a result, the listwise deletion default was used for the analyses.

Factorial Validation of the DEX

The first group (Subset A) comprised 469 participants (*n* = 331 community; *n* = 106 psychiatric; *n* = 59 neurological). There were 259 males (52.2%) and ages ranged from 15 to 72 years (*M* = 29.2; *SD* = 13.5). Subset B comprised 520 participants (*n* = 340 community; *n* = 124 psychiatric; *n* = 56 neurological). There were 258 males (49.6%) and ages ranged from 15 to 72 years (*M* = 30.4; *SD* = 14.2). Age (t [1] = 0.64, *ns*) and gender (t [1] = -1.40, *ns*) were proportionately represented between the groups. Subset A was used to determine the primary factor structure of the DEX using EFA, and to confirm the validity of previous EFA structures (i.e., Burgess et al., 1998; Chan, 2001; Mooney et al., 2006). Subset B was used to

[2] Some neurological participants were able to complete the questionnaire unassisted, whereas others required the researcher’s assistance (i.e., clarification of the meaning of a word, providing an everyday example to aid in interpretation, or by circling responses for participants where motor, reading, or visual difficulties were present).

conduct a series of CFAs that tested the validity of the factor structure determined via EFAs conducted using Subset A.

Exploratory factor analysis via principle components with Subset A. The 20 items of the DEX were subjected to Principle Component Analysis (PCA). Varimax rotation and Kaiser normalization were also used in order to allow comparisons with previous research (i.e., Burgess et al., 1998; Chan, 2001; Mooney et al., 2006). Several criteria were employed to determine final factor structures: (1) minimum factor eigenvalues of 1, (2) exclusion of items with factor loadings less than 0.4, (3) exclusion of items with loadings greater than 0.4 on more than one factor, and (4) conceptual consistency of specific clusters of items (this means sharing both statistical loading and conceptual meanings).

Factor analysis of the 20-item DEX with Varimax rotation resulted in a three-component solution, which explained a total of 51.48% of the variance; this solution yielded the most parsimonious solution (see Table 2). This revised structure was labeled DEX-R. Factor 1 accounted for 36.87% (eigenvalue = 5.53) and was composed of six items (2, 3, 5, 9, 16, and 17), with loadings ranging from 0.52 to 0.73. Factor 1 assessed the dysexecutive symptoms of attention, impulsivity, and inhibition, and was labeled *inhibition.* This factor was most similar to Mooney et al.'s (2006) inhibition and abstract problem solving factors. The second factor accounted for 9.06% of the variance (eigenvalue = 1.36) and had high loadings on seven items (1, 4, 8, 10, 11, 12, and 19), ranging from 0.43 to 0.76. Factor 2 was labeled *volition* as it comprised items measuring the dysexecutive symptoms of volition, indecision, and emotional liability. This factor appeared to correspond with Burgess et al.'s (1998) factors of intentionality, positive affect, and negative affect. In addition, this factor was also similar to Chan's (2001) factors of intentionality, knowing–doing dissociation, and social regulation. The third factor accounted for 7.26% of the variance (eigenvalue = 1.09) and comprised only two items (13 and 20), with factor loadings of 0.77 and 0.80 respectively.

Factor 3 was labeled *social regulation* and appeared to correlate best with Burgess et al.'s (1998) inhibition factor.

Confirmatory factor analysis of the DEX-R. The first series of CFAs attempted to fit the subscales of the DEX as revealed through the EFA on Subset A. Each model is introduced, explained, and assessed in the following sections. Models that use scales as their unit of analysis require some parameters in the model to be estimated in order to achieve identification. Therefore, in line with recommendations of Jöreskog and Sörbom (1990), the error variance for each of the subscales was estimated using the subscale's alpha reliability, which has been demonstrated to be a sound approximation in determining error variance (Netemeyer, Johnson, & Burton, 1990). The second series of CFAs tested rival models (Burgess et al., 1998; Chan, 2001; Mooney et al., 2006; Wilson et al., 1996). The results from the analyses of all models tested are summarized in Table 3.

Insert Tables 2 and 3 about here

Model 1: Three-factor model with 15 items. Using Subset B, the first model tested (Model 1) attempted to fit the 15 items of the DEX-R onto the three subscales. For Model 1, items 2, 3, 5, 16, and 17 were predicted to load onto Factor 1: Inhibition; items 1, 4, 8, 10, 11, and 19 were predicted to load onto Factor 2: Volition; while items 13 and 20 were predicted to load onto Factor 3: Social Regulation. This model was supported by the analysis. As can be seen in Table 2, the Goodness of Fit Index (GFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), and Tucker-Lewis Index (TLI) were greater than 0.90, suggesting an adequate fit to the data (Bentler, 1995; Hu & Bentler, 1999; Marsh, 1993). The Normative Fit Index (NFI) also approximated 0.90; however, Bentler (1999) has recommended that the CFI be the index of choice over the NFI. The Root Mean Square Error of Approximation

(RMSEA) was 0.06, indicating a good fit to the data (Byrne, 2001; MacCallum, Browne, & Sugawara, 1996), with a statistically significant test of closeness-of-fit ($p < .001$). Based on the Root Mean Square Residual (RMR) criterion, Model 1 fitted the data well with interrelationships hypothesized among the factors.

Model 2: Three-factor model with 15 items and a second-order DEX factor. Kline (1998) proposed that in order for a CFA model with a second-order factor to be identified there must be at least three first-order factors, otherwise the direct effects of the second-order factor on the first-order factors or the disturbances might be under-identified.

Using Subset B, Model 2 attempted to fit the 15 items of the DEX-R onto the three factors with a second-order latent variable of executive dysfunction. For Model 2, items 2, 3, 5, 16, and 17 were predicted to load onto Factor 1: Inhibition; items 1, 4, 8, 10, 11, and 19 were predicted to load onto Factor 2: Volition; while items 13 and 20 were predicted to load onto Factor 3: Social Regulation. All three factors were also predicted to load onto the latent executive. This model was also supported by the analysis. As shown in Table 2, the GFI, CFI, IFI, and TLI were greater than 0.90, suggesting an adequate fit to the data. The NFI approximated 0.90; however, as stated above, Bentler (1999) has recommended that the CFI be the index of choice over the NFI. The RMSEA was 0.06 also indicating a good fit to the data, with a statistically significant test of closeness-of-fit ($p < .001$). Based on these RMR criteria, Model 2 fitted the data well, with interrelationships hypothesized among the factors (see Table 2).

Model comparisons. Model 1 and Model 2 were compared for statistical significance in order to assess whether the 15-item model (Model 1) or the 15-item model with a second-order factor (Model 2) was required to model the DEX-R appropriately. In assessing the extent to which each model exhibited an improvement in fit the difference in fit between the two models was examined. Using Subset A, Model 1 (χ^2 [87] = 248.97) was compared with

Model 2 (χ^2 [87] = 248.97), yielding a non-significant χ^2 value difference ($\Delta\chi^2$ [1] = 0, *ns*). This indicates that there is no statistically significant difference in model fit between Model 1 and Model 2. Based on conceptual coherence it was concluded that the two models are equally adequate in explaining the data, and Model 2 should be adopted as the model of choice given that the DEX is supposed to measure the components of executive dysfunction (where executive dysfunction is a second-order factor).

Confirmatory Factor Analyses—Testing Rival Models

In CFA rival models should also be tested to assess their ability to fit the data (Thompson, 2004). As such, a set of previously reported factor structures were tested. Each model is introduced, explained, and assessed in the following sections.

Model 3: Testing Wilson et al.'s (1996) Three-Factor Solution. Wilson et al. (1996) advocated a three-factor model where behavioral, cognitive, and emotional symptoms of executive dysfunction were considered as independent dimensions. Using Subset A, Model 3 was a three-factor model, similar to that proposed by Wilson et al. This three-factor structure did not fit the current dataset (see Table 3).

Model 4: Testing Burgess et al.'s (1998) Five-Factor Model. Burgess et al. (1998) favored a five-factor model, with factors labeled as inhibition, intentionality, executive memory, positive affect, and negative affect (Model 4). This five-factor structure was not as effective as other models (i.e., Models 1 and 2, Subset A, see Table 3).

Model 5: Testing Chan's (2001) Five-Factor Model. Chan (2001) also reported a five-factor model, with the five factors labeled as inhibition, intentionality, knowing–doing dissociation, in-resistance, and social regulation (Model 5). This five-factor structure was also not as effective as other models (i.e., Models 1 and 2, Subset A, see Table 3).

Model 6: Testing Mooney et al.'s (2006) Four-Factor Model. Mooney et al. (2006) reported a four-factor model, with the factors described as inhibition, intention, social regulation, and abstract problem solving (Model 6). Mooney et al.'s four-factor model most closely approximated the current dataset (Subset A). As illustrated in Table 3, for Model 6, the GFI, CFI, and IFI at best approximated 0.90, while RMSEA was 0.07. These indices suggest a mediocre fit to the data.

Model 7: Generalizing Mooney et al.'s (2006) Four-Factor Model. Model 7 was validated by conducting a CFA using data from Subset B. As illustrated in Table 3, the poor GFI indicates that this model did not fit the data well.

Invariance Testing for the DEX-R

Multiple group analysis (Jöreskog & Sörbom, 1990) was used to test for group invariance across sample characteristics (community, psychiatric, and neurological groups) and gender (male and female). A comparison among sample groups between unconstrained [$\chi^2(294) = 709.47$, $p < .01$] and constrained [$\chi^2(306) = 735.04$, $p < .01$] models indicated a non-significant difference [$\Delta\chi^2(12) = 25.56$, *ns*]. A comparison among gender groups between unconstrained [$\chi^2(186) = 535.95$, $p < .01$] and constrained [$\chi^2(192) = 547.62$, $p < .01$] models indicated a non-significant difference [$\Delta\chi^2(6) = 11.67$, *ns*], indicating our proposed DEX-R model has measurement invariance across groups (that is, when the model is applied across groups).

Reliability of the DEX-R

As internal consistency estimates for the DEX have only been reported in one previous study it is important to provide further evidence of the reliability of this questionnaire. According to Tabachnick and Fidell (2007), a reliability coefficient of more than 0.70 is sufficient to satisfy the requirements of internal consistency. Checks for the internal consistency of the DEX revealed high reliability coefficients. For all groups the combined (N = 997) estimate of internal consistency was 0.85, indicating that the 15-item DEX has high internal consistency. Separate checks for internal consistency were performed for the subscales of the DEX. Factor 1 yielded a Cronbach's alpha of 0.80, while Factor 2 had a Cronbach's alpha of 0.75. Factor 3 had a Cronbach's alpha of 0.60; this could be due to the small number of items (two) on this factor and the fact that our sample was relatively homogeneous (Bernadi, 1994).

Concurrent Validity of the DEX-R

Table 4 displays the intercorrelations between the DEX-R Total Score and Factor Scores and other measures of well-being, including the SDS, BAI, DASS-S, GSES, and SWLS. As can be seen from Table 4, the results show that the DEX-R total scores were significantly and positively correlated with total SDS, BAI, and DASS-S scores. Similarly, the DEX-R total scores were negatively and significantly associated with the GSES and SWLS total scores. Table 4 also shows that Factor 1 (Inhibition) and Factor 2 (Volition) of the DEX-R were significantly positively correlated with the total scores for the SDS, BAI, and DASS-S, and were significantly negatively correlated with total scores for the GSES and SWLS. Furthermore, Factor 3 (Social Regulation) of the DEX-R was significantly positively correlated with the total score of the BAI and significantly negatively correlated with total scores for the GSES and SWLS. However, Factor 3 was not significantly related to the total scores for the SDS and DASS-S. There is debate surrounding the stability of Factor 3; however, these results provide evidence for the concurrent validity of Factors 1 and 2 of the DEX-R.

INSERT TABLE 4 HERE

Criterion-Related Validity of the DEX-R: Discriminant Function Analysis

The discriminant validity of the DEX-R was examined by observing group differences on the total score of the questionnaire. Discriminant function analysis using the revised factor structure of the DEX was performed to determine its ability to classify community, psychiatric, and neurological groups in terms of deficits in executive functioning. Using all groups combined (N = 997), the DEX-R Total Score was able to correctly classify 68.6% of cases ($\lambda = 0.90$, χ^2 [2] = 102.51, F [2.990] = 54.00, $p < .001$). Our results revealed that the DEX-R Total Score was able to predict group membership with the majority of the community group and correctly classify almost a quarter of the psychiatric group.

Criterion Validity of the DEX-R Total Score

A one-way between-groups ANOVA was performed to investigate group differences in self-reported dysexecutive symptoms as measured by the DEX-R. There was a statistically significant difference among the groups, F (3, 992) = 36.38, p < .001. Means of executive dysfunction for each group were: community group = 19.49 (SD = 9.97); neurological group = 22.12 (SD = 13.94); and the psychiatric group, comprising the depressed group = 33.51 (SD = 14.68) and anxious group = 33.10 (SD = 14.05). The post-hoc comparisons using the Games-Howell test indicated that the community group reported significantly fewer levels of dysexecutive syndrome than the depressed and anxious (psychiatric) groups. Furthermore, the neurological group reported significantly lower levels of dysexecutive symptoms than the depressed and anxious groups. However, there was no significant difference in dysexecutive symptoms between the community and neurologically impaired groups, as well as between the depression and anxiety groups. In order to determine the sensitivity and specificity of the

DEX-R Total Score we ran a Receiver Operating Characteristics (ROC) analysis to determine the coordinate of sensitivity and specificity of the DEX-R. Our ROC test results illustrated that the cut-off value of the DEX-R score was 37.50, with the ROC curve area = .712 ($p<.001$, STD error = .02), which gave us a good balance of sensitivity (0.9) and specificity (0.7) to correctly classify community, psychiatric, and neurological impaired groups.

Discussion

The results from the EFA and CFA showed the DEX-R three-factor model (the factors being inhibition, volition, and social regulation) with 15 items to be the most parsimonious model. The three factors were not significantly related. We believe the three factors were solid and important but we cannot claim that they are the essence of executive function without further research. According to standard consensus, results revealed that for all groups combined (N = 997) estimates of internal consistency were “high” for the DEX-R Total Score. Results also revealed that Factors 1 and 2 yielded internal consistency estimates that were “moderate to high”. However, Factor 3 yielded a “less than adequate” (Alpha 0.60) measure of internal consistency, but this is not surprising considering this factor only included two items. Given that the internal consistency estimate for Factor 3 was deemed inadequate it would undoubtedly compromise the results obtained when using this factor in subsequent analyses, which is clearly a limitation of the current research. Future research should attempt to increase the internal consistency of this factor by developing new items relating to social regulation and incorporating these into the existing DEX. Subsequent factor analytic research should then also be completed to determine adequate psychometric properties of the questionnaire.

The inhibition and volition factors were significantly positively correlated with the total scores for depression, anxiety, and stress, and significantly negatively correlated with the total scores for self-efficacy and satisfaction with life. These findings were expected and thus support the importance of executive functioning in patients with mood and anxiety disorders. Factor 3, social regulation, was found to correlate with only the total score of anxiety symptoms and was significantly negatively correlated with the total scores for self-efficacy and satisfaction with life (not depression and stress). There are several possible explanations for this result: (1) this factor has only two items which may be an inadequate number of items to yield significant correlations (Thompson, 2004); (2) this factor has poor internal consistency, which may impact on the factor's ability to yield significant correlations (Tabachnick & Fidell, 2007); and/or (3) the items that comprised this factor (i.e., 13: lack of concern, 20: no concern for social rules) may not actually be related to depression and stress. In conclusion, there is debate surrounding the stability of Factor 3; however, these results provide partial evidence for the concurrent validity of Factors 1 and 2 of the DEX-R. Future research should assess concurrent validity by assessing the relationship between the DEX-R Total Score and Factor Scores with other psychometric questionnaires and specific neuropsychological tests of executive dysfunction.

Our results also revealed that the DEX-R Total Score was able to predict group membership, correctly classifying the majority of the community group and almost a quarter of the psychiatric group. However, no cases in the neurologically impaired sample were correctly assigned; most were misclassified as belonging to the community group, indicating that the specificity of the DEX may be limited. This is a significant limitation of the present research. There are a number of potential reasons to explain these results, which may be due to the demographics of the neurologically impaired sample, such as time since injury, injury severity, and location of injury. No previous research has conducted Discriminant Factor analysis (DFA) of the DEX and thus comparisons cannot be made. Future research should conduct DFA to further assess the discriminant ability of the DEX-R. Despite the use of separate groups for the EFA and CFA, the DFA was conducted on the combined sample. In future, separate groups should be used for all analyses to avoid circular statistical methods.

Our results also revealed that participants who reported high levels of executive dysfunction also reported high levels of depression, anxiety, and stress symptomatology (predictive validity). More specifically, the community group reported significantly fewer dysexecutive symptoms than the psychiatric group. Further, the neurological group reported significantly lower levels of dysexecutive symptoms than the psychiatric group. One potential explanation for these results may be related to the moderate levels of comorbidity between neurological impairment and psychiatric disorders (Lucas & Addeo, 2006; Stordal, Morken, Mykletun, Neckelmann, & Dahl, 2008). As the DEX has never been used to measure executive dysfunction in psychiatric populations there is no literature with which to compare these results. Another potential explanation may be due to methodological constraints. Future research is required to further assess the predictive validity of the DEX-R with particular emphasis on controlling comorbidity issues. A further theoretical interpretation for these findings may be based on evidence that has found that emotionally distressed individuals often overestimate their level of impairment and are often “deficit focused” (Morgan, Schoenberg, Dorr, & Burke, 2002), while individuals with neurological conditions often under-report their level of impairment (Chaytor et al., 2006). Therefore, these findings may be explained by a pattern of over-reporting (in the psychiatric group) and under-reporting (in the neurologically impaired group) of symptoms by these two samples.

Further, we found that the community and neurologically impaired groups reported similar levels of dysexecutive symptoms. A number of variables may have contributed to explaining the non-significant difference between the community and neurological groups in terms of their self-reported dysexecutive symptoms. The categorization of cognitive deficits associated with traumatic brain injury (TBI) is typically divided into four successive phases, which are related to the temporal order of events subsequent to the injury: (1) coma, (2) confusion and post-traumatic amnesia, (3) recovery of cognitive functions, and (4) stable cognitive sequelae (Rao & Lyketsos, 2000). In the current research more than three quarters of the neurologically impaired participants were tested more than two years following their injury, which corresponds to the final phase of cognitive recovery. This suggests that the neurological population used in the current research was most likely exhibiting "stable cognitive sequelae", which may have impacted on the research results. More specifically, these participants may have been exhibiting limited deficits in executive functioning due to the period of time tested since their injury (Lucas & Addeo, 2006). This may be a possible explanation for the non-significant difference in self-reported dysexecutive symptoms in the community and neurologically impaired groups. Future research could attempt to address this limitation by recruiting TBI patients who have more recently acquired their injuries to eliminate the possibility of cognitive recovery (Rao & Lyketsos, 2000). Nonetheless, we ran a ROC analysis to determine the coordinate of sensitivity and specificity of the DEX-R, the results of which illustrated that the cut-off value of the DEX-R score was 39.50 with a ROC curve area = .71 (p<.001), which gave us a good balance of sensitivity (0.9) and specificity (0.7) to correctly classify psychiatric and neurological impaired groups.

Further Limitations

One of the major strengths of this research is related to sample size, having employed two groups of participants to conduct the exploratory and confirmatory factor analyses. Nonetheless, our findings are limited to an Australian sample. Further, in the current study it is noted that the psychiatric sample is older than the community sample. As such, age effect was apparent in the DEX between the clinical and community groups, and this could confound the comparisons between the two groups. However, we performed a group difference test and found age (t [1] = 0.64, ns) and gender (t [1] = -1.40, ns). As age and gender were proportionately represented between the groups the confounding effect of these factors was not a significant issue in this study.

In our study it appears that most participants were categorized as Moderate-Severe TBI (28 patients with Mild TBI, seven with Moderate TBI and 35 with Severe TBI), which is a clear limitation of the study. Additional analyses were conducted using injury severity as a further grouping variable for the neurologically impaired sample to determine if group differences were evident between the community and neurologically impaired samples. Results remained unchanged, which may be due to the small number of brain-injured participants used in the analyses (Tabachnick & Fidell, 2007).

Furthermore, medication could have been affecting the cognitive functioning of any of the psychiatric patients. While some studies conclude that psychotropic medications are more likely to stabilize or reduce psychiatric symptoms, other medications may have sedative effects (e.g. Houghton et al., 1999; Mishara & Goldberg, 2004). The use of medication to reduce symptoms would generally stabilize or improve cognitive functioning; however, the sedative effects of Benzodiazepines in anxiety patients, for example, may in fact have the side effect of slowing cognitive functioning. This may, therefore, have had a negative impact on the DEX scores. Our earlier study showed that pre-existing medication in a study involving group cognitive behavior therapy did not detract from or enhance the outcome of symptoms in patients studied (Oei & Yeoh, 1999). This finding was also replicated in the treatment of social phobia (Titov, Andrews, Choi, Schwencke, & Mahoney, 2008). While our study cannot address this issue from a statistical standpoint we acknowledge that this could be a limitation of this study. Future research should aim to include participants of similar age, equal group sizes, and discrete neurological conditions to control for such confounding variables.

Summary

This is a unique study, examining the factor structures and psychometric properties of the DEX by exploring executive dysfunction in individuals with depression and anxiety, and thereby providing evidence for the clinical utility and generalizability of this questionnaire. As a whole, this study revealed that the DEX-R is predominately a valid and reliable instrument that can be used to measure executive deficits in community, psychiatric, and neurological populations. Given that the DEX-R has been found to be psychometrically sound executive deficits in other psychiatric disorders, such as eating, and obsessive and compulsive disorders, should be explored in future research.

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Table 1

Comparison of Previous Exploratory Factor Analytic Structures of the DEX

Item number	Behavioral characteristic	Wilson et al. (1996)	Burgess et al. (1998)	Chan (2001)	Mooney et al. (2006)
1	Abstract thinking problems	-	Inh	In-r	Abs
2	Impulsivity	Beh	Inh	Int	Imp
3	Confabulation	Cog	Exe	In-r	Abs
4	Planning problems	-	Int	Int	Soc
5	Euphoria	Emo	Pos	Inh	Imp/Abs
6	Temporal sequencing deficits	Cog	Exe	-	Abs
7	Lack of insight and social awareness	Beh	Int	Kno	Soc
8	Apathy and lack of drive	Emo	Neg	Kno	Soc
9	Disinhibition	Beh	Inh	Inh	Abs
10	Variable motivation	-	Pos	-	-
11	Shallowing of affective responses	Emo	Neg	Kno	Soc
12	Aggression	Beh	Pos	Soc	Imp
13	Lack of concern	Beh	Inh	Inh	Imp
14	Perseveration	Cog	Exe	In-r	Imp
15	Restlessness-hyperkinesis	Beh	Inh	Inh	Imp
16	Inability to inhibit responses	Beh	Inh	Inh	Imp/Soc
17	Knowing–doing dissociation	-	Int	Kno	Int
18	Distractibility	Cog	Int	Int	Int
19	Poor decision-making ability	Cog	Int	Int	Int
20	No concern for social rules	Beh	Inh	Soc	Soc

Note. Beh = Behavior, Cog = Cognition, Emo = Emotion, Inh = Inhibition, Int = Intentionality, Exe = Executive Memory, Pos = Positive Affect, Neg = Negative Affect, Kno = Knowing–doing Dissociation, In-r = In-resistance, Soc = Social Regulation, Abs = Abstract Problem Solving.

Table 2

Factor Loadings in Response to the 15-item DEX-R (N = 997)

Factors and items	Factor loadings		
	1	2	3
Factor 1 – Inhibition			
3. Confabulation	0.73		
17. Knowing–doing dissociation	0.71		
16. Inability to inhibit responses	0.68		
5. Euphoria	0.68		
2. Impulsivity	0.64		
9. Disinhibition	0.52		
Factor 2 – Volition			
8. Apathy and lack of drive		0.78	
4. Planning problems		0.73	
19. Poor decision making ability		0.67	
11. Shallowing of affective responses		0.60	
1. Abstract thinking problems		0.59	
10. Variable motivation		0.59	
12. Aggression		0.43	
Factor 3 – Social regulation			
20. No concern for social rules			0.80
13. Lack of concern			0.77
Variance explained (Alpha)	36.87(.80)	9.06(.81)	7.26(.57)

Note. Cross loadings less than 0.4 are not displayed.

Table 3

Summary Table of Results from Confirmatory Factor Analyses

Model	χ^2	df	χ^2/df	NFI	GFI	CFI	IFI	TLI	RMSEA	RMR
Goodness of fit cut-offs	-	-	<4	≥0.90	≥0.90	≥0.90	≥0.90	≥0.90	≤0.08	≤0.08
Independence model	248.97	87	2.86	0.00	0.41	0.00	0.00	0.00	0.21	0.34
Original models tested (Subset B)										
1: 3-factor model with 15 items	248.97	87	2.86	0.90	0.94	0.93	0.93	0.91	0.06***	0.05
2: Model 1 with second-order DES factor	248.97	87	2.86	0.90	0.94	0.93	0.93	0.91	0.06***	0.05
Rival models tested (Subset A)										
3: Wilson et al.'s (1996) 3-factor solution	630.65	102	6.18	0.76	0.87	0.79	0.79	0.75	0.10	0.19
4: Burgess et al.'s (1998) 5-factor model	1432.22	164	8.73	0.63	0.79	0.65	0.65	0.60	0.13	0.30
5: Chan's (2001) 5-factor model	490.53	125	3.92	0.85	0.89	0.88	0.88	0.85	0.08	0.06
6: Mooney et al.'s (2006) 4-factor model	500.78	145	3.45	0.86	0.90	0.89	0.89	0.87	0.07***	0.06
7: Generalisation of model 6 to Subset B	554.52	145	3.82	0.85	0.89	0.88	0.88	0.86	0.07	0.06

Note. χ^2 = minimum discrepancy; df = degrees of freedom; NFI = Normed Fit Index; GFI = Goodness of Fit Index; CFI = Comparative Fit Index; IFI = Incremental Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; RMR = Root Mean Square Residual. *** p < .001.

Table 4

Bi-variate Correlations between DEX-R Total Score and Factor Scores and the BAI, SDS, DASS-S, GSES and SWLS

	SDS	BAI	DASS-S	GSES	SWLS
Total Score	0.54**	0.62**	0.58**	-0.66**	-0.47**
N	966	610	610	600	606
Factor 1	0.17**	0.35**	0.32**	-0.32**	-0.11**
n	965	609	609	599	605
Factor 2	0.66**	0.57**	0.56**	-0.67**	-0.56*
n	965	609	609	599	605
Factor 3	0.03	0.10*	0.08	-0.08*	-0.11**
n	965	609	609	599	605

*p < .05. **p < .01