# Use of open-ended questionnaires to examine the effects of tinnitus and its relation to patient-reported outcome measures

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## Abstract

**Objective:** The primary aim of the study was to examine automated linguistic analysis of open-ended problem (PQ) and life-effects (LEQ) questionnaires to understand the psychological effects of tinnitus.

**Design:** The study used a cross-sectional design. Participants completed online questionnaires which included demographic questions, several standardized patient-reported outcome measures (PROMs), and two open-ended questions focusing on PQ and LEQ related to tinnitus. The response to open-ended questions were analyzed using the Linguistic Inquiry Word Count (LIWC) software to identify frequency of text on various linguistic dimensions relevant to tinnitus.

**Study Sample:** 336 individuals with tinnitus.

**Results:** The study results point to two broad findings. First, although PQ and LEQ have some similarities with PROMs (e.g., the linguistic dimension *negative emotions* having a weak positive correlation with anxiety and depression), no correlation with number of dimensions suggest that the open-ended questions identify additional elements that are not captured in PROMs. Second, more linguistic dimensions from the PQ correlate with PROMs compared to LEQ suggesting that the current PROMs are problem oriented.

**Conclusions:** The study results support the idea that use of open-ended questions in addition to PROMs may help optimize the efforts in examining the effects of chronic conditions such as tinnitus.

## Key Words

Tinnitus, Patient-reported outcome measures, Open-ended questions, Natural language processing, Text analysis, Linguistic analysis, Core outcome set

## Introduction

Tinnitus is a common problem affecting millions of people. Prevalence studies suggest that more than 10% of the general population experience tinnitus although this could range between 5 to 30% depending on the study population and inclusion criteria (Bhatt et al., 2016). It is noteworthy that not everyone is equally affected by tinnitus. Approximately 1 in 4 individuals

with tinnitus report their tinnitus as loud whereas less than 1 in 5 describe their tinnitus as disabling or nearly disabling (Kochkin et al., 2011). Moreover, even those who report disabling effects of tinnitus vary widely in terms of perception and reactions to tinnitus (Manning et al., 2019). The presence of tinnitus may affect various functions such as listening, concentration, sleep, emotional wellbeing and quality of life (Trevie et al., 2018; Elarbed et al., 2021). These findings have suggested that tinnitus is a highly heterogeneous condition both in terms of its intrusiveness and its effects on an individual's quality of life. Additionally, tinnitus may be triggered or exacerbated by a variety of otologic conditions or injuries, as well as by co-occurring mental health issues such as anxiety and depression. In addition, older adults with tinnitus also tend to report more distress.

The effect of tinnitus is generally assessed by administering standardized patient-reported outcome measures (PROMs) focusing on tinnitus severity as well as associated comorbidities (Husain et al., 2021). Tinnitus specific outcome measures such as Tinnitus Functional Index (TFI; Meikle et al., 2012) are used to assess the tinnitus severity. In addition, questionnaires such as Patient Health Questionnaire (PHQ-9; Kroenke et al., 2011) and/or Generalized Anxiety Disorders (GAD-7; Spitzer et al., 2006) are also used to measures constructs such as symptoms of depression and anxiety that often concern individuals with tinnitus and their providers. The main advantage of standardized measures is that they focus on elements pertinent to the population of interest, and are validated in ways that support generalizability and test-retest stability. In addition, they are ideal for comparisons within (change over time on same individual) and between individuals (e.g., comparing different individuals over time) as they pose identical items in all administrations. However, the limitations of structured measures is that not all items are applicable and/or considered important by all patients.

Open-ended questions are often used in research and also in clinical practice to assess effects of tinnitus. For example, open ended questionnaires has been used to examine tinnitus awareness (Gomersall et al., 2019), problems and difficulties experienced (Sanchez & Stephens, 1997; Tyler & Baker, 1983; Manchaiah et al., 2018a), patient experiences (Beukes et al., 2018a; McFerran et al., 2018), coping (Beukes et al., 2018b), and treatment related benefits (Andersson et al., 2001). Open-ended questions allow expression of patient views that may not be obtained

via structured measures (Manchaiah et al., 2018a). For this reason, use of open-ended items may be used as "add-on" questions in addition to structured PROMs (Stephens & Pyykkö, 2011).

The responses to open-ended questions are analyzed using qualitative methods such as content or thematic analysis (Graneheim &Lundman, 2004). These methods focus on identifying key meaning units and often involve analysis of a small number of subjects. However, modern text analysis softwares provide a means to quickly and accurately analyze the text responses to open-ended questions to gain insights to various social, psychological, and cognitive dimensions (Popping, 2015; Tausczik & Pennebaker, 2010). These methods can help identify important themes within the data using methods such as cluster analysis or automated content analysis. In addition, some of these softwares can also identify psychologically and linguistically meaningful categories. Using such analysis methods to examine natural language (i.e., words that people write and speak) may help identify important patient-related psychological dimensions including personalities, individual differences, social processes, and mental health (Boyd, 2017; Pennebaker & Graybeal, 2001; Tausczik & Pennebaker, 2010). This approach has however to our knowledge not been applied previously in tinnitus research.

The aim of the current study was to examine the use of open-ended questionnaires in evaluating the effects of tinnitus. The specific objectives included: (a) examining the linguistic aspects within the responses to problems and life-effects open-ended questions for individuals with tinnitus, and (b) examining the association between linguistic aspects identified from open-ended question with standardized PROMs.

## Method

### Study Design and Ethical Considerations

Ethical approval was obtained from the Institutional Review Board at Lamar University, Beaumont, Texas, USA (IRB-FY17-209). The study used a cross-sectional design. Participants included individuals with tinnitus who were registering to enroll in an Internet-based cognitive behavior therapy intervention study (Clinical Trials.gov registration no NCT04004260). Of the 440 people who initiated registration, 104 incomplete and/or Spanish-language respondents were removed; complete data from the remaining 336 participants were included in this study.

**Data Collection**

The data were gathered using online questionnaires which included: (a) demographic questions, (b) self-reported PROMs, and (c) open-ended questions. The standardized questionnaires included: TFI (Meikle et al., 2012) as a measure of tinnitus severity, GAD-7 (Spitzer et al., 2006) as a measure of anxiety, PHQ-9 (Kroenke et al., 2011) as the measure of depression, Insomnia Severity Index (ISI; Bastien et al., 2001) as the measure of insomnia, and the EQ-5D-5L (Rabin & de Charro, 2001), as the measure of general health-related quality of life. The two open-ended questions were focused on the problems and life effects caused as a result of tinnitus (Manchaiah et al., 2018a; Sanchez & Stephens, 1997) and were worded as below. No minimum word limit was set on the open-ended questions.

- Problem question (PQ): Make a list of difficulties, which you have as a result of your tinnitus. Write down as many as you can think of.
- Life effects question (LEQ): Make a list of the effects your tinnitus has on your life. Write down as many as you can think of.

**Data Analyses**

*Linguistic Analysis*

The Linguistic Inquiry Word Count (LIWC) software program was used to analyze the responses to open-ended questions (Pennebaker et al., 2015). LIWC is an automatic text analysis program which uses a word count approach to analyze the linguistic patterns in the text data. Using the built-in dictionary, the software counts and calculates the percentage of words in the dataset and provides the analysis in various emotional, cognitive, social and perceptual dimensions. The software can provide the output in more than 90 categories. However, not all the language dimensions are applicable to any specific study and/or population. In the current study, 12 linguistic variables relevant to tinnitus based on discussion among the research team were employed (three related to engagement and cognitive dimensions, three focused on social and emotional dimensions, four related to biological and perceptual dimensions, and two items identified personal concerns). The general mean values for these linguistic dimensions are provided in the LIWC handbook (Pennebaker et al., 2015). The general means could be seen as

baseline values for each linguistic dimension produced when analyzing the large text data taken from various sources. The resulting baseline values helps understand the typical percentage values in each of the linguistic dimensions studied.

The LIWC has high internal reliability and external validity (Pennebaker et al., 2015; Tausczik & Pennebaker, 2010), and has been extensively used in studies concerning natural language processing in various disciplines including social psychology and healthcare (for review see Tausczik & Pennebaker, 2010).

Only the responses with 10 words or more for PQ and LEQ were included in the linguistic analysis. This is because the LIWC software provides the results in percentages and responses with fewer words may skew the results. For example, a post with a single word "Annoying!" may result in a negative emotion score of 100%, which is not in line with the typical percentage (around 2%) for this category. Such a cutoff is a common convention when performing LIWC (Boyd, 2017).

*Statistical Analyses*

Shapiro-Wilk test results suggested that the data did not meet the assumption of normality. Mann-Whitney U tests was used to examine the difference in demographic and tinnitus related variables between those who provided 10 words or more for PQ and LEQ when compared to those who provided less than 10 words. Wilcoxon signed-rank test was used to examine the difference in linguistic analysis variables among PQ and LEQ. A significance level of .05 was used; all results were Bonferroni-adjusted to account for multiple comparisons. False Discover Rate (FDR) adjusted (alpha 0.05) Spearman's correlation coefficient was computed to examine association between linguistic analysis variables for open-ended questions and structured PROMs. The correlation results were interpreted as weak (values ranging 0 to 0.29), moderate (values ranging 0.3 to .69) and strong (values over 0.7). Spearman's correlation was performed using the R software "psych" package (Version: 3.6.3) and all other analyses were performed using the International Business Machines Corporation Statistical Package for Social Sciences – Version 20 software.

## Results

### Study Population

Of the 336 participants, 201 (59.8%) and 197 (58.6%) provided 10 words or more for PQ and LEQ, respectively. However, only 152 (45.2%) provided 10 words or more in both PQ and LEQ and were included for further analysis.

Table 1 presents the demographic details, tinnitus severity, and other comorbidities in the study sample. The mean age of the participants was 55.4 (SD=13.2) and 55.1 (SD=13) years for the full sample and the sub-sample (i.e., those who provided more than 10 words responses to PQ and LEQ), respectively. 54% of the participants in the full sample and 60.5% of the participants in the sub-sample were females. A majority of the participants were non-Hispanic (ethnicity) and white (race). The mean tinnitus severity scores based on TFI was 53.2 for the full sample and 54.9 for the sub-sample. Figure 1 (histogram) shows the distribution of TFI scores for the full sample as well as the sub-sample. The results suggest good spread of tinnitus severity in both samples (i.e., normal distribution), although participants in the sub-sample had tinnitus severity that had scores in the middle ranges.

Mann-Whitney U test results suggested that there is no difference in participants who provided open-text data with 10 or more words in PQ and LEQ when compared to those who provided less than 10 words in demographic variables such as age ($Z$=-.4, $p$=0.65) and duration of tinnitus ($Z$=-1.7, $p$=0.08) as well as on tinnitus related variables such as tinnitus severity ($Z$=-1.4, $p$=0.16), anxiety ($Z$=-1.2, $p$=0.24), depression ($Z$=-1.3, $p$=0.2), insomnia ($Z$=-.9, $p$=0.3), and quality of life ($Z$=-.4, $p$=0.6). These results suggested that there is no difference in tinnitus patients who engages in open-ended questions by providing good descriptions of their problems and life effects (i.e., 10 words or more) when compared to those who provide limited answers (i.e., below 10 words).

**Table 1: Demographic details (n=336), tinnitus severity and other comorbidities**

|  | All participants (n=336) | | Participants with 10 words or more in PQ and LEQ (n=152) | |
|---|---|---|---|---|
|  | Mean±SD | N (%) | Mean±SD | N (%) |
| Age (in years) | 55.4±13.2 |  | 55.1±13.0 |  |
| Duration of tinnitus (in years) | 12.7±13.4 |  | 11.6±12.7 |  |
| Gender |  |  |  |  |
| ▪ Male |  | 154 (45.8) |  | 60 (39.5) |
| ▪ Female |  | 182 (54.2) |  | 92 (60.5) |
| Ethnicity |  |  |  |  |
| ▪ Hispanic or Latino |  | 26 (7.7) |  | 13 (8.6) |
| ▪ Not-Hispanic or Latino |  | 310 (92.3) |  | 139 (91.4) |
| Race |  |  |  |  |
| ▪ American Indian/ Alaska Native |  | 1 (0.3) |  | 1 (0.7) |
| ▪ Asian |  | 7 (2.1) |  | 2 (1.3) |
| ▪ Native Hawaiian/ Other Pacific Islander |  | 0 (0) |  | 0 (0) |
| ▪ Black or African American |  | 9 (2.7) |  | 4 (2.6) |
| ▪ White |  | 307 (91.4) |  | 141 (92.8) |
| ▪ More than One Race |  | 12 (3.6) |  | 4 (2.6) |
| Education |  |  |  |  |
| ▪ Less than high school |  | 0 (0) |  | 0 (0) |
| ▪ High School |  | 32 (9.5) |  | 10 (6.6) |
| ▪ Some college but not degree |  | 101 (30.1) |  | 35 (23) |
| ▪ A university degree |  | 203 (60.4) |  | 107 (70.4) |
| Work |  |  |  |  |
| ▪ Entry level or unskilled work |  | 6 (1.8) |  | 2 (1.3) |
| ▪ Skilled or professional work |  | 203 (60.4) |  | 97 (63.8) |

| | | | |
|---|---|---|---|
| ▪ Retired | | 103 (30.7) | | 43 (28.3) |
| ▪ Not working | | 24 (7.1) | | 10 (6.6) |
| Hearing disability (self-reported) | | | | |
| ▪ I hear well | | 70 (20.8) | | 31 (20.4) |
| ▪ I have slight problems | | 125 (37.2) | | 61 (40.1) |
| ▪ I have moderate problems | | 39 (11.6) | | 21 (13.8) |
| ▪ I find it very hard to hear | | 28 (8.3) | | 10 (6.6) |
| ▪ I have great problems hearing | | 74 (22.0) | | 29 (19.1) |
| Tinnitus severity (TFI) | 53.2±20.1 | | 54.9±22.0 | |
| Anxiety (GAD-7) | 7.2±5.7 | | 7.5±5.6 | |
| Depression (PHQ-9) | 7.3±5.9 | | 7.7±5.9 | |
| Insomnia (ISI) | 11.3±6.8 | | 11.7±6.8 | |
| Quality of life (EQ-5D-5L) | 7.8±2.7 | | 7.9±2.9 | |
| Quality of life (EQ-5D-5L VAS) | 75.1±15.2 | | 75.4±13.2 | |

**Figure 1: Histogram of tinnitus severity based on Tinnitus Functional Index scores in the study sample**



Figure 1a: All participants (n=336)

Figure 1b: Included in linguistic analysis (n=152)
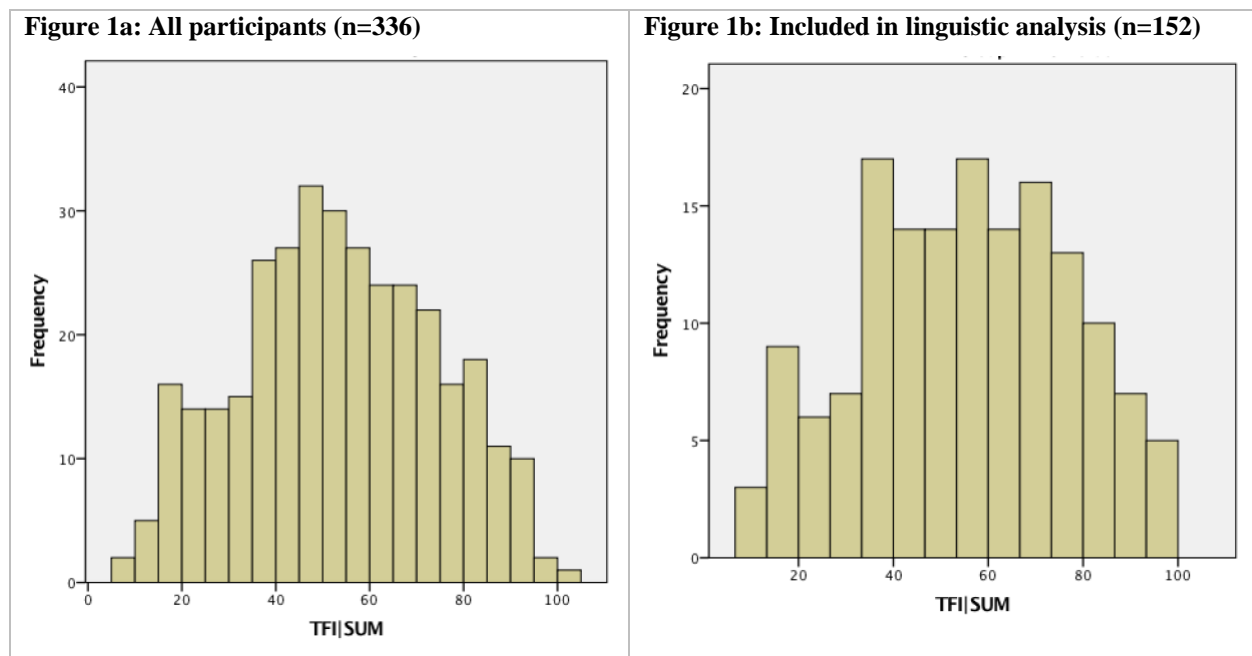
**Linguistic Dimensions in Problem and Life-Effects Questionnaires**

In the full sample, respondents on the PQ and LEQ used on average 18.1 (SD=19.6; Median=12) and 19.3 (SD=23; Median=12) words, respectively, and the difference was not statistically significant ($Z$=-.82, $p$=0.4). However, in the sample used for linguistic analysis (those who provided 10 or more words for open-ended questions), the mean words for PQ and LEQ were 29.1 (SD=22.9; Median=22) and 33.9 (SD=27.4; median=24), respectively and there was a statistically significant difference in number of words for these two questions ($Z$=-2.4, $p$=0.011).

Table 2 presents the linguistic analysis results for PQ and LEQ for the twelve key variables and the general means taken from the LIWC handbook (Pennebaker et al., 2015). Wilcoxon signed rank test results suggested that the linguistic analysis results of PQ and LEQ were significantly different in nine of the twelve key variables (see Table 2). PQ revealed significantly higher *analytical thinking* words when compared to LEQ whereas the LEQ has significantly higher number of I-words (e.g., I, me, mine) when compared to PQ. These results suggest that patients thought about their tinnitus in an impersonal way when asked about their problems, whereas they were likely to provide responses that were personally connected when asked about its effect on their lives. PQ elicited higher number of words on *social processes*, whereas LEQ elicited higher number of words on *negative emotions*, suggesting that PQ focuses more on individual social life whereas the LEQ revels the internal emotions as a result of having tinnitus. PQ elicited more words concerning *body, perceptual processes*, and *hearing* whereas LEQ resulted in higher number of words related to participants *health*. Finally, PE elicited more words related to personal concerns such as *leisurely activities* when compared to LEQ. These results suggest that PQ revels internal and external aspects of the individual (i.e., body, hearing, leisurely activities) whereas the LEQ help understand the perceptions about their own health. No significant differences were observed in number of words concerning dimensions *cognitive processes, position emotions*, and *work*. Overall, these results suggest that responses to PQ and LEQ produced different linguistic patterns as these questions captured different consequences of tinnitus.

**Table 2: Linguistic analysis results for the problem (PQ) and life-effects (LEQ) questionnaires.**

Note: Mean, Standard Deviations (SD), and Wilcoxon signed rank test are provided (significant differences are highlighted in bold). Also, general means on each of the linguistic variable based on the LIWC handbook (Pennebaker et al., 2015) are provided for comparison.

| Linguistic dimensions | General, Mean | PQ: Mean (SD) | LEQ: Mean (SD) | Wilcoxon signed rank test (LEQ-PQ): *Z*-value, *p*-value |
|---|---|---|---|---|
| **Engagement and cognitive processes** | | | | |
| **Analytical thinking:** The degree to which participants think about the topic in a detached professional way. | 56.34 | 67.1 (32.6) | 59.0 (33.3) | **-2.7, 0.006** |
| **I-words:** The degree to which participants use I-words (I, me, my), indicating when patients are looking inward and being self-reflective; I-words are correlated with honesty, anxiety, and self-consciousness. | 4.99 | 4.9 (5.1) | 7.5 (5.9) | **-4.7, <0.001** |
| **Cognitive processes:** The degree to which participants rely on cognitive terms (e.g., think, understand, because) to work through or convey their opinions. | 10.61 | 14.5 (9.0) | 15.7 (7.7) | -1.5, 0.1 |
| **Social and emotional dimensions** | | | | |
| **Social processes:** The degree to which participants think about the social connections they have with spouse or friends they are trying to talk with. | 9.74 | 8.9 (9.2) | 6.0 (7.4) | **-4.3, <0.001** |

| | | | | |
|---|---|---|---|---|
| **Positive emotions:** The degree to which participants express positive emotions. | 3.67 | 3.3 (4.4) | 2.3 (2.9) | -2.3, 0.02 |
| **Negative emotions:** The degree to which participants express negative emotions. | 1.84 | 3.6 (5.3) | 6.2 (6.7) | **-3.7, <0.001** |
| **Biological and perceptual dimensions** | | | | |
| **Body:** The degree to which participants talk about their body. | 0.69 | 2.6 (3.4) | 1.6 (2.8) | **-2.8, 0.006** |
| **Health:** The degree to which participants talk about their health. | 0.59 | 0.65 (1.9) | 1.8 (2.9) | **-4.3, <0.001** |
| **Perceptual processes:** The degree to which participants talk about their perceptual process such as seeing, hearing, or feeling. | 2.7 | 11.8 (8.2) | 7.2 (6.9) | **-6.2, <0.001** |
| **Hearing:** The degree to which participants talk about their hearing. | 0.83 | 9.7 (7.9) | 5.5 (6.1) | **-6.2, <0.001** |
| **Personal concerns** | | | | |
| **Work:** The degree to which participants refer to work. | 2.56 | 2.6 (4.7) | 1.9 (3.2) | -1.2, 0.25 |
| **Leisure:** The degree to which participants refer to leisurely activities. | 1.35 | 5.9 (7.5) | 2.7 (4.8) | **-4.9, <0.001** |

**Association Between Linguistic Dimensions of Open-ended Questions and PROMs**

Tables 3 contains the FDR adjusted (for multiple comparisons) Spearman's correlation showing the association between linguistic variables of PQ with the standardized PROMs. *I-words* had a weak negative correlation with insomnia and weak positive correlation with quality of life. *Cognitive processes* had a weak negative correlation with tinnitus severity. *Social processes* had a weak positive correlation with tinnitus severity. Surprisingly, *positive emotions* had a weak positive correlation with depression. This is because when participants answer was something like "Enjoying quiet time" for the PQ, the word "enjoying" was counted as positive emotions. Here, the LIWC was not taking the context of positive emotion word usage resulting in such

unexpected results. *Negative emotions* had weak positive correlation with anxiety and depression and a weak negative correlation with quality of life. *Body* had weak and moderate positive correlations with anxiety and insomnia, respectively. *Health* had a weak positive correlation with anxiety and depression. *Work* had a weak positive correlation with tinnitus severity and depression. Finally, *leisurely activities* had weak positive correlation with tinnitus severity.

**Table 3: Correlation between linguistic variable results for the problem question and the standardized patient reported outcome measures.**

|  | Tinnitus severity (TFI) | Anxiety (GAD-7) | Depression (PHQ-7) | Insomnia (ISI) | Quality of life (EQ-5D-5L) VAS |
|---|---|---|---|---|---|
| **Analytic thinking** | 0.11 | 0.04 | 0.02 | **0.17*** | -0.1 |
| **I-words** | -0.13 | -0.09 | -0.15 | **-0.19*** | **0.22**** |
| **Cognitive process** | **-0.16*** | -0.1 | -0.08 | -0.14 | 0.14 |
| **Social processes** | **0.25**** | 0.01 | 0.06 | 0.03 | 0.09 |
| **Positive emotions** | 0.15 | 0.04 | **0.17*** | 0.09 | -0.1 |
| **Negative emotions** | -0.06 | **0.23**** | **0.21**** | 0.01 | **-0.17*** |
| **Body** | 0.1 | **0.23**** | 0.15 | **0.32**** | -0.01 |
| **Health** | 0.15 | **0.27**** | **0.19**** | 0.09 | -0.13 |
| **Perceptual processes** | -0.04 | -0.04 | -0.09 | -0.02 | 0.03 |
| **Hear** | -0.05 | -0.06 | -0.1 | -0.04 | 0.002 |
| **Work** | **0.17**** | 0.11 | **0.16*** | 0.13 | -0.06 |
| **Leisure** | **0.22**** | 0.11 | 0.13 | 0.13 | -0.07 |

Table 4 presents the correlation between linguistic variables of LEQ with the standardized PROMs. *Positive emotions* had weak positive correlation with anxiety and insomnia. *Negative emotions* had weak positive correlation with anxiety and depression but weak negative correlation with quality of life. The linguistic dimensions health had a weak positive correlation with anxiety and depression. Overall, these results point to two broad findings. First, PQ and LEQ open-ended questions have some similarities with PROMs but they do identify elements

that are not captured in PROMs. Second, PQ has more relation with PROMs compared to LEQ suggesting that the current PROMs are problem oriented.

**Table 4: Correlation between linguistic variable results for the life effects question and the standardized patient reported outcome measures.**

| | Tinnitus severity (TFI) | Anxiety (GAD-7) | Depression (PHQ-7) | Insomnia (ISI) | Quality of life (EQ-5D-5L) VAS |
|---|---|---|---|---|---|
| **Analytic thinking** | -0.13 | -0.12 | -0.05 | 0.02 | -0.11 |
| **I-words** | 0.09 | 0.05 | 0.04 | -0.05 | 0.04 |
| **Cognitive process** | -0.06 | 0.04 | 0.05 | -0.03 | 0.05 |
| **Social processes** | 0.13 | -0.02 | 0 | -0.05 | 0.8 |
| **Positive emotions** | 0.15 | **0.25**\*\* | 0.13 | **0.23**\* | -0.03 |
| **Negative emotions** | 0.05 | **0.24**\*\* | **0.22**\*\* | 0.11 | **-0.27**\*\* |
| **Body** | 0.08 | 0.1 | 0.05 | 0.14 | -0.1 |
| **Health** | 0.09 | **0.22**\* | **0.21**\*\* | 0.1 | -0.1 |
| **Perceptual processes** | -0.04 | -0.03 | -0.07 | -0.12 | 0.07 |
| **Hear** | -0.06 | -0.08 | -0.11 | -0.19 | 0.06 |
| **Work** | -0.02 | -0.06 | 0.07 | 0.04 | -0.03 |
| **Leisure** | 0 | 0.002 | -0.03 | -0.09 | -0.04 |

## Discussion

The current study examined the use of "problem" and "life-effects" oriented open-ended questions in understanding a patient's perceived tinnitus effects. Automated word counting approach was used to identify linguistic patterns within the text data. In addition, the association between these linguistic dimensions identified from open-ended questions and standardized PROMs was examined. The following will highlight the main findings and implications.

**Linguistic Dimensions in Responses to Open-ended Questions**

Open-ended questionnaires are often used to examine the experiences, life effects and coping strategies used by individuals with tinnitus (Beukes et al., 2018a, 2018b; Manchaiah et al., 2018a; Sanchez & Stephens, 1997; Tyler & Baker, 1983; Watts et al., 2018). These studies have predominantly employed qualitative content analysis to examine the main themes within the data. However, in recent years, emerging text analysis softwares provide means to analyze the open-text responses in a quantitative way. For example, in a recent study Manchaiah et al. (2018b) used the topic-modelling approach to examine the main themes within newspaper articles and social media data about tinnitus. In another qualitative study, Watts et al. (2018) reported eighteen distinct domains of tinnitus-related problems including reduced quality of life, tinnitus-related fear, and constant awareness. In the current study, LIWC software analyzed the linguistic aspects within the open-ended PQ and LEQ. The median word count for PQ and LEQ was 12 words suggesting limited engagement of participants to answer the open-ended questions. This may be because participants have to perform more cognitive tasks (i.e., interpret and understand the question, think carefully about the responses, and have to come up with right words to describe the experiences) when compared to choosing one response from an option in structured questions (Schwarz, 1999).

There was no significant difference in the mean number of responses to PQ and LEQ which was consistent with the previous study that used these open-ended questions on a tinnitus population (Manchaiah et al., 2018a). That qualitative study used ICF classification to map the responses to PQ and LEQ and suggested that most of the problem and life effects experienced by those with tinnitus were related to body function (e.g., emotional function, sleep function, hearing function), followed by activity limitations and participation restrictions (e.g., socialization, handling stress and other psychological demands). Only a few responses related specifically to environmental and personal factors (Manchaiah et a., 2018a). However, the current study results suggested that using a quantitative approach to analyze the open text had some advantages as the differences in linguistic patterns among PQ and LEQ were clearer in this approach. For example, LEQ elicited more *individually concerned responses (i.e., I-words)*, *negative emotions* and words related to their *health*, whereas the PQ elicited responses with higher words concerning *analytical thinking, social processes, body, perceptual processes, hearing, work* and *leisurely activities*. These results suggested that LEQ provided more value regarding individual variation across tinnitus effects,

whereas PQ focused on common tinnitus problems that would facilitate comparisons of patients or patient groups.

It was interesting to note that *positive emotions* were positively correlated with anxiety, depression, and insomnia. Close examination of results revealed that this was because the participants were highlighting loss (or absence) of positive aspects in their life as a result of tinnitus when answering PQ and LEQ. Such reports are common when dealing with psychological conditions where people report absence of psychological aspects (Bakioğlu et al., 2020; Wood & Joseph, 2010). These results point to the fact that well-being is not simply the result of absence of negative aspects, but the presence of positive aspects. On the other hand, illness or disability is not just presence of negative aspects, but the lack of positive aspects in their life as a result of a condition.

**Association Between Linguistic Dimensions of Open-ended Questions and PROMs**
Standardized PROMs are most commonly used to examine the effects of various chronic conditions including tinnitus. Although, researchers and clinicians often use open-ended questions (e.g., "Any other comments") as add-on questions to the PROMs to obtain more in depth information on lived experiences (Stephens & Pyykkö, 2011), such patient responses are not always examined in the same way as PROM results (O'Cathain & Thomas, 2004); hence their associations with PROMs results are unknown. The current study suggests that the association between linguistic dimensions of open-text response with PROMs requires further investigation. For example, dimensions *work* in PQ were related to tinnitus severity and anxiety measured using PROMs. Also, the linguistic dimensions *negative emotions* and *health* in LEQ were related to anxiety and depression measured using PROMs. Surprisingly, we did not see any correlation with *I-words* and aspects such as anxiety and depression as we had anticipated a positive correlation between these variables based on results of a recent meta-analysis (Edwards & Holtzman, 2017). While the correlations noted were generally categorized as weak, it is noteworthy that the correlation between linguistic variables as well as with various psychological dimensions (e.g., anxiety, depression) are generally below 0.35 suggesting that correlations noted in the current study are rather good for the sample size used.

It is noteworthy that there was no correlation observed between various linguistic variables and the PROMs. These results suggest that open-ended questions may help capture aspects of tinnitus not examined using PROMs exclusively. In particular, open-ended questions may help identify effects of tinnitus specific to individual patients. For this reason, use of open-ended questions would be very useful when examining heterogeneous populations such as tinnitus (Manchaiah et al., 2018a). Moreover, using the responses to open-ended questions may help optimize the use of clinical and/or research data as such questions provide an ethical approach to obtaining and analyzing data offered in the patients' own words (O'Cathain & Thomas, 2004).

**Study Implications**

The current study has immediate theoretical and clinical implications. Theoretically, it is interesting to note that we can elicit similar knowledge about the impact of tinnitus as provided by PROMs from open-ended questions using quantitative analyses approach. Until now the responses to open-ended questionnaires were analyzed using time-intensive qualitative techniques whose findings are not generalizable. The current study results suggest that the automated linguistic analysis of response to open-ended questionnaires can be conducted quickly and in a meaningful way. This opens the opportunity to examine the open text responses of large representative tinnitus population to identify trends improve the ability to generalize results. Such an analysis can also be helpful when analyzing large textual data of conversations about tinnitus generated online especially in the social media platforms (Palacios et al., 2020; Manchaiah et al., 2018b). The study also demonstrated that some additional understanding of the chronic conditions such as tinnitus can be captured in open-ended questions and may have value both during clinical practice and in research. For this reason, using open-ended questions as "add-on" to routinely administered PROMs will be useful to gain in-depth understanding of the consequences of tinnitus (Beukes et al., 2018a; Manchaiah et al., 2018a; Stephens & Pyykkö, 2011). In addition, the current study results have implications towards measuring one or more of the core domains identified in the core outcome sets for tinnitus (Hall et al., 2018, 2019).

**Study Limitations and Future Directions**

The current study is to our knowledge the first to quantitatively analyze the open-text responses of tinnitus patients and to study their relation to standardized PROMs. A relatively large sample

and good distribution of tinnitus severity (see Figure 1) are the main study strengths. However, the study also has a few limitations. First, the study sample included those who were registering for an Internet-based intervention. This means the study participants were active Internet users and also self-selected themselves to enroll in the study. This may have introduced some sampling bias. Second, the questionnaires were administered in the same order which may have introduced some order effect. Third, the word counting approach such as LIWC works best when we have participants providing detailed description of their experiences. In the current study, the responses were limited to PQ and LEQ (median word count of 12) which may have skewed the calculation of percentages of linguistic dimensions. Future studies should consider participants to provide at least 50 to 100 words description to open-ended questions so that more meaningful interpretations can be drawn from them. Forth, word counting approach such as LIWC do not take context into account when analyzing the text data (Boyd, 2017; Pennebaker et al., 2015). For example, in this study the positive emotion words were positively correlated with depression. This is because when participants were reporting they are missing out on positive aspects of life as a result of their tinnitus the software was interpreting that as positive emotions rather than lack of positive emotions. For these reasons, the results should be interpreted with caution. Finally, the linguistic analysis in this study was limited to general dimensions based on the in-built LIWC dictionary. For these reasons, the current study results should be treated as preliminary, and more studies are needed before generalizing the findings.

In conclusion, future studies should consider identifying linguistic dimensions more relevant to tinnitus populations, such as coping and habituation and developing a custom dictionary to examine the linguistic patterns within the open-text responses of tinnitus patients. Future studies should examine whether changes in a patient's ability to manage tinnitus over time can be captured using open-ended questions and automated linguistic analysis of intervention-related texts. In addition, traditional qualitative analysis of data presented in this manuscript (e.g., Manchaiah et al., 2018a) may help identify some elements that may have been overlooked in the quantitative textual analysis.

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**Data Availability**

The data that support the findings of this study are openly available in Figshare at http://doi.org/10.6084/m9.figshare.13681924

**References**

Andersson G, Vretblad P, Larsen HC, Lyttkens L. Longitudinal Follow-up of Tinnitus Complaints. *Arch Otolaryngol Head Neck Surg.* 2001;127(2):175–179. doi:10.1001/archotol.127.2.175

Bastien, C. H., Vallières, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, 2(4), 297–307. https://doi.org/10.1016/s1389-9457(00)00065-4

Beukes, E.W., Manchaiah, V., Terlizzi, P.M., Baguley, D.M., Allen, P.M. & Andersson, G. (2018a). Situationally influenced tinnitus coping strategies: A mixed methods approach. *Disability and Rehabilitation*, 40(24), 2884-2894. https://doi.org/10.1080/09638288.2017.1362708

Beukes, E.W., Manchaiah, V., Valien, T., Baguley, D.M., Allen, P.M. & Andersson, G. (2018b). Positive experiences related to living with tinnitus: A cross-sectional survey. *Clinical Otolaryngology,* 43(2), 489-495. doi: 10.1111/coa.13002.

Bhatt, J. M., Lin, H. W., & Bhattacharyya, N. (2016). Prevalence, Severity, Exposures, and Treatment Patterns of Tinnitus in the United States. *JAMA Otolaryngology-- Head & Neck Surgery*, *142*(10), 959–965. https://doi.org/10.1001/jamaoto.2016.1700

Boyd R.L. (2017) Psychological Text Analysis in the Digital Humanities. In: Hai-Jew S. (eds) Data Analytics in Digital Humanities. Multimedia Systems and Applications. Springer, Cham

Edwards, T., & Holtzman, N. S. (2017). A meta-analysis of correlations between depression and first person singular pronoun use. *Journal of Research in Personality*, *68*, 63–68. https://doi.org/10.1016/j.jrp.2017.02.005

Elarbed, A., Fackrell, K., Baguley, D. M., & Hoare, D. J. (2021). Tinnitus and stress in adults: a scoping review. *International journal of audiology*, *60*(3), 171–182. https://doi.org/10.1080/14992027.2020.1827306

Gomersall, P. A., Baguley, D. M., & Carlyon, R. P. (2019). A Cross-Sectional Questionnaire Study of Tinnitus Awareness and Impact in a Population of Adult Cochlear Implant Users. *Ear and hearing*, *40*(1), 135–142. https://doi.org/10.1097/AUD.0000000000000601

Graneheim UH, Lundman B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse Educ Today, 24(2):105-12. doi: 10.1016/j.nedt.2003.10.001.

Hall, D. A., Smith, H., Hibbert, A., Colley, V., Haider, H. F., Horobin, A., Londero, A., Mazurek, B., Thacker, B., Fackrell, K., & Core Outcome Measures in Tinnitus (COMiT) initiative (2018). The COMiT'ID Study: Developing Core Outcome Domains Sets for Clinical Trials of Sound-, Psychology-, and Pharmacology-Based Interventions for Chronic Subjective Tinnitus in Adults. *Trends in hearing*, *22*, 2331216518814384. https://doi.org/10.1177/2331216518814384

Hall, D. A., Hibbert, A., Smith, H., Haider, H. F., Londero, A., Mazurek, B., Fackrell, K., & Core Outcome Measures in Tinnitus (COMiT) initiative (2019). One Size Does Not Fit All: Developing Common Standards for Outcomes in Early-Phase Clinical Trials of Sound-, Psychology-, and Pharmacology-Based Interventions for Chronic Subjective Tinnitus in Adults. *Trends in hearing*, *23*, 2331216518824827. https://doi.org/10.1177/2331216518824827

Husain, F. T., Chappell, J., & Tai, Y. (2021). An online survey study of the association between tinnitus and hyperacusis using validated questionnaires. *International journal of audiology*, 1–8. Advance online publication. https://doi.org/10.1080/14992027.2021.1953712

Kochkin S, Tyler R, Born J. (2011) MarkeTrak VIII: The Prevalence of Tinnitus in the United States and the Self-Reported Efficacy of Various Treatments. *Hearing Review*18(12):10-26.

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Manchaiah, V., Beukes, E.W., Granberg, S., Durisala, N., Baguley, D.M., Allen, P.M. & Andersson, G. (2018a). Problems and life effects experienced by tinnitus research study volunteers: An exploratory study using the ICF classification. *Journal of the American Academy of Audiology,* 29(10), 936-947. DOI: 10.3766/jaaa.17094

Manchaiah, V., Ratinaud, P., & Andersson, G. (2018b). Representation of Tinnitus in the US Newspaper Media and in Facebook Pages: Cross-Sectional Analysis of Secondary Data. *Interactive Journal of Medical Research*, *7*(1), e9. https://doi.org/10.2196/ijmr.9065

Manning, C., Thielman, E., Grush, L., & Henry, J. (2019). Perception versus reaction: comparison of tinnitus psychoacustic measures and Tinnitus Functional Index scores. *American Journal of Audiology, 28*, 174-180. doi:10.1044/2018_AJA-TTR17-18-004.

McFerran, D., Hoare, D.J., Carr, S. *et al.* Tinnitus services in the United Kingdom: a survey of patient experiences. *BMC Health Service Research,* 18**,** 110 (2018). https://doi.org/10.1186/s12913-018-2914-3

Meikle, M. B., Henry, J. A., Griest, S. E., Stewart, B. J., Abrams, H. B., McArdle, R., Myers, P. J., Newman, C. W., Sandridge, S., Turk, D. C., Folmer, R. L., Frederick, E. J., House, J. W., Jacobson, G. P., Kinney, S. E., Martin, W. H., Nagler, S. M., Reich, G. E., Searchfield, G., Sweetow, R., … Vernon, J. A. (2012). The tinnitus functional index: development of a new clinical measure for chronic, intrusive tinnitus. *Ear and Hearing*, *33*(2), 153–176. https://doi.org/10.1097/AUD.0b013e31822f67c0

O'Cathain, A., & Thomas, K. J. (2004). "Any other comments?" Open questions on questionnaires - a bane or a bonus to research?. *BMC Medical Research Methodology*, *4*, 25. https://doi.org/10.1186/1471-2288-4-25

Palacios G, Noreña A, Londero A. (2020). Assessing the Heterogeneity of Complaints Related to Tinnitus and Hyperacusis from an Unsupervised Machine Learning Approach: An Exploratory Study. Audiol Neurootol, 25(4), 174-189. doi: 10.1159/000504741

Pennebaker, J. W., & Graybeal, A. (2001). Patterns of natural language use: Disclosure, personality, and social integration. Current Directions in Psychological Science, 10(3), 90–93. https://doi.org/10.1111/1467-8721.00123

Pennebaker, J. W., Boyd, R. L., Jordan, K., & Blackburn, K. (2015). The development and psychometric properties of LIWC2015. Austin: University of Texas at Austin. https://doi.org/10.15781/ T29G6Z.

Popping, R. (2015). Analyzing open-ended questions by means of text analysis procedures. *Bulletin de Méthodologie Sociologique: BMS*, 128(1):23-39. DOI: 10.1177/0759106315597389

Rabin, R., & de Charro, F. (2001). EQ-5D: a measure of health status from the EuroQol Group. *Annals of Medicine*, *33*(5), 337–343. https://doi.org/10.3109/07853890109002087

Sanchez, L., & Stephens, D. (1997). A tinnitus problem questionnaire in a clinic population. *Ear and Hearing*, *18*(3), 210–217. https://doi.org/10.1097/00003446-199706000-00004

Schwarz, N. (1999). Cognitive research into survey measurement: Its influence on survey methodology and cognitive theory. In M. G. Sirken, D. J. Herrmann, S. Schechter, N. Schwarz, J. M. Tanur, & R. Tourangeau (Eds.), Cognition and Survey Research. New York: John Wiley and Sons.

Spitzer RL, Kroenke K, Williams JBW, Lowe B. (2006). A brief measure for assessing generalized anxiety disorder. *Arch Inern Med*, 166, 1092-1097

Stephens, D., & Pyykkö, I. (2011).How useful are 'add-on' questions in questionnaires? *Audiological Medicine*, 9, 47-49. https://doi.org/10.3109/1651386X.2011.558333

Tausczik, Y. R., & Pennebaker, J. W. (2010). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology*, 29(1), 24–54. https://doi.org/10.1177/0261927X09351676

Trevis, K., McLachlan, N., & Wlison, S. (2018). A systematic review and meta-analysis of psychological functioning in chronic tinnitus. *Clinical Psychology Review, 60*, 62-86.

Tyler, R. S., & Baker, L. J. (1983). Difficulties experienced by tinnitus sufferers. *The Journal of Speech and Hearing Disorders*, *48*(2), 150–154. https://doi.org/10.1044/jshd.4802.150

Watts, E. J., Fackrell, K., Smith, S., Sheldrake, J., Haider, H., & Hoare, D. J. (2018). Why Is Tinnitus a Problem? A Qualitative Analysis of Problems Reported by Tinnitus Patients. Trends in hearing, 22, 2331216518812250. https://doi.org/10.1177/2331216518812250