The Views And Experience Of Audiologists Working in Flemish Hearing Aid Centers
Concerning Cognition Within Audiological Practice

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ABSTRACT

**Purpose** This study aimed to get insight into the views and experience of audiologists, employed in Flemish hearing aid centers, concerning cognition within audiological practice.

**Method** An online 49-item questionnaire was developed and subdivided into five categories: (1) work setting, (2) practical experience regarding hearing aid fitting linked to cognition, (3) knowledge regarding the auditory-cognitive perspective of speech understanding, (4) willingness and guidelines to implement cognitive measures within audiological practice, and (5) demographics. Respondents were surveyed during January and February 2021.

**Results** One hundred twenty-nine audiologists working in Flemish hearing aid centers responded to the entire questionnaire and showed a mean work experience of 8.0 years. Results revealed that cognition was taken into account, especially within the anamnesis interview and general communication strategy, whereas only a minority took cognition into account when actually fitting hearing aids. Knowledge and experience did not determine whether or not respondents took cognition into account. A willingness to implement cognitive measures in a time efficient manner in audiological practice was observed among respondents.

**Conclusions** Evidence-based guidelines regarding hearing aid fitting based on an individual’s auditory-cognitive profile are needed to improve the quality of hearing rehabilitation.
INTRODUCTION

It is estimated that more than 60% of adults above the age of 70 are affected by hearing loss (Lin et al., 2011), with aging as the major cause (Haile et al., 2021). In addition to a decreased everyday speech communication, untreated age-related hearing loss (i.e. presbyacusis) can lead to social isolation, depression, loss of self-esteem, and can ultimately have long-term negative consequences in terms of general health and quality of life (CHABA, 1988; Dalton et al., 2003; Davis et al., 2021; Gates & Mills, 2005). These primary and secondary hearing-related consequences clearly emphasize the importance of audiological rehabilitation within older adults.

Audiological rehabilitation aims to improve quality of life by minimizing hearing loss-induced deficits affecting a listener’s functioning, activity, and participation (Meyer et al., 2016). In this respect, sensory management is a cornerstone within audiological rehabilitation (Tremblay & Backer, 2016). Sensory management is typically focused on providing access to sound and speech through the provision of a digital hearing aid (CHABA, 1988; Tremblay & Backer, 2016). It has been reported that approximately one-fifth of hearing aid users are unsatisfied, leading to non-usage (Abrams & Kihm, 2015). This non-usage might be related to hearing aid effectiveness which varies considerably across listeners, especially in difficult listening situations (Eurotrak, 2017; Knudsen et al., 2010). In clinical practice, digital signal processing features are mainly fitted based on the individual’s audiometric outcomes (Kollmeier & Kiessling, 2018). However, over the last decades, speech understanding has been considered a bidirectional phenomenon involving both bottom-up and top-down processing (Dryden et al., 2017; Mattys et al., 2012; Pichora-Fuller et al., 2016). In addition to the peripheral and central auditory system, high-level cognitive resources are utilized to understand speech, especially in adverse listening conditions. Specifically, selective attention, processing speed, working memory, and cognitive inhibition and flexibility were reported as important cognitive resources to understand speech, especially within hearing-impaired
elderly (Akeroyd, 2008; Dryden et al., 2017; Pichora-Fuller et al., 2016; Ronnberg et al., 2013). Possibly, incorporating an individual’s cognitive ability into the fitting of hearing aids could improve aided benefit, and consequently satisfaction (for reviews see Kestens et al., 2021; Lunner et al., 2009; Souza et al., 2015).

Within older adults, an increased probability of developing hearing impairment, resulting in less audible and distorted signals, is superimposed by age-related decrement in cognitive performances (Pichora-Fuller & Singh, 2006; Tremblay & Backer, 2016; Tun et al., 2012). The magnitude of these age-related changes in ear-brain structure and function show interindividual differences and may explain the observed variability in aided benefit across elderly. Hearing aid users with smaller cognitive capacities might be more susceptible to altered acoustic signals produced by specific hearing aid features (Kestens et al., 2021; Lunner et al., 2009; P. Souza et al., 2015). For example, fast-acting amplitude compression will result in greater distortion of the speech envelope compared to slow-acting amplitude compression. Hence, it was observed that hearing aid users with poorer cognitive functioning might perform better with slow-acting compared to fast-acting amplitude compression (Cox & Xu, 2010; Lunner et al., 2009).

This observed relationship between cognition and aided benefit coincides with the Ease of Language Understanding (ELU) model (Ronnberg et al., 2013). According to the ELU-model, a listener compares the incoming auditory speech signal to representations in the semantic long-term memory. Due to hearing loss, the incoming speech signal will be attenuated and degraded, resulting in a mismatch between the incoming signal and the representation in the semantic long-term memory. As a result, semantic and contextual cues, as well as more explicit and slower high-level cognitive processes need to be utilized to reconcile a match, and thus, to successfully understand the speech signal. This expended
attentional and cognitive effort used to understand speech is defined as listening effort
(Bourland Hicks & Tharpe, 2002; Pichora-Fuller et al., 2016).

Hearing aids partially compensate for the occurred mismatch within hearing-impaired elderly, resulting in improved speech understanding and decreased listening effort compared to the unaided condition (Kollmeier & Kiessling, 2018). However, the more a particular feature setting causes distortion of the speech signal (e.g. fast-acting compared to slow-acting amplitude compression), the greater the mismatch will be, which eventually might lead to a greater contribution of cognitive resources during aided speech understanding. In this respect, evidence-based recommendations for hearing aid fitting based on an individual’s auditory-cognitive need seem essential to optimize elderlies’ hearing aid benefit. Currently, hearing research has focused primarily on elucidating how cognition should be taken into account when fitting hearing aids. However, the views of audiologists regarding cognition within audiological practice have barely been subject of interest. As audiologists play a vital role in the rehabilitation process of hearing-impaired elderly, identifying their views and experience on this topic is considered essential.

Therefore, a questionnaire was developed aiming to get a better insight into (1) audiologists’ practical experience regarding hearing aid fitting linked to cognitive functioning, (2) the theoretical knowledge of audiologists regarding the auditory-cognitive perspective of speech understanding and listening effort, (3) audiologists’ willingness to implement cognitive testing within daily audiological practice, and (4) possible guidelines regarding the implementation of cognitive tests in daily audiological practice, suggested by audiologists. These findings may be relevant to determine strengths and weaknesses of the current hearing aid rehabilitation process. As such, important aspects to focus on in terms of professionalization of audiological practice might be uncovered which eventually will contribute in improving the quality of hearing rehabilitation in hearing-impaired elderly.
METHOD

The current study was approved by the local Ethics Committee and was conducted in accordance with the Helsinki Declaration. Prior to participation, an online informed consent was signed.

Questionnaire

A Dutch questionnaire was developed by the authors aiming to get a better insight into the views and experience of audiologists concerning cognition within audiological practice. The questionnaire included novel questions as well as adapted questions from a previous survey examining the knowledge of audiologists regarding cochlear implants (Chundu & Buhagiar, 2013) to better approach the needs of the current study. In the initial stage of development, an expert review of the 47-item questionnaire was conducted in which nine audiologists, all working with hearing-impaired elderly in Flemish hearing aid centers, evaluated whether the questionnaire was clearly written, the questions were relevant and complete, and whether the entire questionnaire could be completed within approximately 10 minutes. Based on the feedback of the expert panel, minor revisions were suggested, whereby some additional statements were added to the questionnaire. These statements were (1) “If cognition is found to have a significant link to hearing aid benefit I am willing to assess cognition only within specific patients (e.g., patients who I suspect and/or know are cognitively impaired),” and (2) “I suspect that the patient’s immediate environment will not object to cognitive testing being administered in audiological practice, when its usefulness is properly framed”.

The final questionnaire consisted of 49 items, subdivided into five categories: (1) work setting, (2) practical experience regarding hearing aid fitting linked to cognitive functioning, (3) knowledge regarding the auditory-cognitive perspective of speech understanding and
listening effort, (4) willingness and guidelines to implement cognition within audiological practice, and (5) demographics. The entire questionnaire could be completed in approximately 10 to 15 minutes. The original Dutch and English translated questionnaires are provided in Supplemental Digital Contents 1 and 2, respectively.

Work setting Seven questions (Q1 – Q7) evaluated audiologists’ professional situation with emphasis on years of experience, type of employment (i.e., working independently or within a clinic providing hearing aid services), and type and amount of patients fitted with hearing aids.

Practical experience Audiologists’ practical experience regarding hearing aid fitting linked to cognitive functioning was assessed by sixteen questions (Q8 – Q23). All questions had to be completed for adult patients with age-related hearing loss. The latter was instructed at the start of the questionnaire and was repeated within the subscript of each question.

The first eight questions (Q8 – Q15) focused on the anamnesis and particularly, how patients’ cognitive status and amount of listening effort are evaluated within daily practice, e.g. “I question listening effort in everyday situations literally during the anamnesis interview?”. Seven questions had to be answered on a four point Likert scale: never – sometimes – usually – always, whereas one was a yes-no question.

The following three questions (Q16 – Q18) focused on hearing aid fitting within cognitively-impaired patients. The term ‘cognitively-impaired’ had to be broadly interpreted, ranging from early symptoms of cognitive decline (e.g., forgetfulness, decreased speed of information processing, or absent-mindedness) to dementia, but did not include a low intelligence quotient (e.g., individuals with intellectual disabilities). This definition was provided within the questionnaire. First, respondents had to specify the ratio of the number of patients they know and/or suspect to be cognitively impaired to the number of patients having
a cognitively normal profile. Predefined ratios were given of which the participants had to select the most appropriate for his/her practice (e.g., 10% cognitively impaired, 90% normal cognitive profile). Second, it was interrogated if and how audiologists alter their general strategy (e.g., more involvement of significant others, slower speech rate, providing easier instructions, and etcetera) when fitting cognitively-impaired individuals by means of a multiple choice question. Third, the last question regarding hearing aid fitting included six statements that evaluated whether audiologists alter their strategy to fit specific hearing aid features (i.e., noise reduction, microphone directionality, amplitude compression, frequency compression, amplification, and manual programs) when working with cognitively-impaired individuals, e.g., “I fit noise reduction differently with patients who are cognitively impaired compared to cognitively stronger patients. For example: enabling/disabling noise reduction, adjusting the strength of the noise reduction system, and etcetera”. Each statement had to be answered with ‘yes’, ‘no’, or ‘do not know’. If respondents had chosen the answer ‘yes’, which indicated differences in fitting strategy, they could provide additional information to specify their answer.

The last five questions (Q19 – Q23) evaluated differences in hearing aid benefit between cognitively impaired and cognitively normal individuals. More specifically, it was questioned whether audiologists experience differences in the overall subjective (i.e., patients’ experience) and objective (i.e., test outcomes) hearing aid benefit between cognitively impaired and cognitively normal individuals. Moreover, differences in benefit between those two groups with a specific technology level as well as differences in motivation and the willingness to purchase hearing aids were assessed, e.g., “I feel that patients who are cognitively impaired benefit more from a higher technology level compared to cognitively stronger patients.”. All statements had to be answered with ‘yes’, ‘no’, ‘no difference’, or ‘do not know’.
Knowledge Ten statements (Q24 – Q33) assessed audiologists’ theoretical knowledge regarding the link between hearing loss, cognition, speech understanding, listening effort, and hearing aid benefit. Audiologists had to score their own knowledge on a visual analogue scale (VAS) ranging from 0 (no to limited knowledge) to 100 (very good knowledge). In addition, three multiple choice questions (Q34 – Q36) evaluated how audiologists had obtained their theoretical knowledge (e.g., congresses, internal training programs, and etcetera).

Willingness and guidelines Through two VAS (0 = no willingness, 100 = willingness) the willingness of audiologists to implement tests for cognition and listening effort within audiological practice was evaluated (Q37 – Q38). Moreover, audiologists’ opinion regarding practical aspects of such an implementation (i.e., type of cognitive tests, duration, and etcetera) was explored by five VAS, two multiple choice, and one open question (Q39 – Q46).

Demographics The last three questions (Q47 – Q49) asked audiologists’ sex, date of birth, and educational institution of the audiological studies.

Data collection

The questionnaire was disseminated online through the Research Electronic Data Capture (REDCap) surface. A link to the questionnaire was sent through email to Flemish audiologists, via a contact person within Flemish hearing centers or through professional associations for Belgian audiologists. Respondents were surveyed in January and February 2021. Solely respondents working in Flanders (i.e. the Flemish part of Belgium which contains six major regions: Antwerp, East Flanders, West Flanders, Flemish Brabant, Limburg, and Brussels Capital Region) were included. Respondents who did not complete the entire questionnaire or who had previously participated in the expert review were excluded.

Statistics
Statistical analysis was performed using IBM SPSS version 24. Descriptive parameters were established for all questionnaire outcomes. To reliably process open answers (e.g., some questions had the option to specify an answer), two investigators independently developed categories and attributed each answer to a specific category. Afterwards, the attribution of each open answer to a specific category was compared. In 2.4% of the cases, disagreement between the two investigators appeared. In these cases, a third investigator was assigned to determine the final category.

Furthermore, the relationship between some questions was assessed. First, it was investigated if years of experience determined whether or not audiologist take cognition into account when fitting specific hearing aid features (six statements of Q18). In this respect, the continuous variable ‘years of experience’ was transformed into an ordinal variable. Values equal or below the median (i.e. ≤ 5.5 years) were labeled as ‘little experience’ whereas values above the median (i.e. > 5.5 years) were labeled as ‘much experience’. As such, six 2x3 chi-square test of independence were performed between experience (little or much) and the answers (yes, no, I do not know) given to each statement regarding hearing aid fitting. The assumption that all expected cell frequencies were greater than five was checked and met (Statistics, 2016). A p-value of 0.05 was considered as criterion of statistical significance. In case of a statistically significant association, Cramer’s V was used as a measure of effect size (Statistics, 2016) and interpreted using the Cohen’s guidelines, i.e. small (0.10 – 0.29), medium (0.30 – 0.49), or large (≥ 0.50) effect size (Cohen, 1988). Subsequently, post hoc testing was performed using adjusted standardized residuals (Statistics, 2016).

Second, similar analyses were conducted to evaluate whether the amount of knowledge determined if audiologist take cognition into account when fitting specific hearing aid features. In this respect, a compound knowledge score was calculated by averaging the VAS-scores of all ten knowledge related statements (Q24 – Q33). Subsequently, this
continuous compound score was changed into an ordinal variable. Values equal or below 50 on the VAS were labeled as ‘little knowledge’ whereas values above 50 were labeled as ‘much knowledge’. As such, six 2x3 chi-square test of independence could be performed between knowledge (little or much) and the answers (yes, no, I do not know) given to each statement regarding hearing aid fitting. The procedure to conduct chi-square analyses is identical as previously described.

Last, the relationship between two continuous variables, years of experience and theoretical knowledge (Q24 – Q33), was assessed by means of Spearman correlation coefficients. To interpret these coefficients the following guidelines were used: a weak correlation for values between 0.00 - 0.29, a moderate correlation for values between 0.30 - 0.49, and a strong correlation for values greater than 0.50 (Cohen et al., 2013). A p-value of 0.05 was considered as criterion of statistical significance.

RESULTS

Work setting and demographics

One hundred twenty-nine Flemish audiologists working in hearing centers (119 females and 10 males) responded to the entire questionnaire and showed a mean work experience of 8.0 years (standard deviation (SD): 6.7 years, range: 3 months to 31.4 years).

The majority (92.2%) reported working in a clinic that provides hearing aid services, whereas 7.8% reported working as an independent audiologist. Respondents were employed in Antwerp (23.4%), East Flanders (22.1%), West Flanders (21.4%), Flemish Brabant (17.5%), Limburg (12.3%), and Brussels Capital Region (3.1%).

Adults were the most frequent patient group treated by the respondents (mean (SD) ratio: 96.2% (8.1) adults versus 3.8% (8.1) children), and in particular adults with moderate age-related hearing loss (mild hearing loss: 22.6%, moderate hearing loss: 56.6%, severe
hearing loss: 16.5%, profound hearing loss: 5.1%). As presented in Table 1, the respondents
tested and fitted numerous hearing-impaired adults who registered for the first time within the
hearing center on an annual basis (i.e., later denoted as new patients).

**Practical experience**

**Anamnesis** All respondents evaluated patients’ cognitive status and amount of
listening effort during an anamnesis interview. Specifically, information regarding the
cognitive status was indirectly inferred from the anamnesis interview by all respondents
(always: 10.9%, usually: 62.0%, sometimes: 27.1%, never: 0.0%), whereas only few directly
questioned patients’ cognitive status through questioning (always: 3.9%, usually: 9.3%,
sometimes: 41.9%, never: 45.0%) or screening (yes: 2.3%, no: 97.7%). Furthermore, relevant
information regarding patients’ cognitive status was sometimes reported by significant others
(always: 1.6%, usually: 30.2%, sometimes: 67.4%, and never: 0.8%). Most of the respondents
were confident in recognizing cognitively impaired patients (always: 3.9%, usually: 70.5%,
sometimes: 25.6%, never: 0.0%). Information regarding listening effort was indirectly
inferred from the anamnesis interview by all respondents (always: 9.3%, usually: 49.6%,
sometimes: 41.1%, never: 0.0%), whereas most but not all respondents also directly
interrogated patients’ listening effort through questioning (always: 16.3%, usually: 36.3%,
sometimes: 41.9%, never: 5.4%).

**Hearing aid fitting** All respondents indicated working with cognitively impaired
patients, whereby most respondents estimated that approximately 11 to 20% of their patients
are cognitively impaired (0-10% cognitively impaired patients: 10.1%, 11-20% cognitively
impaired patients: 43.4%, 21-30% cognitively impaired patients: 35.7%, 31-40% cognitively
impaired patients: 10.9%). When working with these (known or suspected) cognitively
impaired patients, all respondents altered their general strategy by involving a significant
other (98.4%), providing easier instructions (96.9%), speaking more slowly (79.1%), using
more visual instructions (70.5%), providing more time for a consult (67.4%), using more
goalie hearing tests (47.3%), and using easier word lists for speech audiometry (13.2%). Few respondents (5.4%) indicated to alter their general strategy by also performing other aspects than those given within the multiple choice options such as additional repeating of instructions and counseling regarding expectations.

Most respondents did not take cognition into account when fitting specific digital hearing aid features such as noise reduction (yes: 31.8%, no: 54.3%, do not know: 14.0%), microphone directionality (yes: 34.1%, no: 55.8%, do not know: 10.1%), amplitude compression (yes: 30.2%, no: 59.7%, do not know: 10.1%), frequency compression (yes: 10.9%, no: 80.6%, do not know: 8.5%), or amplification (yes: 38.8%, no: 53.5%, do not know: 7.8%). In addition, the amount of manual programs in the hearing aid was diminished within cognitively impaired individuals by most of the respondents (yes: 67.4%, no: 31.0%, do not know: 1.6%).

Within the group of respondents that indicated to alter their fitting strategy within cognitively impaired individuals, the majority of the respondents specified their answer (average response rate of 95.2%). All answers were attributed to a specific category. As presented in Table 2, diverse methods to take cognition into account were described by the respondents. Nevertheless, some small trends were observed. Specifically, within cognitively impaired individuals most audiologists (1) set noise reduction more strongly, (2) used identical directional microphone settings in each listening condition, (3) preferred slow-acting amplitude compression, (4) only exceptionally activated frequency compression, (5) built-up gain more slowly, and (6) did not add additional hearing aid programs.

To investigate if years of experience determined whether or not audiologist take cognition into account when fitting specific hearing aid features, six 2x3 chi-square tests of independence were performed. There was no statistically significant association between
years of experience (mean (SD): 8.0 years (6.7 years)) on the one hand and the fitting strategy regarding noise reduction ($X^2(2) = 3.996$, $p = 0.136$), microphone directionality ($X^2(2) = 2.413$, $p = 0.229$), frequency compression ($X^2(2) = 0.523$, $p = 0.770$), amplification ($X^2(2) = 0.087$, $p = 0.958$), and the amount of manual programs ($X^2(2) = 3.883$, $p = 0.143$) within cognitively impaired individuals on the other hand. Nevertheless, a statistically significant association between years of experience and the fitting strategy of amplitude compression was found ($X^2(2) = 6.710$, $p = 0.035$). This association, small in effect size (Cramer’s value of 0.228), showed that respondents with more work experience were more likely to adapt the way they fitted amplitude compression within cognitively impaired individuals. In which way they did, differed across respondents.

Hearing aid benefit The majority of the participants indicated less hearing aid benefit, both subjective (less benefit: 32.6%, no difference: 29.5%, higher benefit: 12.4% do not know: 25.6%) and objective (less benefit: 35.7%, no difference: 30.2%, higher benefit: 8.5% do not know: 25.6%) for cognitively impaired compared to cognitively normal individuals.

Regarding the hearing aid technology level in specific, no difference between both groups was indicated by most respondents (more benefit with a higher technology level: 16.3%, more benefit with a lower technology level: 25.6%, no difference: 38.8%, do not know: 19.4%).

Last, most respondents did not point out differences in motivation (more motivated: 6.2%, less motivated: 35.7%, no difference: 48.8%; do not know: 9.3%) or the willingness to purchase hearing aids (less withdrawal: 16.3%, more withdrawal: 27.1%, no difference: 48.8%, do not know: 7.8%) between both groups.

Knowledge

A detailed description of all knowledge-related statements is presented in Table 3. All statements were completed within almost the entire range of the VAS (0: no or limited knowledge, 100: very good knowledge). On average, the respondents evaluated their
knowledge regarding the auditory-cognitive perspective of speech understanding and listening effort as intermediate. Strikingly, knowledge regarding tests to measure cognition and/or listening effort was evaluated the lowest out of all statements. The acquired knowledge was obtained from courses taught at the audiological educational program (70.5%), internal trainings within the hearing center (36.4%), scientific research articles (27.2%), (inter)national congresses (23.3%), or webinars (8.6%).

For none of the statements, a statistically significant relationship between respondents’ knowledge and experience was found, as indicated by non-significant (p > 0.05) Spearman correlation coefficients. Moreover, respondent’s knowledge did not determine whether or not audiologists take cognition into account when fitting specific hearing aid features, determined by non-significant (p > 0.05) chi-square results for each individual feature setting.

**Willingness and guidelines**

Based on the VAS results (0 = no willingness, 100 = willingness), respondents showed willingness to implement cognition in audiological practice (mean (SD) = 66.50 (22.35)), but mostly when cognitive testing should only be conducted in specific patient populations such as cognitively impaired individuals (mean (SD) = 82.77 (21.03)). Respondents were somewhat more reluctant to evaluate cognition within each individual patient. Approximately half of the respondents were concerned implementing cognition within audiological practice because (1) it might be a reluctant factor purchase hearing aids (50.4%), (2) they are scared of unpleasant reactions from patients after describing cognitive results (48.1%), and (3) it does not seem possible timewise (42.6%).

Collaboration with other disciplines (e.g. neuropsychology) and an internal training were reported as important factors before audiologists can implement cognition into the hearing aid fitting procedure. Moreover, implementing cognitive testing within audiological
practice was preferred to take not more than ten minutes on average (SD: 5.3, range: 2 – 30).

Respecting this time limit, most respondents indicated implementing cognitive testing by means of (1) an amnestic interview (66.7%), a questionnaire (71.3%), a screening test (79.8%), or one specific cognitive test such as a working memory test (59.7). Only few respondents were willing to implement two (8.5%) or more (1.6%) cognitive tests.

**DISCUSSION**

Within the past decades, hearing research prioritized unravelling the auditory-cognitive perspective of speech understanding and formulating evidence-based guidelines for hearing aid fitting based on the auditory-cognitive needs of the hearing aid user (Kalluri & Humes, 2012; Kestens et al., 2021; Ronnberg et al., 2013). As audiologists play a vital role in the rehabilitation process of hearing-impaired elderly, identifying their views and experience on this topic was considered essential and might contribute in improving the quality of hearing rehabilitation in hearing-impaired elderly. In this respect, the current study was the first to explore the views and experiences of audiologists concerning cognition within audiological practice by means of a newly developed non-validated questionnaire. Nevertheless, in a later stage, when the questionnaire would be used to, for example, evaluate the knowledge of audiologists before and after a training to conduct hearing aid fitting based on the auditory-cognitive needs of the hearing aid user, a validated questionnaire should be used with clearly defined and validated subscales.

**Work setting and demographics**

A large number of audiologists filled in the entire questionnaire. The exact response rate of the current questionnaire, however, could not be calculated since the exact number of employed audiologists working in Flemish hearing aid centers is unknown. The majority of the respondents reported working within a clinic providing hearing aid services, which was not surprising as most Flemish hearing aid clinics are part of a bigger hearing aid company.
Overall, the respondents indicated working with hearing-impaired elderly of which some showed cognitive impairment.

The majority fitted less than 100 new patients with presbyacusis on an average annual basis, which was the lowest answer option. As this question solely focused on new patients, existing patients were not included. Likely, even more patients are yearly treated by the respondent and thus respondents were considered as highly experienced with the target group of this study. In further research, however, this question should be revised by for example providing more answer options or by including all (i.e. new and existing) treated patients.

Regarding the cognitive status, the term ‘cognitively impaired’ had to be broadly interpreted ranging from early symptoms of cognitive decline to dementia. Consequently, it was unknow if respondents filled in the questionnaire based on their experience with patients showing mild cognitive impairment or dementia and thus, the influence of the degree of cognitive impairment could not be taken into account.

Practical experience

Positively, audiologists take cognition into account in their daily practice. How this is considered, differs across the different phases within the hearing aid fitting procedure. Within the anamnestic interview, patients’ cognitive status and amount of listening effort are standardly evaluated. Notably, information on the cognitive status was mostly indirectly inferred, whereas listening effort was more directly questioned. Audiologists seem thus to be more reluctant to directly question patients’ cognitive status, which might be related to the sensitivity of the topic. When working with (known or suspected) cognitively impaired patients, all audiologists alter their general communication strategy. Specifically, diverse strategies (e.g., slower speaking rate, using more visual instructions, and etcetera) are used to facilitate information transfer and thus communication.
Regarding the hearing aid fitting itself, only the minority takes cognition into account when fitting specific digital hearing aid features. This observation was not surprising. Although hearing research already revealed a relationship between cognition and aided benefit (Kestens et al., 2021; Lunner et al., 2009; Pamela Souza et al., 2015), concrete evidence-based guidelines regarding hearing aid fitting based on the auditory-cognitive needs of the hearing aid user are still lacking. With some caution, however, previous research suggested that hearing aid users with smaller cognitive capacities might be more susceptible to altered acoustic signals produced by specific hearing aid features (Lunner et al., 2009), and thus, that those hearing aid users derived more aided benefit from hearing aid settings facilitating the matching process between the incoming auditory signal and representations stored in long-term memory (Kestens et al., 2021). The strategies that were mostly reported by the respondents that alter their fitting strategies within cognitively impaired individuals coincides these research outcomes. However, it cannot be ignored that, in general, very diverse strategies were reported by the respondents in this study. Hence, it was suggested that audiologist primarily rely on their intuition when fitting hearing aids in cognitively impaired individuals. Likewise, experience and knowledge did not determine whether or not cognition is considered within the fitting procedure. Hence, these results highlight the importance of constructing evidence-based guidelines.

Regarding the overall benefit with a hearing aid, it was unclear whether cognitively impaired individuals show less, equal, or more benefit compared to cognitively normal individuals. This observed ambiguity in responses is in agreement with previous research in which equivocal results were found regarding both objective and subjective hearing aid benefit in relation to cognition (e.g. Dawes & Munro, 2017; Lopez-Poveda et al., 2017; Tognola et al., 2019). Within the current study, the term hearing aid benefit was not specified and might therefore be interpreted differently across respondents. With overall hearing aid
benefit, the difference in performances between aided and unaided was intended. However, aided benefit might be confused with aided performance which can significantly have affected respondents’ answers. According to the ELU-model (Ronnberg et al., 2013), speech understanding in noise evolves the contribution of both the auditory and cognitive system. Hence, it was suggested that individuals with better cognitive functions will show better aided speech-in-noise performances (Dryden et al., 2017; Yumba, 2019). However, when considering hearing aid benefit instead of performances the opposite was suggested (Kestens et al., 2021). Specifically, hearing aid users with poorer cognitive functions are expected to utilize more of their cognitive capacity to understand speech in noise compared to hearing aid users with better cognitive functions. The difference between aided and unaided performances was therefore expected to be more favorable for hearing aid users with poorer cognitive functions. Also, because aided benefit was not defined, respondents could have answered in terms of several hearing aid outcomes such as speech understanding or listening effort. On the positive side, objective and subjective aided benefit were separately interrogated as previous research found differences between those measurements (e.g. Lopez-Poveda et al., 2017; Tognola et al., 2019).

No clear difference in motivation, benefit with a specific hearing aid technology level, or willingness to purchase a hearing aid between cognitively impaired and cognitively normal individuals was indicated by most of the respondents. To the best of our knowledge, limited research regarding these topics have been performed, though a link between those aspects might be expected.

Knowledge

Respondents scored their theoretical knowledge regarding the auditory-cognitive perspective of speech understanding and listening effort as intermediate. Moreover, knowledge did not show any relationship with years of experience and whether or not
respondents take cognition into account when fitting hearing aids. The lack of relationship might be related to the manner knowledge was examined. On the one hand, a compound knowledge score was calculated by averaging VAS scores which might not be the most appropriate method. On the other hand, knowledge was only subjectively assessed by means of respondents’ opinion. No test was performed to actually determine respondents’ theoretical knowledge. Hence, the obtained subjective scores might differ from their actual acquired theoretical knowledge, which in turn, might explain the lack of relationship. Also, the lack of relationship might be related to the aforementioned suggestion that respondents primarily use their intuition when fitting hearing aids in cognitively impaired individuals. In this respect, more effort should be given to educate audiologists regarding new scientific insights regarding the auditory-cognitive perspective of speech understanding.

**Willingness and guidelines**

Positively, respondents showed willingness to implement cognition in audiological practice, but mostly when cognitive testing should only be conducted in specific patient populations such as cognitively impaired individuals. Respondents major concerns to implement cognition into daily audiological practice are mainly related to the sensitivity of the topic and time efficiency.

**Priorities for research and clinical practice**

Despite the influence of cognition in audiological practice is noted by audiologists, internationally accepted guidelines to conduct hearing aid fitting based on the auditory-cognitive profile of the individual hearing aid user are lacking. Nevertheless, such guidelines could significantly improve the quality of hearing rehabilitation in hearing-impaired elderly. In this respect, some key priorities for research and clinical practice are summarized here.
Once the cognitive functions underlying speech understanding and listening effort are identified, it should be evaluated which cognitive tests, either alone or in combination, are most suitable for implementation in daily audiological practice, taken into account time efficiency. There are a large number of potentials cognitive tests but few have been sufficiently standardized for usage in audiological practice. Among other things, research should focus on assessing the ecological validity of cognitive tests to determine how well they correlate with listener’s everyday experience. Subsequently, it should be examined whether aided benefit is related to the user’s auditory-cognitive profile, so that eventually, evidence-based guidelines could be formulated and thus, existing hearing aid interventions could be reframed. In this respect, training should be provided to educate audiologists these newly developed guidelines as well as to provide guidance to confidently discuss cognitive aspects with patients. In addition, awareness regarding the effectiveness of implementing cognition within audiological practice should be provided to the broader public. Before achieving these long-term goals, it remains important to regularly share in-between research outcomes across an interprofessional audience (e.g., audiologists, psychologists, geriatricians, or nose-throat-ear specialists).

**Conclusion**

Hearing aids are the primary audiological rehabilitation devices to compensate for presbyacusis, though different results regarding aided performances are documented. Within older adults, the magnitude of age-related changes in ear-brain structure and function show interindividual differences which may explain the observed variability in aided benefit across elderly.

Flemish audiologists take cognition into account within audiological practice, especially within the anamnesis interview and their general communication strategy, whereas only a minority takes cognition into account when actually fitting hearing aids. Hence,
evidence-based guidelines regarding hearing aid fitting based on an individual’s auditory- 
cognitive profile are needed as they might improve the quality of hearing rehabilitation.

Conflicts of interest

None to report.

Acknowledgements

A sincere thanks to all contact persons of the Flemish hearing centers and professional 
associations for Belgian audiologists to distribute the questionnaire as well as to all Flemish 
audiologists for responding. Last, the authors would like to thank Freya De Meuleneire for her 
willingness to contribute in the recruitment of audiologists for the expert review as well as to 
assist with data input.
REFERENCES


Table Legends

Table 1: The amount of participants (%) that answered a specific response to questions five and seven regarding the amount of patients tested and fitted with hearing aids, respectively.

Table 2: Reported methods to alter fitting strategies within cognitively impaired hearing aid users. The percentage indicated how many respondents used that specific strategy, but solely within the group of respondents taking cognition into account.

Table 3: Detailed description (mean, standard deviation (SD), and range) of all knowledge-based statements. Each statement had to be answered on a visual analogue scale ranging from 0 (no to limited knowledge) to 100 (very good knowledge).
Table 1: The amount of participants (%) that answered a specific response to questions (Q) five and seven regarding the amount of patients tested and fitted with hearing aids, respectively.

Q5 Specify how many new adult patients with age-related hearing loss you test on an average annual basis (regardless of whether they were subsequently fitted with hearing aids). New clients do not mean existing clients, but only first-time applicants. This may be a rough estimate. Please specify this for you personally and not for the entire hearing center.

<table>
<thead>
<tr>
<th>Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>30.2%</td>
</tr>
<tr>
<td>Between 100 and 150</td>
<td>31.8%</td>
</tr>
<tr>
<td>Between 150 and 200</td>
<td>23.3%</td>
</tr>
<tr>
<td>Between 200 and 250</td>
<td>9.3%</td>
</tr>
<tr>
<td>More than 250</td>
<td>5.4%</td>
</tr>
</tbody>
</table>

Q7 Specify how many of these new adult patients with age-related hearing loss you have fitted with bilateral hearing aids on an average annual basis, leading to the purchase of hearing aids. This may be a rough estimate. Specify this for you personally and not for the entire hearing center.

<table>
<thead>
<tr>
<th>Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>54.3%</td>
</tr>
<tr>
<td>Between 100 and 150</td>
<td>39.5%</td>
</tr>
<tr>
<td>Between 150 and 200</td>
<td>6.2%</td>
</tr>
<tr>
<td>Between 200 and 250</td>
<td>0.0%</td>
</tr>
<tr>
<td>More than 250</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Table 2: Reported methods to alter fitting strategies within cognitively impaired hearing aid users. The percentage indicated how many respondents used that specific strategy, but solely within the group of respondents taking cognition into account (n).

<table>
<thead>
<tr>
<th>Noise reduction (n = 41)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stronger noise reduction settings</td>
<td>89.7%</td>
</tr>
<tr>
<td>Weaker noise reduction settings</td>
<td>2.6%</td>
</tr>
<tr>
<td>Noise reduction settings that automatically adapt to listening conditions</td>
<td>5.1%</td>
</tr>
<tr>
<td>Identical noise reduction settings in each listening condition</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Microphone directionality (n = 44)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Directional microphone</td>
<td>26.2%</td>
</tr>
<tr>
<td>Omnidirectional microphone</td>
<td>14.3%</td>
</tr>
<tr>
<td>Microphone directionality that automatically adapts to listening conditions</td>
<td>16.7%</td>
</tr>
<tr>
<td>Identical directional microphone setting in each listening condition</td>
<td>42.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amplitude compression (n = 39)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher compression ratio</td>
<td>5.6%</td>
</tr>
<tr>
<td>Lower compression ratio</td>
<td>16.7%</td>
</tr>
<tr>
<td>Slower attack and release times</td>
<td>58.3%</td>
</tr>
<tr>
<td>Faster attack and release times</td>
<td>2.8%</td>
</tr>
<tr>
<td>Higher maximal power output</td>
<td>2.8%</td>
</tr>
<tr>
<td>Lower maximal power output</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency compression (n = 14)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No frequency compression</td>
<td>25.0%</td>
</tr>
<tr>
<td>Exceptionally activation of frequency compression</td>
<td>41.7%</td>
</tr>
<tr>
<td>Stronger frequency compression</td>
<td>25.0%</td>
</tr>
<tr>
<td>Slower attack and release times</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amplification (n = 50)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>More gain</td>
<td>13.3%</td>
</tr>
<tr>
<td>Less gain</td>
<td>17.8%</td>
</tr>
<tr>
<td>Slower build-up of gain</td>
<td>60.0%</td>
</tr>
<tr>
<td>Faster build-up of gain</td>
<td>8.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manual programs (n = 87)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No manual programs</td>
<td>67.4%</td>
</tr>
<tr>
<td>Limited manual programs</td>
<td>32.6%</td>
</tr>
</tbody>
</table>
Table 3: Detailed description (mean, standard deviation (SD), and range) of all knowledge-based statements. Each statement had to be answered on a visual analogue scale ranging from 0 (no to limited knowledge) to 100 (very good knowledge).

<table>
<thead>
<tr>
<th>Question</th>
<th>mean</th>
<th>SD</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q24 How do you rate your knowledge of cognition?</td>
<td>52.47</td>
<td>20.00</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Q25 How would you rate your knowledge about the link between cognition and speech understanding?</td>
<td>51.43</td>
<td>20.60</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Q26 How would you rate your knowledge of the link between cognition and age-related hearing loss?</td>
<td>52.06</td>
<td>20.09</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Q27 How would you rate your knowledge of the link between cognition and the hearing aid benefit?</td>
<td>48.25</td>
<td>21.68</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Q28 How would you rate your knowledge of listening effort?</td>
<td>57.60</td>
<td>18.14</td>
<td>0 – 95</td>
</tr>
<tr>
<td>Q29 How do you rate your knowledge about the link between cognition and listening effort?</td>
<td>51.16</td>
<td>19.48</td>
<td>0 – 85</td>
</tr>
<tr>
<td>Q30 How would you rate your knowledge of the link between listening effort and age-related hearing loss?</td>
<td>56.79</td>
<td>19.54</td>
<td>0 – 90</td>
</tr>
<tr>
<td>Q31 How would you rate your knowledge of the link between listening effort and the hearing aid benefit?</td>
<td>56.80</td>
<td>19.44</td>
<td>0 – 90</td>
</tr>
<tr>
<td>Q32 How would you rate your knowledge regarding tests that map cognition?</td>
<td>32.40</td>
<td>19.99</td>
<td>0 – 96</td>
</tr>
<tr>
<td>Q33 How would you rate your knowledge of tests that map listening effort?</td>
<td>39.81</td>
<td>22.97</td>
<td>0 – 96</td>
</tr>
</tbody>
</table>