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Validation of the Subjective Neuropsychological Symptoms Scale (SNPSS) in Injured Motorists

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Abstract

Background: *There is a need for scales for standardized assessments of subjective neuropsychological symptoms reported by diverse patient populations such as injured motorists, patients with multiple sclerosis, very severe anorexia, and neurotoxin exposure. This article introduces the Subjective Neuropsychological Symptoms Scale (SNPSS) and describes its validation on a sample of persons injured in high-speed motor vehicle accidents (MVAs). The SNPSS consists of post-concussion items not included in the Rivermead Post-Concussion Symptoms Questionnaire (that is, e.g., tinnitus, impaired balance, word finding difficulty), items to assess motor symptoms (e.g., hand tremor), and symptoms frequently observed in patients with spinal injury or deterioration (tingling, numbness, or reduced feeling in the limbs).*

Method: *De-identified file data of 141 post-MVA patients (49 men, 92 women, average age 39.4 years, SD=13.0) included their responses to the SNPSS, the Rivermead Post-Concussion Symptoms Questionnaire, Insomnia Severity Index, the PCL-5 measure of PTSD according to DSM5,the ratings of worst, least, and average pain on the Brief Pain Inventory and ratings of depression, anger, and anxiety on the Whiplash Disability Questionnaire. The patients' responses to the SNPSS and the Rivermead were compared to those of a sample of 23 normal controls (11 men, 12 women, average age 45.0 years, SD=21.2).*

Results: *Average SNPSS score of patients (20.3 points, SD=11.3) was significantly higher than of normal controls (average of 2.5 points, SD=4.8): the magnitude of this relationship (r=.51, p<.001) indicates satisfactory criterion validity of the SNPSS on post-MVA patients. With respect to convergent validity, the SNPSS correlated significantly (r=.79, p<.001) with the Rivermead scores. The SNPSS also correlated significantly with clinical variables often associated with neurological trauma in injured motorists: pain (r=.37), insomnia (r=.45), and PTSD (r=.56). Cronbach alpha coefficient of the SNPSS is very satisfactory (.90).*

Discussion and Conclusions*: Criterion and convergent validity data of SNPSS on injured motorists in this study are satisfactory. Validation data from populations other than injured motorists are much needed, e.g., survey data from patient groups with neurological disease such as multiple sclerosis or those accidentally exposed to neurotoxins.*

Keywords: *neurology, neuropsychology, whiplash, concussion*

Introduction

The Subjective Neuropsychological Symptoms Scale (SNPSS) was developed from a previously published scale entitled the Post-MVA Neurological Symptoms scale (PMNS, see Cernovsky et al., 2018, Cernovsky, Istasy, Hernández-Aguilar, et al., 2019) which was designed for the assessment of neuropsychological symptoms present in persons injured in high speed motor vehicle accidents (MVAs). The SNPSS represents an expanded version of the PMNS.

The SNPSS is intended to be administered jointly with the Rivermead Post-Concussion Symptoms Questionnaire (Eyres et al., 2005), and consists of items to assess symptoms missing in the Rivermead scale. These include subjective symptoms such as tinnitus, impaired balance, stutter, difficulty articulating words, word finding difficulty, and also symptoms often reported in association with the whiplash syndrome, spinal injuries or deterioration, or more generally peripheral or autonomic neuropathy (hand tremor, reduced muscular control over leg, arm, or hand, tingling or numbness, or reduced tactile sensitivity in the limbs, and reduced bladder or bowel control), see Table 1. The SNPSS facilitates the assessment and scientific investigation of symptoms reported not only by injured motorists, war veterans, or injured construction workers, but also by patient groups such as those presenting with severe anorexia nervosa, multiple sclerosis, or with signs of exposure to neurotoxins.

The purpose of the SNPSS is to facilitate research on neurological disorders by systematizing the clinical assessment, quantitative data collection, and comparison of patient groups.

The present article describes the procedure in which this scale has been validated on persons with chronic symptoms from high-speed motor vehicle accidents (MVAs).

Table1. *the Subjective Neuropsychological Symptoms Scale (SNPSS)*

	Not at all	*In the past, but **not** within the last one month*	*A mild problem in the last month*	*A moderate problem in the last month*	*A severe problem in the last month*
1. Impaired balance					
2. Excessive hand tremor: *Please circle here if **Left =L, Right=R, or Both=B***					
3. Instances of reduced control over leg muscles. *Please circle here if L, R, or B*					
4. Instances of reduced muscular control over hand or arm. *Please circle here if L, R, or B*					
5. Tingling in the arm, or hand, or leg. *Please circle the location: arm/hand L, R, B; Leg L, R, B*					
6. Numbness in the arm, or hand, or leg. *Please circle the location: arm/hand L, R, B; Leg L, R, B*					
7. Reduced feeling in the arm, or hand, or leg					
8. Some loss of bladder control					
9. Some loss of bowel control					
10. Stutter					
11. Word finding difficulty					
12. Difficulty articulating words					
13. Noise inside of the ears (tinnitus). *Please circle if: rare, occasional, frequent, or persistent. Please also circle if similar to a ringing, buzzing, hissing, humming, high pitched, or other sound.*					

Scoring: the SNPSS is scored analogously to the Rivermead scale. i.e., 0=symptom absent, 1=symptom noted in the past, but not within the last month, 2=a mild problem, 3=a moderate problem, 4=a severe problem.

Method

Archival de-identified data were available on a sample consisting of 141 patients (49 men, 92 women) injured in high-speed vehicular accidents. Age ranged from 15 to 70 years, with the average at 39.4 years (SD=13.0). Their accident occurred 7 to 194 weeks earlier (average =53.5weeks, SD=40.7). All still experienced persistent post-MVA symptoms that required therapeutic attention. In their MVAs, 102 (72.3%) were drivers, 21 (14.9%) were passengers, 17 (12.1%) were pedestrians, and one drove a motorcycle.

Their data included scores on the Subjective Neuropsychological Symptoms Scale (SNPSS), Rivermead Post-Concussion Symptoms Questionnaire (Eyres et al, 2005), Immediate Concussion Symptoms scale (Cernovsky et al., 2018), Insomnia Severity Index (Morin et al., 2011),and on the PCL-5 measure of PTSD developed by the U.S. National Center for PTSD(see Weathers et al., 2013). The data also included Items 3, 4, and 5 of the Brief Pain Inventory (Cleeland and Ryan, 1994), i.e., the patients' ratings of the worst pain, least pain, and of average pain on a scale from 0 ("no pain") to 10 ("pain as bad as you can imagine"). The data also included the patients' ratings on Items 10 to 12 of the Whiplash Disability Questionnaire (Pinfold et al., 2004), i.e., ratings of depression, anger, and of anxiety via scales from 0 ("not at all") to 10 ("always").

De-identified data on the SNPSS and Rivermead were also available for a sample of 23 normal control participants (11 men, 12 women) undiagnosed with any major physical or psychiatric illness. Age ranged from 22 to 84 years, with the average of 45.0 years (SD=21.2). When administering the SNPSS and Rivermead to the sample of normal controls, the instructions were modified as follows:*"Some medical symptoms can cause worry or are a nuisance, if they occur more often than normal. Consider the list below: please rate yourself if you indeed have been experiencing any of those symptoms over the last month. Please check your answer in the most appropriate column."*

Statistical comparisons of neuropsychological scores of patients with those of normal controls were carried out with 1-tailed rather than 2-tailed tests because it is reasonable to expect the patients to have higher scores. Statistical significance of correlations between Rivermead and SNPSS items was also calculated with 1-tailed tests as the direction of these correlations was anticipated on basis of the clinical lore.

The patients did not significantly differ from normal controls with respect to age in the t-test calculated for independent samples with unequal variances (t=1.2, df=24.8, p=.224).

No significant difference was noticed between these two samples in the proportion of women versus men (x^2 test, x^2=1.5, p=.227).

Results

Frequencies of the Subjective Neuropsychological Symptoms

Average SNPSS scores of the patients and of normal controls are listed in Table 2. As mentioned, each symptom was scored as follows: 0=symptom absent, 1=symptom noted in the past, but not within the last one month, 2=a mild problem, 3=a moderate problem, 4=a severe problem.

Table2. *Average scores of MVA patients and of normal controls on the SNPSS*

SNPSS Items:	Average scores (SDs):		Pearson point biserial	P values, 1-tailed
	MVA Patients	Normal Controls	correlation	
Total SNPSS score	20.3 (11.3)	2.5 (4.8)	.51	p<.001
Impaired balance	2.2 (1.3)	0.2 (0.6)	.47	p<.001
Excessive hand tremor	1.4 (1.4)	0.1 (0.3)	.33	p<.001
Instances of reduced control over leg muscles	1.4 (1.5)	0.1 (0.4)	.32	p<.001
Instances of reduced control over hand or arm	1.2 (1.4)	0.0 (0.0)	.29	p<.001
Tingling in the arm, or hand, or leg	2.6 (1.4)	0.3 (0.8)	.53	p<.001
Numbness in the arm, or hand, or leg	2.4 (1.4)	0.3 (0.9)	.49	p<.001
Reduced feeling in the arm, or hand, or leg	1.3 (1.5)	0.1 (0.4)	.30	p<.001
Some loss of bladder control	0.9 (1.3)	0.4 (0.9)	.13	p=.049
Some loss of bowel control	0.5 (1.1)	0.0 (0.0)	.17	p=.013
Stutter	0.8 (1.1)	0.2 (0.5)	.19	p=.006
Word finding difficulty	2.1 (1.3)	0.4 (0.8)	.43	p<.001
Difficulty articulating words	1.7 (1.4)	0.2 (0.5)	.38	p<.001
Noise inside of the ears (tinnitus)	1.8 (1.5)	0.3 (0.9)	.35	p<.001

All correlations are significant. This indicates that all 13 SNPSS items differentiate the post-MVA patients from normal controls. The patients scored higher on all 13 items.

Criterion Validity of the Subjective Neuropsychological Symptoms Scale (SNPSS)

The criterion validity of a test or scale is the extent to which the test or scale indeed does what it was intended to do. In the case of the SNPSS (a measure of relatively abnormal neuropsychological symptoms), the scale should differentiate patients with relevant subjective neuropsychological symptoms from samples of normal controls.

The scores of our patients on the SNPSS ranged from 0 to 52 points with an average of 20.3 points (SD=11.3). Those of normal controls ranged from 0 to 21 points, with an average of 2.5 points (SD=4.8). The difference is statistically significant in the t-test with unequal variances (t=12.9, df=70.1, p<.001). The corresponding Pearson point biserial coefficient is .51, i.e., of moderate strength: the post-MVA patients had significantly higher total scores on the SNPSS.

The same is true about all individual items of the SNPSS, see Table 2: our post-MVA patients scored higher on all of these items than normal controls.

Convergent Validity of the Subjective Neuropsychological Symptoms Scale (SNPSS)

Convergent validity is the extent to which the scores of a new scale correlate with other scales or measures with which the new scale is theoretically expected to correlate. In the case of the SNPSS, positive correlations were expected to scores on the Rivermead Post-Concussion Symptoms Questionnaire (Eyres et al, 2005). Indeed, the correlation between the two measures was high, r=.79 (p<.001).

Correlations of SNPSS Scores to Individual Items of the Rivermead Post-Concussion Symptoms Questionnaire

The responses to individual items of the Rivermead scale were available for 65 patients and 23 normal controls: Pearson correlation coefficients of Rivermead items to SNPSS are listed in Table 3. Since some authors prefer nonparametric correlations to Pearson coefficients, Spearman's rho coefficients are also listed.

All correlations were highly significant (p<.001, 1-tailed) for all Rivermead items.

Table3. *Correlations of SNPSS total score to Rivermead items*

Rivermead Items:	Pearson correlation	Spearman Correlation
Headaches	.68	.68
Dizziness	.67	.67
Nausea and/or Vomiting	.60	.62
Noise Sensitivity (phonosensitivity)	.69	.69
Sleep Disturbance	.69	.72
Fatigue	.72	.78
Irritability	.66	.65
Feeling Depressed or Tearful	.67	.68
Feeling Frustrated or Impatient	.61	.62
Forgetfulness, poor memory	.73	.74
Poor Concentration	.71	.71
It Takes Longer to Think	.74	.74
Blurred Vision	.52	.61
Light Sensitivity (photosensitivity)	.61	.62
Double Vision (diplopia)	.46	.46
Restlessness	.69	.72

Correlations of SNPSS Scores to the Patients' Recall of Immediate Concussive Symptoms

We examined correlations of the SNPSS to scores on the Immediate Concussion Symptoms (ICS) scale. The ICS evaluates, via retrospective recall by the patients, the presence or absence of the following symptoms of cerebral concussion in the immediate aftermath of vehicular collision: feeling dizzy, dazed, stunned, confused, disoriented, and loss of consciousness (Cernovsky et al, 2018). In the ICS scale, the 5 first items (i.e., all except the loss of consciousness) are scored as follows: 0=absent, 1=present. If the patient lost consciousness, these first 5 items are scored on

the basis of symptoms as they occurred within the very first minutes upon regaining consciousness. The loss of consciousness (LOC) is scored as follows: 0=absent,1=not certain, 2=brief loss of consciousness, 3=loss of consciousness lasting more than 5 minutes.

As shown in Table 4, the correlations of the SNPSS to our patients' retrospective recall of which concussion symptoms they experienced in the immediate aftermath of their accident were not statistically significant, perhaps due to inaccuracies in recall of past symptoms or to individual differences in the patterns or speed of the recovery process from neuropsychological symptoms listed in the SNPSS.

The only significant correlation was to "feeling dazed," however, the correlation coefficient is too small (.16), i.e, too weak to be of theoretical or clinical significance as it would explain only 2.6% of the variance in SNPSS scores.

Table4. *Correlations of SNPSS to recalled immediate symptoms of cerebral concussion*

Immediate Concussion Symptoms scale (ICS), scores of patients only, N=137	Pearson correlations	P level
Total ICS score	.06	p=.211, n.s.
Feeling dazed	.16	p=.032
Feeling stunned	-.05	p=.265, n.s.
Feeling confused	.07	p=.213, n.s.
Feeling disoriented	.04	p=.310, n.s.
Feeling dizzy	.14	p=.055, n.s.
Loss of consciousness	.05	p=.299, n.s.

Legend: n.s.=not significant, p<.05, 1-tailed

A related noteworthy phenomenological difficulty with evaluating the immediate symptoms of cerebral concussion has been discussed elsewhere as follows: "*Some persons are unable to retrospectively determine if they really lost consciousness because they have a related amnesia or also because the loss of consciousness, rather than being a distinct dichotomy, can be conceived as a dimension ranging from a partial, minor, or subtle to a more distinct impairment*" (see Cernovsky et al, 2018).

Correlations of SNPSS Scores to Other Clinical Measures

Of clinical interest are correlations of SNPSS to measures of pain (ratings of the worst, the least, and the average pain on the Brief Pain Inventory), sleep problems (scores on the Insomnia Severity Index), the patients' ratings of depression, anger, and anxiety (Items 10 to 12 of the Whiplash Disability Questionnaire), and PTSD scores on the PCL-5, see Table 5.

Table5. *Correlations of SNPSS scores to clinical variables and other data*

	Pearson correlation	p values (2-tailed)
Age in years, N=164	-.05	.531, n.s.
Gender, N=164	.04	.630, n.s.
N of weeks since MVA (patients only), N=141	-.09	.289, n.s.
N of prior serious MVAs associated with injuries (patients only), N=141	.11	.210, n.s.
Ratings on Items 3 to 5 of the Brief Pain Inventory (patients only)		
Worst pain, N=141	.42	p<.001
Least pain, N=141	.36	p<.001
Average pain, N=140	.37	p<.001
Insomnia Severity Index (patients only), N=140	.45	p<.001
PCL-5 scores for PTSD(patients only), N=50	.56	p<.001
Ratings on Items 10 to 12 on the Whiplash Disability Questionnaire(patients only), N=141		
Depression	.36	p<.001
Anger	.30	p<.001
Generalized Anxiety	.35	p<.001

Legend: n.s.=not significant, p<.05, 2-tailed

The correlational pattern indicates that SNPSS scores in this sample of patients correlate at a weak to moderate strength with ratings of PTSD, pain, insomnia, depression, anger, and generalized anxiety.

The SNPSS correlations to age and gender were not significant (p>.05).

Similarly, the number of weeks since the accident and also the number of previous accidents were not significantly correlated with the SNPSS: all patients in our sample still experienced active pathological symptoms requiring therapeutic attention.

Correlations of SNPSS Items to Rivermead Scores

Of theoretical and clinical interest are correlations of individual SNPSS items to the total Rivermead scores, as listed in Table 6.

All correlations in Table 6 are significant at p equal or smaller than .002, 1-tailed. Since some authors prefer nonparametric correlations to Pearson coefficients, Spearman's rho coefficients are also listed.

Table6. *Correlations of SNPSS items to total Rivermead scores*

SNPSS Items:	Pearson correlation	Spearman correlation
Impaired balance	.71	.69
Excessive hand tremor	.53	.57
Instances of reduced control over leg muscles	.42	.41
Instances of reduced control over hand or arm	.53	.63
Tingling in the arm, or hand, or leg	.70	.61
Numbness in the arm, or hand, or leg	.72	.67
Reduced feeling in the arm, or hand, or leg	.48	.48
Some loss of bladder control	.31	.34
Some loss of bowel control	.34	.43
Stutter	.43	.44
Word finding difficulty	.71	.71
Difficulty articulating words	.61	.64
Noise inside of the ears (tinnitus)	.63	.61

In Table 6, the correlations involving stutter, muscular control over legs, bladder and bowel control are of weak magnitude, those involving hand tremor, reduced feeling in the limbs, and reduced muscular control of upper limbs could be categorized as of moderate magnitude, and all other correlations are high. It may appear surprising that paresthesias (tingling and numbness in the limbs) are so highly correlated with total scores of cerebral concussion, however, perhaps the persistent disquieting or sometimes painful paresthesias contribute extensively to Rivermead symptoms such as impaired sleep, the overall fatigue, restlessness, sense of frustration, and irritability.

Internal Consistency of the SNPSS

Cronbach alpha coefficient of internal consistency was .90. The item total correlations (those of each item to the sum of remaining items) ranged from .47 for bladder control to .72 for tingling in the limbs. The deletion of none of the 13 individual items led to major change in Cronbach alpha coefficients based on the remaining items, they all still ranged from .89 to .90.

Discussion

The SNPSS is intended for "mapping" the presence and location of neuropsychological symptoms to allow systematic and quantitative routine clinical assessments of the individual symptom picture of each patient. No cutoff score is provided at this time because it is theoretically feasible that a patient with all 13 symptoms marked as "severe" might be, in an extreme case, less seriously disabled than another one who marked only one or a few symptoms as "severe," but experiences a more adverse deterioration of the quality of life (e.g., when the only reported symptom would be an extremely reduced muscular control over legs after spinal injury).

The main purpose of the SNPSS in clinical work is to provide descriptive clinical data based on a standardized systematic assessment rather than using a quantitative diagnostic cutoff in individual cases.

The measures of some SNPSS and Rivermead symptoms may be confounded by side-effects of medications prescribed after an MVA. For example, elderly patients could experience "blurred vision" while on Ibuprofen, motor symptoms in their legs or cognitive symptoms while on statins, "dizziness" with "impaired balance" while on bisoprolol or perindopril, and "incontinence" while on certain alpha-blockers, sedative-hypnotics, antidepressants, or antipsychotics. The patient's current medications need to be reviewed in order to understand the meaning of the symptom profile.

Another clinical consideration should be given to possible exposure of the patients to neurotoxins as it could account for some symptoms reported by the patient on the SNPSS or Rivermead scale. Neurotoxicity could result from exposure to industrial and/or cleaning solvents, certain foods additives, pesticides, lead, arsenic, or mercury, as well as substances used in oncological chemotherapy or radiation treatment. The symptoms might include headaches, paresthesias such as tingling or numbness in the limbs, impaired control over limbs, memory and concentration problems, mental dullness, irritability, and impaired vision (Kamel and Hoppin, 2004, Mason et al., 2014). Even prescribed antibiotics can have neurotoxic effects in the elderly such as peripheral neuropathy or encephalopathy (Grill and Maganti, 2011). The SNPSS and Rivermead serve to provide a quantified symptom picture of each patient, but the etiological hypotheses and treatment strategies depend on the skills and experience of the clinician.

The data from this particular study show satisfactory criterion and convergent validity of the SNPSS on post-MVA patients. Similar SNPSS and Rivermead studies on other diagnostic groups are much needed to systematically evaluate their subjective symptom patterns in a quantified manner.

In certain cases, the clinician should also use additional neuropsychological scales for assessing oculomotor symptoms (Cernovsky, Bureau, Mann, et al., 2020) or those of cauda equina (Cernovsky, Mateos-Moreno, Oyewumi, et al., 2020), or the procedures or scales to assess particular motor symptoms such as in the Huntington or Parkinson's disease.

There is a need for developing further specialized neuropsychological scales, for example, for the assessment of the formication syndrome (the subjective sensation as if insects are crawling or running on the skin or moving under the skin). Formication has been considered as too "implausible"to be genuine and was hence considered as indicative of malingering by some authors, e.g., by Widows and Smith (2005) and by Miller (2001) in their questionnaires for the assessment of malingering. However, the formication syndrome is not uncommon in whiplash patients, or those with other spinal injuries, and in conditions such as diabetic neuropathy, some other neurological diseases, and with exposure to neurotoxins. For example, Zeigelboim's research team (2006) found that formication in the limbs was reported by 50% and formication in the face by 37.5% of patients with multiple sclerosis.

Adequately ruling out the presence of "any"neuropsychological symptoms is more difficult than assessing more narrowly defined ones, such as those of cauda equina syndrome. Systematic assessment of pain, insomnia, and of subjective post-concussive and whiplash symptoms is critical in reports prepared by insurance contracted psychologists. Failure to address such concerns often occurs in insurance litigations and results in patients being declared as "free of psychological or neuropsychological impairments." Pain, insomnia, and post-concussive and whiplash symptoms are important psychological impairments. Clearly, such cases require a systematic evaluation by an expert clinician.

In order to advance neurology and neuropsychology, further clinical research based on systematic assessments with instruments such as the Rivermead combined with SNPSS is much needed on diverse patient groups such as those with multiple sclerosis, neurotoxin exposure, very severe anorexia, or those experiencing side-effects of particular medications.

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