A factor analytic assessment of the English translation of the neuropsychological vertigo inventory (NVI)

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ABSTRACT

Purpose: Vestibular impairments have been associated with a variety of cognitive deficits, most notably deficits in visuo-spatial memory. The Neuropsychological Vertigo Inventory (NVI) was developed to measure self-reported cognitive deficits in patients with dizziness and/or vertigo. The original French language version of the NVI includes 28 items and 7 subscales. The purpose of the present investigation was to determine whether the statistical assessment of an English language version supported the presence of the same cognitive constructs as the French version of the NVI.
Method: The English language adaptation of the NVI (referred to here as the NVIe) was administered to an unselected sample of 280 patients that were being evaluated for dizziness and/or vertigo in a tertiary care dizziness clinic. The individual item scores from the NVIe were subjected to an exploratory factor analysis (EFA).
Results: The results of the data analysis supported a 22-item NVIe consisting of 4 constructs: affective state, temporal memory, spatial memory, visual spatial cognition.
Conclusions: The NVIe is a new tool for screening cognitive constructs that may be affected by vestibular impairments. Prior to clinical implementation of the NVIe, additional studies of reliability and convergent validity are needed.

1. Introduction

Recent epidemiological studies have indicated that individuals reporting vertigo suggestive of a vestibular disorder have an eight-fold increase in the odds of experiencing concentration or memory deficits (Bigelow et al., 2016). Further, large cohort studies from the Baltimore Longitudinal Study of Aging have shown a relationship between vestibular impairments, as defined by measuring cervical vestibular evoked myogenic potentials, and performance on specific tests of visuo-spatial memory but not tests of other cognitive constructs (Bigelow and Agrawal, 2015). However, others have shown general cognitive deficits in patients with bilateral vestibular hypofunction (BVH) and bilateral vestibular failure (BVF) when their functional balance is challenged (Alsalaheen et al., 2016; McGeehan et al., 2017).

Although there exist multiple methods for quantifying vestibular function and self-report dizziness disability/handicap, until recently there were no methods for easily measuring the impact of vestibular loss on cognitive function. Currently, patients reporting symptoms associated with cognitive impairments must undergo a behavioral test battery consisting of specialized tests administered by a trained individual. Lacroix et al. (2016) attempted to fill this void with the development of the Neuropsychological Vestibular Inventory (NVI).

The NVI is a 28-item, self-report questionnaire, originally developed in the French language and recently translated into English (Lacroix et al., 2016). The items are a series of statements that patients answer using a 5-point Likert scale where a 1 represents a "never" response, 2 represents "rarely", 3 represents "sometimes," 4 represents "very often", and 5 represents "always". A maximum total score is 140 points (i.e. the larger the number the greater the impairment. The authors assigned the 28-items to the "seven most relevant question categories … renamed as subscales

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of cognitive complaints …" These subscales are "space perception," "time perception," "attention," "memory," "emotion," "vision," and "motor." Each of the 7 subscales consisted of 4 items. The authors made a priori designations as to what subscales each of the items belonged and validated the questionnaire in a sample of 108 vertiginous patients and 104 non-vertiginous control participants. The authors found that performance differed for the subscales of "attention," "emotion," "vision," "motor," and the total score. No difference was observed for "space perception," "time perception," or "memory." Principal component analysis was completed using the data culled from the participants with vertigo. Percentage of variance explained for each subscale ranged from 65.31 for "space perception" to 40.85 for "motor" function. Cronbach's alpha was satisfactory to good for five of the subscales: "space perception," "attention," "memory," "emotion," and "vision."

It should not be assumed that an instrument's validity is maintained after translation. Further, health status questionnaires need to be validated in the setting and with the sample they are designed to assess. The purpose of the present investigation was to assess the construct validity of the NVIe in an unselected sample of dizzy patients seen in a tertiary care vestibular clinic in the United States.

2. Methods

2.1. Participants

Participants were 280 patients (mean age 56.10, sd 14.96 years, 169 female) who were evaluated in the Balance Disorders Laboratories of the Division of Vestibular Sciences, at Vanderbilt University Medical Center. The protocol was reviewed and approved by the Institutional Review Board (IRB, 180915). Full informed consent was obtained from each participant before data collection commenced.

3. Materials

The NVI was originally developed in French. An English language translation of the French language inventory is available (http://www.nvi-questionnaire.com/en/) and is shown in Table 1. Table 1 also shows several items that were modified in an effort to improve the clarity of the statement and/or grammatical corrections. For example, we modified the item "*I don't know which season we are in*" to read "*I have difficulty knowing what is the current season.*" The change was made in an effort to improve the grammatical construction of the phrase (i.e. by removing the preposition at the end of the statement). The item "*When I go out I have trouble finding my way back*" was edited to read, "*I think I have more trouble than most finding my car in a large parking lot*" to improve the clarity for an American audience.

3.1. Procedure

The edited version of the NVIe was administered to 280 participants using a paper/pencil response technique. The response mode was a 5-point Likert scale where the choices were, "never" (scored as zero points), "rarely" (scored as 1 point), "sometimes" (scored as two points), "often" (scored as three points) and "always" (scored as 4 points).

3.2. Statistical analyses

The individual item scores from the NVIe were subjected to an exploratory factor analysis (EFA) with Varimax rotation. Eigenvalues greater than the nominal value of 1.0 were considered. This analysis was designed to determine whether the factor structure was statistically robust in this specific patient population. Once the factors were extracted, efforts were made to identify the underlying constructs.

4. Results

The results are shown in Table 2. There were 6 factors identified that collectively explained 59% of the variability in the data. The items and the associated factor loadings are shown in Table 2. Factor 1, which explained 16.84% of the variability, appeared to index the manifestations of depression (e.g. difficulty concentrating, depression, moodiness, fatigue, distractibility and disorganization) and the category was termed "affective state." Factor 2, which explained 11.2% of the variability in the data, described disorders of "spatial memory" (e.g. difficulty in map reading, getting lost walking or driving, difficulty using directions, difficulty finding a car in a large parking lot). Factor 3 explained 10.65% of the variability in the data and described difficulties with "temporal memory" (e.g. failure to remember appointments, birthdays, what day of the week it is). Factor 4 explained 9.18% of the variability and included 4 items that were categorized in the original NVI under the constructs of vision and motor (e.g. "Newspaper columns appear jumbled.", "I am clumsy, my balance is poor."). These items link visual attention to ones' body perception in space affecting balance and were termed "visual spatial cognition."

These last 2 factors, Factors 5 and 6, consisted of 2 items each, but no unifying construct underlying these items was identified. Accordingly, items from Factors 5 and 6 were eliminated from the NVIe.

5. Discussion

The NVI was developed in France as an internet-based questionnaire designed to assess cognitive and emotional neuropsychological complaints that are frequently associated with vestibular impairments. The questionnaire was validated in French, but the psychometric qualities have not been demonstrated for the English translation version of the NVI. The purpose of this study was to begin the validation process of the NVIe through an assessment of its construct validity. We employed an empirically-based exploratory factor analysis in an attempt to reveal the factor structure of the NVIe when used in an unselected population of dizzy patients. Results from this investigation support a 22-item questionnaire with a 4-factor structure with items clustering around the four subscales of "affective state," "spatial memory," "temporal memory," and "visual spatial cognition." This version is shown in Table 3.

The result of the psychometric analysis of the NVIe differed from the original. The French language version of the NVI consists of 7 subscales including: space perception, time perception, attention, memory, emotion, vision, and motor. However, the authors did not use statistical techniques to identify and validate the presence of content domains. In this regard, the investigators stated that, "We conducted principal component analyses (PCA) *on each pre-defined subscale* [italics ours] and on the total score to refine the NVI." Additionally, we modified several items from the original NVI to improve clarity for native English-speaking patients (Table 1). The subsequent factor analysis of the modified English version failed to produce the same 7 factors as did the French version. Indeed, factors 5 and 7, consisted of only 2 items each. Further, we could not identify any unifying constructs underlying the items for these factors. For example, the items comprising Factor 5 (e.g. "I am not certain what season we are in.", "I am not certain what year it is.") would suggest the construct of "temporal memory" but did not group with other items probing temporal memory. It is likely that

Table 1

The English language translation of the Neuropsychological Vertigo Inventory (NVI) items are listed in the left column. The right column shows the re-worded items where this occurred.

Original NVI	Edited items for the NVIe
I can't place major historical events in the right chronological order.	
I find it difficult to locate myself on a map.	*I rely on others to use maps.*
I am a slow reader.	
I feel tired.	*I am tired much of the time.*
I don't know which season we are in.	*I have difficulty knowing what is the current season.*
I forget my appointments.	*I forget appointments*
I tend to lose track of what I am reading and have to start all over again.	
I have problems with my memory.	
I find it difficult to organize myself.	*I find it difficult to get organized.*
My eyes feel tired when I use the computer or watch television.	
For me, table entries and newspaper columns appear jumbled.	
I forget birthdays and anniversaries.	
I have a poor sense of direction.	*I rely on others to remember and use directions I have requested.*
I don't always know what year we are in.	*I am not certain what is the current year.*
I am not very good with my hands when it comes to do it yourself, drawing or sculpture.	
When I go out I have trouble finding my way back.	*I think I have more trouble than most finding my car in a large parking lot.*
I feel depressed.	
I am moody.	
I find it difficult to concentrate.	
I am clumsy.	
I find it hard to remember names of people.	*It is difficult for me to remember people's names.*
I am absent-minded.	
I don't think my handwriting is neat.	
I tend to go the wrong way when I set off to go somewhere.	*It is easy for me to get lost walking or driving in an unfamiliar area.*
My balance is poor.	
I find it difficult to get up in the morning.	
I get confused about what day of the week this is.	
I am easily distracted.	

Table 2

Result of the exploratory factor analysis showing the 6 factors that were identified. The factor loads for each item are in parenthesis. A criterion factor load of 0.45 was required in order to be included in the solution. The items that are displayed with a strikethrough indicate that the item was eliminated either due to low factor loading or there was no underlying construct for the entire factor so the factor, and its items, were eliminated from the NVIe.

Factor 1 – Affective state

I am a slow reader. (.48)
I am tired much of the time. (.65)
I tend to lose track of what I am reading and have to start over again. (.62)
I have problems with my memory. (.57)
I find it difficult to get organized. (.49)
I feel depressed. (.67)
I am moody. (.65)
I find it difficult to concentrate. (.66)
I find it difficult to get myself going in the morning. (.62)

Factor 2- Spatial memory

I have difficulty placing major historical events into chronological order. (.55)
I rely on others to use maps. (.85)
I rely on others to remember and use directions I have requested. (.60)
I think I have more trouble than most finding my car in a large parking lot. (.56)
It is easy for me to get lost walking or driving in an unfamiliar area. (.65)

Factor 3 – Temporal memory

I forget appointments. (.76)
I forget birthdays and anniversaries. (.71)
I am absent-minded. (.59)
I get easily confused about what day of the week it is. (.54)

Factor 4 – Visual spatial cognition

My eyes feel tired when I use the computer or watch television. .64
Table entries and newspaper columns appear jumbled to me. .59
I am clumsy. .70
My balance is poor. .58

Factor 5

Factor 6

these two items represent more extreme deficits in temporal memory that are not likely to be encountered in an outpatient vestibular disorders clinic. The items that grouped under Factor 6 (e.g. sloppy hand writing) appear to assess the construct of "visual spatial cognition" (i.e. which includes motor items) but did not group with the other visual and motor items. For these reasons,

items from Factors 5 and 6 were eliminated from the NVIe.

The different factor structure between the NVI and NVIe is not surprising as it is well-accepted that an original questionnaire and translated questionnaire are not equivalent instruments (Francis et al., 2004). Best practice recommendations include assessments of validity and reliability of the translated questionnaire as

Table 3
Final version of the 22-item, 4 subscale, NVIe.

I am a slow reader	Never	Rarely	Sometimes	Often	Always
I have difficulty placing major historical events into chronological order	Never	Rarely	Sometimes	Often	Always
I forget appointments	Never	Rarely	Sometimes	Often	Always
I am tired much of the time	Never	Rarely	Sometimes	Often	Always
I rely on others to use maps	Never	Rarely	Sometimes	Often	Always
I am absent-minded	Never	Rarely	Sometimes	Often	Always
I tend to lose track of what I am reading and have to start over again	Never	Rarely	Sometimes	Often	Always
Table entries and newspaper columns appear jumbled to me	Never	Rarely	Sometimes	Often	Always
I have problems with my memory	Never	Rarely	Sometimes	Often	Always
I rely on others to remember and use directions I have requested	Never	Rarely	Sometimes	Often	Always
I find it difficult to get organized	Never	Rarely	Sometimes	Often	Always
I forget birthdays and anniversaries	Never	Rarely	Sometimes	Often	Always
I am clumsy	Never	Rarely	Sometimes	Often	Always
I feel depressed	Never	Rarely	Sometimes	Often	Always
I find it difficult to get myself going in the morning	Never	Rarely	Sometimes	Often	Always
I think I have more trouble than most finding my car in a large parking lot	Never	Rarely	Sometimes	Often	Always
I get easily confused about what day of the week it is	Never	Rarely	Sometimes	Often	Always
I am moody	Never	Rarely	Sometimes	Often	Always
My balance is poor	Never	Rarely	Sometimes	Often	Always
It is easy for me to get lost walking or driving in an unfamiliar area	Never	Rarely	Sometimes	Often	Always
My eyes feel tired when I use the computer or watch television	Never	Rarely	Sometimes	Often	Always
I find it difficult to concentrate	Never	Rarely	Sometimes	Often	Always

prerequisites for their use. That is, it is not enough to just translate a questionnaire. It is important then to validate the translated items in a sample drawn from the population in which the questionnaire will be used. The development of a self-report questionnaire designed to assess cognition in vestibular patients is much needed and the NVI may play a valuable role in the evaluation of these patients. Symptoms of cognitive impairments associated with vestibular disorders have long been acknowledged. In fact, nearly every self-report questionnaire developed for dizzy patients includes at least one question assessing some domain of cognition and there is a growing body of research showing associations between vestibular dysfunction and cognitive performance deficits (Alsalaheen et al., 2016; Bigelow and Agrawal, 2015; Bigelow et al., 2016; Brandt et al., 2005; Cohen et al., 2017; Ellis et al., 2017; Harun et al., 2017; Hitier et al., 2014; Hüfner et al., 2007; Lucieer et al., 2018; McGeehan et al., 2017; Popp et al., 2017; Seemungal, 2014; Semenov et al., 2016; Smith, 2017).

To date, there is no accepted protocol for assessing cognitive impairments that are unique to patients with severe to profound peripheral vestibular impairments. There are discrepancies in the literature as to whether vestibular loss has an adverse effect on general cognition, specific cognitive domains such as visuospatial memory, or if these effects are limited to specific populations of vestibular patients such as those with BVF. Although there are several neuropsychological test batteries that have been used to assess vestibular cognition, these tend to be costly, time consuming, and require training to administer. A simple self-report questionnaire like the NVI that can be administered to, and independently completed by patients, has the potential to contribute to the identification of cognitive deficits and determining which patients may be in need of a referral for a more extensive testing. The results of the present investigation suggest that it is possible to modify the English-language translation of the NVI (i.e. the NVIe) to detect disorders of affective state, temporal memory, spatial memory, and, visual spatial cognition that occur secondary to severe to profound vestibular impairment. The resulting constructs are different from the French version of the NVI, most likely due to changes in translation, modifications of some items for native-English speakers, and the fact that the original version used predefined subscales whereas the NVIe was subjected to a systematic factor analysis to determine its constructs.

The findings of the current investigation support the following courses of action: 1) to assess patients suspect of having higher-order cognitive impairments secondary to vestibular impairments with the four-factor NVIe that has been described herein, or, 2) if the factor structure of the NVIe is insufficient for the detection of other higher cortical functions not assessed with the NVIe the present results support the development of a new English language metric for the assessment of functional impairments unique to individuals with vestibular system impairments.

6. Conclusions

The original French NVI includes 28 items and 7 subscales, each with four items. The results of the current investigation support a 22-item, 4 subscale, English language version of the NVI termed the NVIe. The subscales identified in the current investigation appeared to be supported by our statistical analysis. Prior to widespread use in a clinical population, additional studies on reliability and convergent validity are needed to fully recommend the widespread implementation of the NVIe in a tertiary care dizziness clinic.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.joto.2019.09.005.

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