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Prevalence and dimensionality of hallucination-like experiences in young adults

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Abstract

Background: The study of hallucination-like experiences (HLEs) in non-clinical populations is increasingly used to corroborate etiological models of psychosis. This method capitalizes on the absence of confounding factors that typically affect the study of hallucinations in clinical subjects.
Aim: To estimate the prevalence of HLEs in young adults; validate the mutidimensionality and explore the correlates of latent HLEs clusters.
Methods: Cross-sectional survey design. The extended 16-item Launay–Slade Hallucination Scale (LSHS-E) and the 12-item General Health Questionnaire (GHQ-12) were administered to 649 Italian college students (males: 47%). Confirmatory factorial analysis was used to test multidimensionality of the LSHS-E. Hierarchical nested, progressively constrained models were used to assess configural, metric and scalar invariance of the LSHS-E. Latent class analysis was used to test the existence of different profiles of responding across the identified hallucination-proneness dimensions.
Results: Factor analysis showed that the four-factor model had the best fit. Factors were invariant across demographic variables and levels of psychological distress. Three latent classes were found: a large class with no HLEs (70% of participants), a multisensory HLEs class (18.8%), and a high hallucination-proneness class (11%). Among those reporting high levels of HLEs, approximately half reported scores indicative of considerable psychological distress.
Conclusions: Although HLEs have a relatively high prevalence in the general population, the majority of those experiences happen in isolation and are not associated to psychological distress. Approximately half of those individuals experiencing high levels of HLEs report significant psychological distress. This may be indicative of general risk for mental health conditions rather than specific risk for psychosis.

1. Introduction

Hallucinations are considered a hallmark symptom of psychosis; however, a significant minority of healthy individuals from the general population experience them in the absence of clear indicators of psychopathology [1,2]. The investigation of hallucination-like experiences (HLEs) in non-clinical populations is increasingly used as a method to corroborate etiological models of hallucinations [3–7].

HLEs have been conceptualized as a continuum of experience underlying a latent vulnerability to experiencing hallucinations, from vivid daydreams, intrusive and vivid thoughts to the occasional experience of sounds with no clearly identifiable source, and even the brief experience of voices [8,9]. This continuum of experience is expected to be related to a continuum of risk, with some people unlikely to ever note the occurrence of sporadic HLEs in their life and other reporting them with greater and greater frequency, until the occurrence of more severe forms of auditory hallucinations [10–14]. The investigation of HLEs in non-clinical individuals can be useful to detect subthreshold hallucinations at their onset and to evaluate their correlates in the absence of confounding factors typically affecting the study of

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hallucinations in individuals with a psychiatric diagnosis, such as medications, self-selection, co-morbid disorders [15], the role of stigma [16].

Undergraduate college students are the ideal candidates to investigate HLEs since they were found to be more forthcoming in providing answers to socially undesirable topics [17], and because they are less likely to misunderstand the items of self-report tools and interviews [18,19]. Students are also generally in an age range when the risk of developing psychosis is the highest. Lastly students are widely used for this type of research and results are easy to compare with the existing literature.

Past investigations of HLEs in non-clinical individuals focused on auditory HLEs, and verbal auditory HLEs in particular [2,20]. The study of the multidimensionality of HLEs may provide better knowledge on the etiology of these experiences. For example, the psychometric characterization of clusters of individuals with homogeneous set of HLEs may prompt more detailed investigation in these groups and help characterizing specific pathways accounting for transition to psychosis. Different HLEs clusters may also bear a different association with well-being. Groups with different levels of distress but similar level of HLEs can be useful to study the role of coping strategies, predisposition and appraisal in dealing with the emergence of HLEs. To be valid for such a comparison, a questionnaire should measure identical constructs with the same structure across different groups. The assessment of measurement invariance by confirmatory factor analysis (CFA) serves the purpose of demonstrating that the participants, across groups of interest (e.g., gender, age), interpret the single items, as well the underlying latent factor, in the same way. Conversely, failure to prove measurement invariance indicates that groups or individuals interpret the items differently, and as a consequence factor means cannot be compared [21,22].

This study aims to: 1) assess the prevalence of HLEs in a representative sample of undergraduate college students; 2) explore the dimensionality of HLEs using two data reduction methods: CFA to consolidate dimensions observed in previous studies and, for the first time, Latent Class Analysis (LCA) to explore latent constructs distribution; 3) examine the relationship of these dimensions with wellbeing.

2. Methods

This study is part of the **Ca**gliari — **P**sychosis: **I**nvestigation on **R**isk **E**mergence (CAPIRE, which means “to understand” in Italian), a study of screening tools to assess and diagnose mental states at risk of psychosis; the study is focused on university undergraduate students. The institutional review board approved the study protocol in accordance with the guidelines of the 1995 Declaration of Helsinki (as revised in Tokyo in 2004). All participants provided informed consent; participation was voluntary and no fee or other compensation was paid for participation.

2.1. Participants

Participants were recruited within the CAPIRE study. This study targets university undergraduates attending courses at the University of Cagliari. Participants were enrolled using a snowball procedure [23], with a method that avoids self-selection, the bias occurring when recruiters only use their personal social networks [24].

Overall, 962 people were been asked to take part in the study; 120 declined after having had a look at the booklet; 842 people accepted to participate; 153 did not return the booklet, and 689 participants actually returned the booklet; 40 cases were not considered because their questionnaires were left blank in some parts; 649 participants were included in this study (67% overall participation rate).

2.2. Measures

All participants provided written informed consent and received a booklet containing several questionnaires. For the purpose of this study, the following questionnaires were considered: the Italian version of the 12-item General Health Questionnaire (GHQ-12) [25,26], as a measure of general psychological distress, and the Italian version of the extended, 16-item Launay–Slade Hallucination Scale (LSHS-E) [8,9,27,28].

The GHQ-12 is a screening questionnaire aiming to identify people suffering from psychological distress and compromised wellbeing [25]. Respondents have to rate the presence and frequency of each symptom on a 4-point scale (i.e. “not at all”, “less than usual”, “more than usual”, “rather more than usual”) within the past four weeks [25,26]. For the purpose of this study, a dichotomous scoring system was used, attributing one point to each item with a “more than usual” or “rather more than usual” response. Previous research using this scoring method showed that a total score of 4 or more is likely to be associated with a common mental disorder [26].

The LSHS-E is a self-report scale investigating the multidimensionality of hallucinatory experiences in the general population and taps into all major sensory modalities beyond the auditory modality, such as the visual, olfactory, and tactile modalities, and it is particularly apt to investigate the multidimensionality of HLEs (Table 1).

The original version of the LSHS [27] had dichotomous items (i.e., “true/false”), but it was modified to account for different intensities replacing the binary choice with a five-point Likert scale [29]. A further, revised version of the scale was created (LSHS-R) including items tapping on visual hallucinations [8,28]. The LSHS-E includes items tapping into all major sensory modalities. On the LSHS-E respondents have to rate each item on a five-point scale: (0) “certainly does not apply to me”; (1) “possibly does not apply to me”; (2) “unsure”; (3) “possibly applies to me”; and (4) “certainly applies to me” [8,28]. The considered time interval covers the latest 5 years. Depending on the response format and the number of items included in the scale,

Table 1
Descriptive statistics for the items and factor analysis of LSHS with factor loading of confirmatory factor analysis: n = 649.

	Mean (SD)	Skewness	Kurtosis	% Apply to me	Factor 1 Intrusive thoughts	Factor 2 Vivid daydreams	Factor 3 Multisensory HLEs	Factor 4 Auditory/ visual HLEs
1. Sometimes a passing thought will seem so real that it frightens me	0.98 (1.20)	0.89	−0.45	15.1%	0.710			
2. Sometimes my thoughts seem as real as actual events in my life	0.86 (1.11)	1.04	−0.09	12.0%	0.736			
3. No matter how hard I try to concentrate on my work unrelated thoughts always creep into my mind	1.93 (1.41)	−0.09	−1.36	43.3%	0.529			
4. In the past I have had the experience of hearing a person's voice and then found that there was no-one there	0.50 (1.01)	1.93	2.49	9.2%				0.708
5. The sounds I hear in my daydreams are generally clear and distinct	0.51 (0.96)	1.96	3.08	6.3%		0.709		
6. The people in my daydreams seem so true to life that I sometimes think that they are	0.38 (0.82)	2.23	3.96	5.4%		0.770		
7. In my daydreams I can hear the sound of a tune almost as clearly as if I were actually listening to it	0.47 (0.95)	2.08	3.44	7.2%		0.821		
8. I often hear a voice speaking my thoughts aloud	0.25 (0.68)	3.03	9.28	2.8%				0.677
9. I have been troubled by hearing voices in my head	0.23 (0.63)	3.03	9.02	2.2%				0.705
10. On occasions I have seen a person's face in front of me when no-one was in fact there	0.24 (0.73)	3.39	11.35	3.9%				0.642
11. Sometimes, immediately prior to falling asleep or upon awakening, I have had the experience of having seen, felt or heard something or someone that wasn't there, or I had the feeling of being touched even though no one was there	1.09 (1.44)	0.83	−0.92	25.3%			0.808	
12. Sometimes, immediately prior to falling asleep or upon awakening, I have felt that I was floating or falling, or that I was leaving my body temporarily	1.27 (1.50)	0.60	−1.28	30.0%			0.643	
13. On certain occasions I have felt the presence of someone close who had passed away	0.71 (1.18)	1.44	0.72	13.1%			0.638	
14. In the past, I have smelt a particular odour even though there was nothing there	0.87 (1.29)	1.13	−0.20	17.4%			0.325	
15. I have had the feeling of touching something or being touched and then found that nothing or no one was there	0.72 (1.22)	1.42	0.54	15.4%			0.803	
16. Sometimes, I have seen objects or animals even though there was nothing there	0.39 (0.88)	2.37	4.77	5.9%				0.658

SD = Standard deviation.
"% Apply to me" includes those who replied possibly (3) or certainly (4) apply to me on the item.
HLEs = hallucinatory-like experiences.

two-factor [30–32], three-factor [33–35] and four-factor models [8,36,37] have been described. Using the LSHS-E a four-factor solution was retrieved in Italian [9] and Spanish [38] samples. These factor solutions were characterized as representing an increasing level of hallucinatory severity, with factors including intrusive thoughts and vivid daydreams associated with less severity while factors including auditory and visual or multisensory HLEs were associated with lower levels of well being.

2.3. Statistics

Once entered in a database by a researcher data were rechecked by another researcher. Error rates were less than 1% and all were corrected based on the questionnaires. All data were coded and analyzed using the Statistical Package for Social Sciences (SPSS) version 20. All tests were two-tailed. Due to multiple testing, the significance threshold was set at $p < 0.0001$. According to Bayesian interpretations, at this threshold results have the highest chance of being confirmed in future studies [39].

Scales reliability was measured by Cronbach's alpha. For group comparisons, reliability values of 0.70 are considered satisfactory, and when dealing with subscales derived from a single questionnaire, values around 0.6 are considered acceptable [40]. Correlation coefficients were compared according to Steiger's z test [41].

2.4. Confirmatory factor analysis

CFA was carried out with the *lavaan* package [42] running in R [43]. The results obtained using this package have been shown to be consistent with other software packages [44].

Maximum likelihood estimation with robust standard errors and Satorra–Bentler scaled test statistic were used to test CFA models. This method was chosen since it is robust against deviation from normality [45]. The ratio chi-square degrees of freedom (df) was calculated in addition to chi-square to evaluate model fitting; ratios larger than 3 indicate poor fit [46,47]. Additional parameters for fit estimation were: the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). RMSEA values of 0.08 or lower, SRMR values of 0.09 or lower and CFI values of 0.90 or higher are considered acceptable [48,49].

Three models were tested: 1) unidimensional model, assuming that all items load on a single factor; 2) two-factor model, assigning items 1 to 7 to a subclinical or non-psychopathological factor and items 8 to 16 to a clinical or psychopathological factor, as in Serper et al. [32]; 3) a four-factor model that distinguishes among an "intrusive thoughts" factor, a "vivid daydreams" factor, a "multisensory HLEs" factor and an "auditory and visual HLEs" factor, as in Vellante et al. [9]. No cross-loading was allowed, and on the basis of item content and plausibility of the association of the items, items 4 and 16 were assigned to the "auditory and visual HLEs" factor (see Table 1).

The three-factor model described in some past studies [33–35] was not tested, since all these studies were conducted using the 12-item version of the scale. The LSHS-E includes more items exploring hallucinations occurring across all sensory modalities and does not include items on religious experiences (i.e. "In the past I have heard the voice of God speaking to me", "I have heard the voice of the Devil") since these experiences were rarely endorsed in non-clinical samples and were less helpful in discriminating across levels of HLEs occurrence. Models were compared on the basis of goodness-of-fit indices and the Akaike Information Criterion [50]. Models with the lowest AIC should be preferred [51]. A factor loading of 0.32 (10% of variance) was the minimum requirement for an item to be included in the final global score [52].

Measurement invariance by gender, age and level of psychological distress on the GHQ was calculated according to Byrne and van de Vijver [53], by using R *semTools* package [54]. Typically, a hierarchical set of steps is followed when invariance is tested, starting with the determination of a well-fitting baseline model and then establishing successive equivalence constraints in the model parameters across groups. Configural, metric and scalar invariance was tested. Configural invariance refers to whether the same CFA is valid in each group. Metric invariance concerns the equivalence of the factorial loadings across groups. Scalar invariance is assumed when the item intercepts and the factor loadings are equally constrained across groups. The confirmation of the invariance of the intercepts allows comparison of the latent means in both groups. Models were compared on the basis of changes in CFI (delta-CFI). When delta-CFI is greater than 0.01 between two nested models, it is assumed that the additional constraints have led to a poorer fit and the more constrained model has to be rejected [55]. The Bayesian information criterion was also used to compare models [56], with models with larger BIC showing a poorer fit [57].

2.5. Latent class analysis

LCA posits that a heterogeneous group can be reduced to several homogeneous subgroups by evaluating and then minimizing the associations among responses across multiple variables, and tests for the existence of discrete groups with a similar symptom or item endorsement profile [58,59]. LCA was conducted with Mplus 3 [60].

LSHS-E items were dichotomized (0/1), assigning the value "1" to the replies "3" ("possibly applies to me") and "4" ("certainly applies to me"); the value "0" was assigned to the replies "0" ("certainly does not apply to me"), "1" ("possibly does not apply to me") and "2" ("unsure").

Model selection was based on fitting indices such as likelihood ratio (−2*Ln(L)), the AIC, the BIC, and the sample-size adjusted BIC (SSABIC) [61]. For these indexes, lower values indicate better fit. The Lo–Mendell–Rubin's adjusted likelihood ratio test (LRT) was also used to compare models with different number of latent classes [62]. Standardized entropy measure was used to assess accuracy of participants' classification (0 to 1), with higher values indicating better classification.

Multinomial logistic regression was used to assess the association between class membership and demographic variables (i.e. gender and age) or clinical indexes (GHQ caseness). Differences between classes were expressed with odds ratio (95% confidence interval [CI]). For descriptive purposes, mean and standard deviations of LSHS-E subscales by classes were reported, and the effect sizes of differences between classes were calculated according to Cliff's delta (with C.I.), which is appropriate in case of violations of normality [63]. Cliff's delta (or Cliff's δ) represents the degree of overlap between the two distributions of scores: it ranges from −1 to +1 (according to the order of overlap between two groups), and takes the expected value of zero if the two sample distributions are extracted from the same population.

Suggested thresholds for interpreting Cliff's delta are: delta value of 0.147 = small effect size; delta value of 0.330 = medium effect size; delta value of 0.474 = high effect size.

3. Results

In the sample there were 305 males (47%) and 344 females (53%). Participants had an average age of 24 years (SD = 3.4). Nineteen participants declared to be married (2.9%) and 325 reported to be in a stable relationship (50%). The participants whose parents had a high school diploma were 287 (44%), while the participants whose parents had a university degree or a higher qualification were 86 (13%).

Table 2
Goodness of fit indexes (with corrected robust estimation) for the proposed models (sample: n = 649).

Model	χ^2	df	p	χ^2/df	CFI	RMSEA (90% CI)		SRMR	AIC
One-factor	670.51	104	0.0001	6.4	0.729	0.092	0.087–0.097	0.079	27,019.59
Two-factor	603.33	103	0.0001	5.8	0.761	0.087	0.081–0.092	0.082	26,884.97
Four-factor	268.08	98	0.0001	2.7	0.919	0.052	0.046–0.057	0.050	26,314.75

3.1. Descriptive statistics

Cronbach's alpha was 0.85 for the GHQ and 0.89 for the LSHS-E.

Mean scores were 3.3 (SD = 3.1) on the GHQ and 11.4 (10.6) on the LSHS.

Females scored higher than males on the GHQ (3.7 ± 3.2 versus 2.8 ± 2.9; Mann–Whitney U test: $z = -3.90$, $p < 0.0001$), but not on the LSHS-E (11.6 ± 10.2 vs 11.2 ± 11.2).

Age was, marginally, negatively associated to the scores on the LSHS-E (−0.109, $p = 0.006$).

In the sample there were 241 participants scoring 4 or higher on the GHQ-12 (37.1% of the sample). Females were marginally more likely to be a case on the GHQ (n = 147; 42.7%) than males (n = 94; 30.8%): $\chi^2 = 9.32$, df = 1, $p = 0.002$.

3.2. Frequency of hallucinatory-like experiences on the LSHS-E

The incidence of hallucinatory experiences reported with certainty varied from 2% to 43% depending on the experience. Sleep-related (e.g., hypnopompic and hypnagogic) experiences were reported with higher frequency (25%–30%) compared to auditory or visual hallucinatory experiences (less than 5%). Items with a more apparent pathological content (e.g., item 8 on echoing of thoughts or item 9 on hearing voices in the head) were rarely endorsed with certainty (i.e. around 2%). Among those reporting auditory hallucinations (item 9; n = 14), only 1 participant reported visual hallucinations (item 16; n = 38).

3.3. Confirmatory factor analysis of the LSHS-E

The one-factor model and the two-factor model were rejected on the basis of chi-square, the ratio of chi-square to degrees of freedom, and the CFI (Table 2).

The best fit was observed for the four-factor model. In the four-factor model, factor loading was acceptable (> 0.32) for all items (Table 1 for details).

Factors were interrelated: the "intrusive thoughts" factor correlated with the "vivid daydreams" factor ($r = 0.60$, $p < 0.0001$), with the "multisensory hallucinatory-like experiences" factor ($r = 0.49$, $p < 0.0001$), and with the "auditory and visual hallucinatory-like experiences" factor ($r = 0.56$, $p < 0.0001$). The "vivid daydreams" factor correlated with the "multisensory hallucinatory-like experiences" factor ($r = 0.52$, $p < 0.0001$), and with the "auditory and visual hallucinatory-like experiences" factor ($r = 0.73$, $p < 0.0001$). The "auditory and visual hallucinatory-like experiences" factor correlated with the "multisensory hallucinatory-like experiences" factor ($r = 0.77$, $p < 0.0001$).

The "vivid daydreams" factor had a higher level of association with the "auditory and visual hallucinatory-like experiences" factor than with the "multisensory hallucinatory-like experiences" factor (Steiger's $Z = 10.38$, $p < 0.0001$). Similarly, the "intrusive thoughts" factor, had a, marginally, greater association with the "auditory and visual hallucinatory-

Table 3
Fit indices (with corrected robust estimation) for invariance tests of the four-factor model (sample: n = 649).

Model	χ^2	df	p	χ^2/df	CFI	RMSEA	BIC	delta-CFI
Gender: males (n = 305) versus females (n = 344)								
Configural invariance	401.74	196	0.0001	2.0	0.903	0.057	26697.37	
Metric invariance	416.34	208	0.0001	2.0	0.902	0.056	26655.43	−0.001
Scalar invariance	444.29	220	0.0001	2.0	0.895	0.056	26605.29	−0.007
Age: 19–24 years old (n = 368) versus 25 years old and older (n =281)								
Configural invariance	404.94	196	0.0001	2.0	0.901	0.057	26760.53	
Metric invariance	418.27	208	0.0001	2.0	0.900	0.056	26711.55	−0.001
Scalar invariance	438.07	220	0.0001	1.9	0.896	0.055	26648.51	−0.004
Levels of psychological distress: GHQ ≤ 3 (n = 408) versus GHQ ≥ 4 (n = 241)								
Configural invariance	390.32	196	0.0001	1.9	0.909	0.085	26688.94	
Metric invariance	401.31	208	0.0001	2.0	0.909	0.083	26630.40	−0.000
Scalar invariance	435.58	220	0.0001	1.9	0.899	0.083	26590.12	−0.010

Table 4
Fit indices for the latent class analysis of the LSHS-E items.

Model	−2*Ln(L) (df) *P*	AIC	BIC	SSABIC	LRT P	Entropy
2 classes	6149.51	6215.51	6363.20	6258.42	1062.1 <0.0001	0.885
3 classes	6000.01	6100.01	6323.78	6165.03	148.2 0.042	0.887
4 classes	5907.62	6041.62	6341.47	6128.75	91.5 0.533	0.801
5 classes	5853.88	6021.88	6397.82	6131.12	50.5 0.045	0.760

LRT = Lo–Mendell–Rubin's adjusted likelihood ratio test.

like experiences" factor than with the "multisensory hallucinatory-like experiences" factor (Steiger's Z = 3.16, p = 0.0016).

3.4. Measurement invariance

Configural, metric and strong invariance across gender, age and levels of psychological distress of participants was explored for the four-factor model (Table 3).

Invariance was examined by dividing the sample into two subgroups of 19–24 year-old and 25 year-old and older. There was an overall reduction of fit with increasingly constrained models, but the models could still be considered acceptable on the basis of the ratio of chi-square to the degrees of freedom and the RMSEA.

As can be seen from Table 3, the difference in the CFI between the configural and the more constrained models did not exceed 0.01. In all comparisons the BIC was lower than in the preceding model, suggesting that the model had a better fit. The results support configural, metric and strong invariance of the LSHS-E across gender, age and levels of psychological distress of participants.

Thereafter, factors' mean scores were calculated by summing up items scores and then averaging the sum by the number of items for each factor. This was to compensate for the unequal number of items of the factors. Cronbach's alpha was 0.68 (95% CI: 0.63–0.72) for the "intrusive thoughts" factor; 0.81 (0.78–0.83) for the "vivid daydreams" factor; 0.83 (0.80–0.85) for the "multisensory hallucinatory-like experiences" factor; 0.79 (0.77–0.82) for the "auditory and visual hallucinatory-like experiences" factor.

Mean scores were 1.25 (SD = 0.97; 95% CI = 1.18–1.33) for the "intrusive thoughts" factor; 0.45 (0.77; 0.39–0.51) for the "vivid daydreams" factor; 0.93 (1.02; 0.85–1.01) for the "multisensory hallucinatory-like experiences" factor; 0.32 (0.59; 0.27–0.37) for the "auditory and visual hallucinatory-like experiences" factor. On the basis of the confidence of interval of the mean, participants scored significantly higher on "intrusive thoughts" and "multisensory hallucinatory-like experiences" factors than on the "vivid daydreams" and "auditory and visual hallucinatory-like experiences" factors.

3.5. Latent class analysis of LSHS-E

The 3-class solution was the best compromise between all the considered indexes (Table 4).

The AIC and the SSABIC progressively declined across the different models. The BIC values in the 4-class and the 5-class solution were higher than in the 3-class solution, and the Lo–Mendell–Rubin's LRT indicates that the 4-class solution was no more significant than the 3-class solution, and therefore the 3-class solution should be preferred on the basis of parsimony.

In the 3-class solution the entropy was 0.88, which indicated a good classification of participants in the model. This solution yields to a baseline class (LC1) with low endorsement of most LSHS-E items, including 461 (70.1%) participants, a non-pathological HLEs class (LC2), with high endorsement on the "multisensory hallucinatory-like experiences" factor and including 121 (18.8%) participants, and a third class of high-proneness to HLEs (LC3), with high endorsement on pretty all LSHS-E factors (on average, 30%

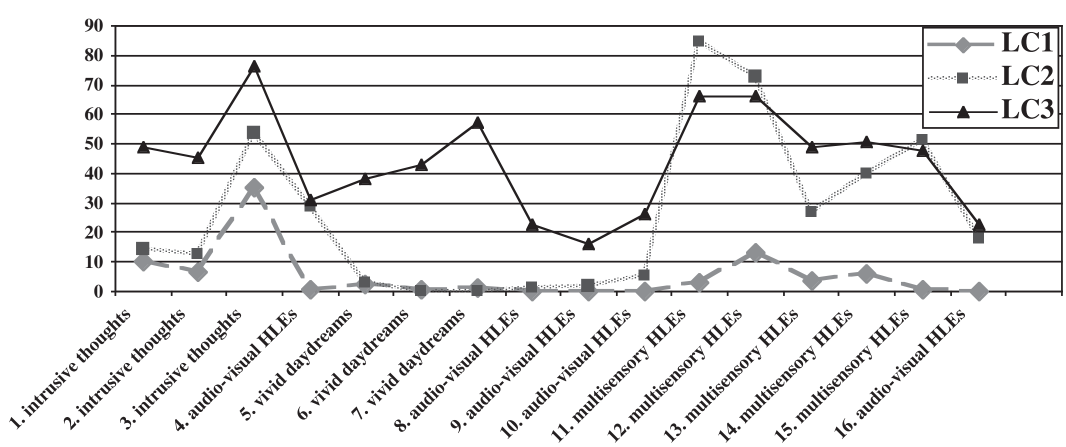

Fig. 1. Profile plot for the latent class analysis of the LSHS-E (16 items). The Y-axis represents the class-specific mean scores as proportions of the maximum score for the indicator concerned. The X-axis contains the 16-item profile of the LSHS-E grouped by factor.

to 60% of certainty replies on the items) and including 67 (11.1%) participants (Fig. 1).

Compared to the baseline class, those in the LC2 scored higher on all LSHS-E factors, with high effect size (Cliff's delta) on the "multisensory hallucinatory-like experiences" factor and the "auditory and visual hallucinatory-like experiences". Compared to the baseline class, those in the LC3 scored higher on all LSHS-E factors, with high effect size on all factors.

There were no differences by gender. Younger people and people scoring above the threshold for a clinical case on the GHQ-12 were more likely in the high-proneness to HLEs (LC3) compared to the baseline class (Table 5).

However, in the high-proneness to HLEs class about 50% of participants scored in the GHQ-12 non-pathological range.

4. Discussion

In our sample of putatively healthy university students, 18.8% reported multisensory HLEs, principally hypnagogic or hypnopompic hallucinations, and 11.1% admitted HLEs with a more severe pathological connotation. The prevalence of auditory verbal HLEs was 2.2% and the prevalence of visual HLEs was 5.9%. These prevalence figures are in line with those reported in past studies. A systematic review from Linscott and van Os [64] reported a median prevalence rate for hallucinations (not otherwise defined) of 4.1% (80% CI: 0.6 to 20.8). In the first worldwide cross-national study on the prevalence of psychotic-like experiences in the general population, Nuevo et al. [65] reported that the weighted and sex-age standardized prevalence estimates for hallucinations were 2.4% in high/upper-mid-income countries and 5.5% in mid low- and low-income countries. Sensibly higher prevalence estimates of hallucinations were reported in the past, up to 71% [66], by the inclusion of very common experiences (e.g., "heard own name in a shop").

4.1. HLEs multidimensionality

Propensity to experience HLEs applies to various dimensions including intrusive thoughts vivid daydreams, multisensory and audio-visual HLEs. Dimensions of hallucination-like experiences, as measured by the LSHS-E, are invariant across gender and age, and across levels of psychological distress. This is congruent with past findings of Serper et al. [32], who found a very similar factor-analytic solution for three groups of psychotic patients with active hallucinations, psychotic inpatients without hallucinations, and a group of university students.

The results of the LCA did not support a simple continuum model of increasing severity of HLEs. A large proportion of our sample had a low endorsement rate of most LSHS-E items while two other clusters had a relatively higher item endorsement. The first of these two clusters can be characterized as expressing a non-pathological propensity to HLEs manifested by hypnagogic or hypnopompic hallucinations. The second cluster includes a subset of individuals experiencing HLEs more similar to those experienced by people with psychosis. These people admit auditory and visual HLEs besides hypnagogic or hypnopompic hallucinations, and half of these cases reported levels of psychological distress

Table 5
Association between latent classes, demographics and levels of psychological distress. Latent Class I is used as a reference term.

All data: n (%) or mean (SD)	LC1	LC2	LC3
	n = 461 (71.0%)	n = 121 (18.6%)	n = 67 (10.3%)
Sex			
Males	225 (48.8%)	49 (40.5%)	31 (46.3%)
Females	236 (51.2%)	72 (59.5%)	36 (53.7%)
	1	OR = 1.35 (0.90–2.05)	OR = 0.96 (0.57–1.63)
Age			
19–24 years old	252 (54.7%)	68 (56.2%)	48 (71.6%)
25 years old and older	209 (45.3%)	53 (43.8%)	19 (28.4%)
	1	OR = 0.99 (0.94–1.05)	**OR = 0.88 (0.81–0.96)**
GHQ			
GHQ ≤ 3	303 (65.7%)	72 (59.5%)	33 (49.3%)
GHQ ≥ 4	158 (34.3%)	49 (40.5%)	34 (50.7%)
	1	OR = 1.25 (0.82–1.89)	**OR = 1.84 (1.09–3.11)**
LSHS-E			
"intrusive thoughts" factor	1.04 (0.90)	1.46 (0.83)	2.38 (0.85)
		Cliff' δ = 0.29 (0.07–0.48)	**Cliff' δ = 0.70 (0.39–0.87)**
"vivid daydreams" factor	0.45 (0.77)	0.37 (0.56)	2.11 (0.85)
		Cliff' δ = 0.13 (0.00–0.28)	**Cliff' δ = 0.91 (0.78–0.96)**
"multisensory hallucinatory-like experiences"	0.45 (0.52)	2.22 (0.63)	2.21 (1.03)
		Cliff' δ = 0.96 (0.87–0.98)	**Cliff' δ = 0.87 (0.71–0.94)**
"auditory and visual hallucinatory-like experiences"	0.15 (0.25)	0.65 (0.66)	1.22 (0.95)
		Cliff' δ = 0.55 (0.43–0.65)	**Cliff' δ = 0.77 (0.61–0.87)**

Latent Class I, corresponding to the baseline class with low endorsing of LSHS-E items was used as a referent term.
Confidence intervals not including unity indicate statistical significance ($p < 0.05$). Significant results in bold.

possibly indicative of need for care. It is interesting to note that in this cluster those reporting auditory HLEs do not report visual HLEs and vice versa. This observation may lend further support to the multidimensionality of HLEs in the general population.

4.2. Clinical considerations

Studies conducted on the general population and in particularly on selected samples (such as university students) may be limited in relation to their translational value to clinical recommendations. However, these types of studies for size and methodological rigor constitute a valid hypothesis gathering ground for future more specific investigations.

In this sample the reporting of HLEs was negatively related to age, a finding congruent with studies showing higher prevalence rates of HLEs in children and adolescents than in adults [20,67]. Recall bias may have contributed to this finding [68], particularly for those who experienced HLEs in childhood. A large majority of children who experience HLEs at 7 and 8 years of age do not report these experiences any more by age 12–13 [69]. However, the type and the quality of the instruments used for the assessment may lead to over reporting in children [19]. It can be also advanced that the expressivity of hallucination-proneness may soften over time or people learn, with age, to avoid the self-disclosing of potentially stigmatizing experiences. Alternatively, people with the more extreme expressiveness of HLEs vulnerability may not be part of the oldest age groups because they left school as a result of mental health complications. Rubio et al. [67] reported that in young people, 0.6% to 1.3% of the individuals experiencing hallucinations converted to diagnoses of psychosis each year (see also [70]).

Among those endorsing the highest number of items approximately half were more likely to admit psychological distress. In past studies, auditory and visual hallucinations were the only subcomponents that differentiated patients with schizophrenia from non-psychotic or individuals with no psychiatric diagnoses [71]. While it is correct not to assume that auditory verbal hallucinations (AVH) and auditory hallucination-like experiences are interchangeable, some of the auditory HLEs considered by the scale are within the phenomenological dimension of clinical AVHs (e.g., item 4).

There is some agreement that the propensity to HLEs exists along a continuum, but at a certain level of symptom severity (but not frequency) these experiences become discontinuous and dysfunctional [50,72,73]. There is also some evidence that the emergence of hallucinations, and of auditory hallucinations in particular, precedes the formation of delusions in the development of psychosis [11,13,14].

The mechanism relating HLEs vulnerability to frank psychosis is largely unknown [74–76]. Our findings suggest, in line with previous investigations, that certain types of hallucinatory modality (i.e. auditory HLEs) may be more related to distress and possibly contribute to increase the risk of psychosis. Both risk and protective factors might be involved in the pathways leading from HLEs vulnerability to frank psychosis. Some studies indicate that despite experiencing a greater risk of depressive and substance use disorders, a large proportion of those experiencing auditory hallucinations in childhood or adolescence do not convert to psychosis [77]. Factors contributing to transition to psychosis among those who experience hallucinations are a concomitant delusional interpretation of the experience [78,79], and negative emotional states (e.g., depressed mood) [80]. The appraisal of the experience but also developmental and environmental factors such as personality and access to social and emotional support may influence the progression from HLEs to persistent hallucinations in those who eventually receive a diagnosis of psychosis.

4.3. Implications for research

This study confirmed the multidimensionality of the hallucination-proneness, with intrusive thoughts and vivid daydreams being specifically related to auditory and visual hallucinatory-like experiences. Previous research showed that intrusive thoughts were related to a higher chance of experiencing auditory hallucinations in patients diagnosed with schizophrenia [71,81]. Fantasy proneness and daydreams might represent additional vulnerability factors for experiencing hallucinations [71,82,83]. Indeed, sleep-related experiences and auditory anomalous perceptions related to hyper-vigilance were the most often reported HLEs in healthy community samples [84,85]. Confusion between visual mental images and perception was related to a higher propensity to experience visual hallucinations [86].

Incidental retrieval of episodic memories, which may be related to intrusive thoughts, might have a role in HLEs vulnerability. Indeed, memories of past episodes frequently come to mind incidentally, without directed search [87]. A recent study found that 39% of people with schizophrenia reported their hallucinating voices being similar to conversations they had experienced [88].

Besides intrusions from memory, abnormal self-monitoring of inner speech was suggested to favor the formation of AVHs both in patients with psychosis [89,90], and in non-clinical populations [5,6,90]. More generally, misattribution of internally generated cognitive events to external sources was purported to contribute to self-monitoring deficit in the development of AVHs [91]. There is evidence that psychopathology increases the reporting of HLEs. Similarly to fever, HLEs may indicate an underlying problem, which, in most cases, is not very serious (a simple cold for fever, stress or fatigue for HLEs). Psychosis as an outcome is likely to be confined to a small fraction of those reporting HLEs [19,92]. We think that frequencies and intensity of HLEs may represent proxies for some more important features of HLEs such as appraisal, distress and preoccupation [93]. It is the meaning attributed to the experience that seems to have a larger impact on mental health [94]. This is supported by first-person accounts indicating that the “voices” may serve the purpose of communicating feelings that the patients themselves were unable to communicate [95].

4.4. Limitations and strengths of the study

This is a cross-sectional study, so no firm statement on causality can be done. Findings on the association between psychological distress and the HLEs prone classes should be confirmed with longitudinal studies. College students might not be representative of the general population and no information on the clinical status of the students was available besides self-report data. Evidence on the factor structure of the LSHS-E and its measurement invariance should be replicated in clinical samples, particularly to assess whether measurement invariance holds across different types of psychotic disorders (i.e., schizophrenia, bipolar disorder with psychotic features, major depression with psychotic features). The use of state-of the-art statistics and the large sample are the main strengths of this study. In particular, the use of latent class analysis provides a novel investigation approach to HLEs.

5. Conclusions

This study's findings support the multidimensionality of hallucinatory-like experiences in a non-clinical sample. The multidimensional nature of HLEs vulnerability makes it unlikely that a single model could account for the complexity of these unusual subjective experiences. Models that hold for verbal hallucinations may not hold for visual hallucinations (e.g., [96]).

In our sample, high levels of psychological distress were found in only half of the individuals reporting significantly higher levels of hallucination-proneness. This suggests that even HLEs endorsed with certainty may not be necessarily associated with psychological distress. This finding can open the field to the investigation of the factors associated with resilience or coping mechanisms. Preliminary investigations in this area had suggested some psychological mechanisms that may protect against hallucination exacerbation [7,93,97–99]. However, it is important to note that HLEs can occur without apparent distress and without serious implication for the onset of mental illness [100–102]. Characterizing these experiences as pathological may be arbitrary, stigmatizing and unhelpful for those experiencing them [103].

Declaration of interest

None.

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