Abstract

Background

There remains a debate about whether symptoms of psychosis lie on a continuum with healthy functioning or exist separately and are taxonic. This issue has important implications for the classification, assessment and treatment of psychosis. Research has highlighted that some symptoms of psychosis, such as paranoia, have a dimensional latent structure but it remains to be seen whether this is true for other symptoms.

Aim

To assess the latent structure of hallucinations in a diverse sample using taxometric methods.

Methods

Three taxometric procedures; MAMBAC, MAXEIG and L-MODE, were applied to a dataset of clinical (n=290) and non-clinical (n=1580) participants who had completed the Launay-Slade Hallucinations Scale- revised (LSHS-R). Analyses were initially conducted with a non-clinical group before a clinical group was included, increasing the likelihood of producing a pseudo-taxon.

Results

Three out of six taxometric analyses found a strong dimensional result (non-clinical sample; MAXEIG and L-Mode analyses. Whole sample; MAXEIG analysis). Two of the other three results were more in favour of a dimension (non-clinical sample; MAMBAC analysis and L-Mode analyses). The final analysis (whole sample; MAMBAC) supported neither a dimension nor a taxon.

Discussion

Despite some ambiguity in the findings, we observe some indications that hallucinations, like paranoia, could be dimensional, especially in the non-clinical sample. Clinical implications of these findings are discussed. Potential issues with the LSHS-R mean that results should be interpreted with some caution. The development of additional scales or assessments for hallucinations, expanding recruitment to more diverse non-clinical and clinical populations, is recommended.

Keywords: Hallucinations, taxometrics, MAMBAC, MAXEIG, L-MODE

1. Introduction

There has been a long-standing debate about whether symptoms of psychosis exist on a continuum of severity with sub-clinical signs and traits that exist across general population samples (Lawrie et al., 2010). This debate had largely focussed on schizotypal traits, with more recent attention being given to specific symptoms (Linscott & van Os, 2013; Elahi et al., 2017).

Hallucinations are a common symptom of psychosis that can cause significant distress (Clark et al., 2017). They refer to perceptions of events that are not present in objective reality (i.e. sensory experiences that are not perceived by others), which can be auditory, visual, tactile or olfactory in nature (Larøi, Marczewski, & Van der Linden, 2004; Larøi & Woodward, 2007). These experiences can vary from simple experiences (e.g. patterns or noises) to more complex ones (such as, visualisations of people/objects or voices of people speaking). Auditory-verbal hallucinations have been reported in 60%-80% (Bauer et al., 2011) and visual hallucinations have been reported in 16%–72% of patients with psychotic disorders (Collerton et al., 2012; Oorschot et al., 2012). Various psychological models have been proposed to account for these experiences. Cognitive models such as those by Morrison (2001) and Garety et al. (2007), argue for a multi-factorial explanation for hallucinations and psychotic disorders, and there is consistent evidence that hallucinations are associated with deficient source monitoring (Bentall, 1990; Brookwell, et al., 2013).

Epidemiological studies have reported that hallucinations are reported by a substantial minority of the general population (Tien, 1991; Scott et al., 2009; Temmingh et al., 2011). Additionally, life-course developmental features of hallucinations have been found in a general population sample from early adulthood to old age (Yates et al., 2021). These

findings have often been interpreted within a general framework of psychosis as a spectrum running from normal functioning, through schizotypal features to psychotic illness (Linscott and van Os, 2010). This hypothesis can be tested using taxometric methods (Meehl, 1995) which are designed specifically to test for discontinuities in a spectrum of psychopathology. Taxometric methods include a collection of analyses that can be used on a dataset (Ruscio, et al., 2006) and have been used to test the dimensionality of paranoia and schizotypy, with a dimensional construct being supported in paranoia (Elahi et al., 2017) and mixed findings for schizoptypy (Rawlings et al., 2008; Lenzenweger, 2010). A meta-analysis of taxometric research by Haslam and colleagues (2020) reported that, when taxometric methods had been applied to psychopathology, dimensional constructs were most often generated, with the exception being schizotypy where results were more ambiguous. This could be due to the focus on a broad diagnostic concept rather than specific symptoms.

Taxometric methods have been applied to hallucinations when grouped under the umbrella of 'positive psychotic like experiences' in a study of adolescents conducted in Ghana (Adjorlolo et al., 2021), which reported that these experiences have a dimensional structure. However, to our knowledge, no research has been conducted applying taxometric methods to hallucinations specifically and in adults. Therefore, we aimed to explore whether hallucinatory disposition, measured using the Launay-Slade Hallucination Scale-Revised (Bentall & Slade, 1985), is dimensional or not. Should hallucinations be found to be dimensional, this would mean that individuals in the general population vary in their predisposition to hallucinations with those who experience clinical hallucinatory symptoms sitting on the end of this continuum. This finding would enable hallucinations to be studied

in general population samples and inform intervention or prevention clinically. For example, it might suggest that currently healthy individuals scoring high on a measure of hallucinatory disposition have an at-risk mental state that might benefit from some kind of preventative intervention.

However, a taxonic finding would suggest that those who do and do not experience hallucinations form two completely separate groups. This would mean that it is unlikely that general population research on hallucinations could inform clinical practice and, indeed, could be misleading. We conducted taxometric analyses on data collected using a large population sample as well as patients with psychosis or with an at-risk mental state (ARMS; Yung et al., 2005). The data was compiled from published and unpublished studies conducted over a seven-year period (2008 to 2015).

2. Methods

2.1 Participants

Anonymised secondary data, from clinical and non-clinical populations assessed using the Launay Slade Hallucinations Scale- Revised (LSHS-R; Bentall & Slade, 1985) was provided from collaborating researchers (see below). Datasets involved adult populations who were able to provide informed consent and had granted permission for their data to be used in future research. Data from a total of 1913 participants was obtained, sufficient for taxometric analysis (Ruscio et al., 2011). Missing data for the LSHS-R was removed list-wise, resulting in a final total sample size of 1870 participants (290 clinical and 1580 non- clinical).

The non-clinical participants were mostly students who were recruited through cross-sectional designed studies at Liverpool, Bangor, and Manchester universities (Pickering, et al., 2008; Melo et al., 2009; Udachina et al., 2009; Varese., 2011; Varese et al., 2012) and unpublished studies conducted for PhD qualifications by F. Varese and A. Udachina (both awarded in 2012). The LSHS-R measures were completed in face-to-face interviews or online. Datasets were anonymised prior to being used in this study. Clinical samples were recruited through cross-sectional studies. These studies were by Varese et al. (2011, 2012 Morrison et al. (2013), Sellwood et al. (2013), Udachina et al. (2014) Wickham et al. (2015) Sitko et al. (2014) and Haarmans et al. (2016). All the studies from which data had been obtained had received approval from University and/or NHS research ethics committees.

Forty-three percent of the clinical sample had completed the Positive and Negative Symptoms Scale (PANSS; Kay et al., 1987) and 32% of the clinical sample completed the Psychotic Symptoms Rating Scale (PSYRATS; Haddock et al.,1999) to establish clinical status. However, 25% of the clinical sample did not complete these assessments, therefore other information was used to attain clinical status. All the clinical samples were considered to have forms of psychotic disorders except for 2 who met criteria for obsessive compulsive disorder (OCD). Within the clinical sample, 21 participants were actively hallucinating and 181 were considered to have psychosis at the time of the study. Demographic details are provided in Table 1.

INSERT TABLE 1 HERE

2.2 Measures

The LSHS-R is a self-report questionnaire that was designed to measure predisposition to hallucinatory experiences in healthy individuals, but which has been used in a number of clinical studies. The scale consists of 12 items that explore past and present experiences on a five-point scale. The items were selected to adhere to the Rasch model (Wright, 1977), which assumes that they form an ordered sequence of severity, and that each person has a unique position on the underlying latent trait. Total scores range from 0-48, and higher scores indicating greater predisposition to hallucinatory experiences. The five-point scale rates from 0 = certainly does not apply, to 4 = certainly applies. The LSHS-R has good psychometric properties, (Jones et al., 2008; Fonseca-Pedrero et al., 2010) and good test-retest reliability (Bentall & Slade, 1985). Internal consistency for this study was sufficient (α = 0.84) and comparable to the Positive and Negative Symptoms Scale (PANSS) internal consistency (PANSS; α = 0.85). For complete data of both groups, LSHS-R total scores ranged between 0-48 (mean = 16.74, SD = 9.6).

Walters and Ruscio (2010) advise using quasi-continuous indicators for taxometric analyses which are variables that appears continuous but may have categorical distinctions. Each one reflects a gradual variation in symptoms but can also show threshold points where conditions become clinically significant. The three subscales meet this criterion as the questions are all asked on Likert scales where individuals have limited response options. The MAXEIG analyses requires a minimum of three indicators. During development of indicators for the taxometric analyses, the decision was taken to remove spiritual-based items of the

LSHS-R (e.g. those relating to the voice of God or the voice of the Devil), as these may link to other experiences, particularly as religiosity was not recorded for either the clinical or non-clinical sample. These items may also be construed as being distinct from hallucinatory experiences by individuals with higher levels of religiosity, potentially impacting on the external validity (the Cronbach's alpha for the total scale remained > 0.80 when these items were removed). Three subscales were created on conceptual grounds "Intrusive Vivid Thoughts" (LSHS1, LSHS3, LSHS4; $\alpha = 0.71$), "Vivid Daydreams" (LSHS2, LSHS5, LSHS6; $\alpha = 0.77$) and "Clinical Hallucinations" (LSHS7, LSHS9, LSHS12; $\alpha = 0.68$). The lowest correlated items from each subscale were then selected to act as indicators as this is necessary for taxometric analyses (Ruscio et al., 2011).

Analyses were then conducted to produce visual graphs that helped to identify whether data was either categorical or dimensional. Taxometric data analyses were initially run on non-clinical sample data sets before running these on the whole dataset (non-clinical and clinical data combined) to reduce the likelihood that a pseudo-taxon would be produced because of the two different populations involved. By conducting the analyses on one group first, it reduces the chances of this happening as we can be confident the results are due to the nature of the phenomenon being investigated (hallucinations) rather than group composition. Correlational analyses for the indicators and total LSHS-R scale are shown in Table 2.

INSERT TABLE 2 HERE

2.3 Statistical analyses and procedure

Preliminary analyses involved t-tests and reliability analysis to ensure the data was suitable for taxometric methods. Consistent with the approach utilised by Elahi et al. (2017) and Ruscio et al., (2013), taxometric programs for R (version 2014-07-29) were employed (available at http://ruscio.pages.tcnj.edu/quantitative-methods-program-code/).

The validity of item indicators was calculated within R stats programme; a requirement prior to conducting taxometric analyses, where analyses are conducted on the whole sample is to establish whether item indicators are sufficient. This was calculated through a base rate classification method (Ruscio et al., 2013) that uses the standardized mean differences of the cases assigned to the taxon and complement groups.

Data analyses were conducted to produce graphs, involving Mean Above Minus a Cut (MAMBAC; Meehl & Yonce, 1994), Maximum Eigenvalue (MAXEIG; Waller & Meehl, 1998) and Latent Mode Factorial Analysis (L-Mode; Waller, & Meehl, 1998) analyses. Each analysis examines a different component of the data such as the mean (MAMBAC), the covariance (MAXEIG), and factorial analyses (L-Mode). MAMBAC uses the assumption that if two groups exist there will be an optimal cutting score to distinguish them, where if a cutting score can be found, a taxon can be assumed to exist (Meehl & Yonce, 1994; Ruscio, et al., 2013). MAXEIG aims to assess the associations between two or more output indicators, through calculating the first eigenvalue of a modified covariance matrix (Waller & Meehl, 1998). L-Mode on the other hand uses factor score estimates to graph estimated scores on a single latent factor (Waller & Meehl, 1998). Overall, six analyses were conducted (non-clinical; MAMBAC, MAXEIG, L- Mode. whole sample; MAMBAC, MAXEIG, L-Mode).

A Comparison Curve Fit Index (CCFI, Ruscio & Kaczetow, 2009) was utilised to measure the fit of the curves within the produced graphs. CCFI values are between 0 (dimensional) and 1 (categorical), where the more a scare deviates from 0.5, the stronger the result. As well as the CCFI scores, graphs were visually reviewed to determine the structure of hallucinations.

3. Results

LSHS total scores ranged from 0 to 48 for the clinical samples (mean=22.3, SD 10.8) and 0 to 46 for the non-clinical samples (mean=15.72, SD 9), with a significant difference between the two samples for the total LSHS-R scores (F=19.31, t=9.735, p=<0.001, CI: 5.22-7.88). In terms of validity, there were significant positive correlations coefficients between PANSS 3 (hallucinations) and the LSHS total scores ($r = 0.279$, $p < 0.01$), indicating construct validity.

See Table 3 for results for the whole sample (n=1870) and nonclinical sample alone (n=1580). If a taxon was present, it would be more likely to be within the whole sample rather than within the nonclinical sample alone. The estimated validity of item indicators for the whole sample fell between Cohen's d values of 1.8 and 2.2, which was within the recommended range for taxometric analyses (recommended to be at least 1.5 or above; Meehl, 1995).

Overall, a continuous rather than taxonic relationship was found within hallucinatory experiences based on the LSHS-R, with CCFI values ranging from 0.2-0.5. However, three of the six analyses (whole sample; MAMBAC, and L-Mode analyses. Non-clinical; MAMBAC)

showed ambiguous findings (CCFI values falling between 0.4-0.6) meaning there was a lack of clear consensus in these analyses as to whether the results were taxonic or dimensional. See Table 3.

INSERT TABLE 3 HERE

Figures 1 (non-clinical data) and 2 (whole sample) provide graphical representations of these results. Within both figures, the grey lines show simulations that reflect potential dimensional or categorical solutions based on parameters of the sample data, and the dark lines show the actual sample data allowing for comparison to establish whether a dimensional or taxonic solution is probable. Therefore, comparing dimensional and categorical graphs for each analysis can help show the most likely solution (the closer the dark lines fit within the grey lines). For instance, the MAXEIG graph in Figure 1 shows a dimensional result, with the dark lines fitting closer to the grey lines.

Overall, despite 3 of the CCFI scores being between 0.4 and 0.6 and, therefore, needing to be interpreted with caution; two of them (0.4 for MAMBAC non-clinical and 0.402 for L-MODE whole sample), these are still much closer to 0.4 so more indicative of a dimension rather than a taxonic structure. This also appears to be somewhat supported by the graphs which do show the dark line aligning better with the graphs representing dimensional constructs. The MAMBAC whole sample, is more ambiguous (CCFI = 0.51) as it does not indicate either a dimensional or taxonic structure.

INSERT FIGURE 1 HERE

INSERT FIGURE 2 HERE

4. Discussion

This study explored the latent structure of hallucinations in a clinical and general population. Overall, a dimensional structure was found in the large sample. However, there was some ambiguity in results where neither a taxon nor a dimension was supported. As such the results potentially support the hypothesis that hallucinatory experiences exist on a continuum; consistent with findings from other research conducted with non-clinical samples (Rehman, 2017; Shevlin et al., 2017; Unterrassner, et al., 2017).

The findings are also consistent with Rawlings et al.'s (2008) taxometric analysis of schizotypy and Elahi et al.'s (2017) taxometric study of paranoia, which also found a dimensional pattern. However, the result stand in contrast to those of Lenzenweger (1999) and Morton et al. (2017) who found taxonic structures in schizotypy. However, these studies were limited in terms of samples and had potential methodological issues (Haslam et al., 2012). This includes small samples sizes (n<600) and low validity of item indicators.

There were several limitations associated with the current study which may have contributed to the ambiguity. Recruitment bias may have occurred, particularly if participants were selected from specific University courses (potentially not representative of the general population), or clinical samples who experience mild-moderate distress. Individuals with severe distressing hallucinatory experiences may not have been recruited due to struggling with consent or being perceived as inappropriate for research.

An important limitation of this study was also the use of the LSHS-R (the only measure available for our purpose) as the correlations between the indicators were higher than desirable, and correlation coefficients between PANSS and the LSHS-R were notably weak. However, it can be difficult to achieve low correlations between indicators, especially when items have been selected to systematically vary in severity, as is the case for the LSHS-R. In fact, most LSHS-R items refer to experiences in the auditory modality, with only one focusing explicitly on the visual modality. Previous authors have been highlighted the lack of tools to assess visual or tactile hallucinatory experiences (Aynsworth et al., 2017; Bell et al., 2010). Consequently, these results may only capture a continuum for vivid daydreams, intrusive thoughts and auditory clinical hallucinatory experiences and further research may be needed to develop ways of assessing other types of hallucinations.

The study has some important implications. From a research perspective, a dimensional structure for hallucinations implies that useful information about psychological mechanisms and causal factors can be gained from studying healthy people who score highly on the underlying disposition. For example, factors that might be considered could include

demographic and social variables such as culture, spirituality, gender or age (Larøi, et al., 2014; Theodoridou et al., 2019) or family histories and potential trauma (Longden et al., 2016) or neurobiological variables. It will be particularly important to consider how these variables relate to distress and hence the transition from nonclinical hallucinations to hallucinations requiring intervention. Such research might facilitate the early identification of people who, if provided with timely support, might avoid the need for more intensive intervention.

Studies have highlighted how being diagnosed with a mental disorder can be stigmatising (Burke et al., 2016; Wong et al., 2009; Wood et al., 2015) which can lead to secondary difficulties such as disruptions in close relationships (Baba et al., 2017). A continuum model has the potential to be an important psychoeducational tool, helping to normalise psychotic experiences and reduce stigma, and enabling people to seek help when these experiences become distressing. Finally, a continuum model also creates opportunities for clinicians to explore specific symptoms and experiences in the context of psychological therapies (Schmidt, 2015).

In conclusion, there is some ambiguity in results supporting dimensionality of hallucinations, especially in clinical sample; but we provide preliminary evidence that a continuum of clinical and non-clinical hallucinations cannot be dismissed. It may be useful for further research to examine the latent structure of other psychotic symptoms, such as thought disorder and nonparanoid delusions.

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