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Aging and P300 potential responses in noise: A systematic review

Envelhecimento e respostas do potencial P300 no ruído: Uma revisão sistemática

Envejecimiento y respuestas potenciales del P300 al ruido: Una revisión sistemática

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Abstract
Introduction: Understanding speech is more difficult in noisy environments and tends to degrade even further with aging. Hearing in noise is a complex process that requires multiple systems, including cognition, which can be assessed through the P300 auditory potential. It is widely believed that speech perception worsens in noise, but this performance varies between individuals, even with similar pure-tone audiograms. Objective: To analyze whether P300 latency and amplitude differ significantly between older and younger adults in quiet and noise. Method: This systematic review searched for observational studies comparing the differences in P300 latency and amplitude results between older and younger adults in quiet and noise, without language or date restrictions, in the following databases: MEDLINE, ScienceDirect, Scopus, Web of Science, SciELO, Cochrane Central, Embase, LILACS, and Circumpolar Health Bibliographic. Results: The search on the databases found 21,727 results, of which 302 titles were selected. Of these, 61 were excluded due to repeated titles, leaving 241 abstracts to be read. Then, 40 full texts were selected. Next, 37 articles were excluded for not meeting the eligibility criteria, leaving 3 articles eligible. Conclusion: The elderly presented a prolonged mean P300 latency in silence compared to the young. In the presence of noise, the mean P300 latency was prolonged in both groups.
Keywords: Aging; Event-Related Potentials, P300; Noise.

Resumo
Introdução: A capacidade de compreensão da fala se tornar mais difícil em um ambiente ruidoso e, tende a se degradar ainda mais com o envelhecimento. Ouvir diante um ruído é um processo complexo, que necessita do emprego de múltiplos sistemas, incluindo a cognição, que pode ser avaliada através do potencial auditivo P300. Apesar de ser difundido que o desempenho da percepção de fala piora na presença no ruído, existe uma variabilidade de desempenhos entre os indivíduos, mesmo com audiogramas de tons puros semelhantes. Objetivo: Analisar se existem diferenças significativas na latência e amplitude do P300 entre idosos e adultos jovens, no silêncio e na presença do ruído. Método: Revisão sistemática de estudos observacionais que comparam as diferenças das medidas de latência e amplitude do P300 entre idosos e adultos jovens no silêncio e na presença do ruído, sem restrições de idiomas ou datas, nas seguintes bases de dados: MEDLINE, ScienceDirect, Scopus, Web of Science, SciELO, Cochrane Central, Embase, LILACS, Circumpolar Health Bibliographic. Resultado: Dos 21.727 resultados presentes a partir das buscas nas bases de dados, foram selecionados 302 títulos, e desses, foram excluídos 61 títulos repetidos, ficando assim, 241 resumos para serem lidos, e desses, 40 textos completos foram selecionados. Após a leitura, 37 artigos foram excluídos por não se adequar aos critérios de elegibilidade, restante 3 artigos elegíveis. Conclusão: Os idosos apresentaram latência média do P300 no silêncio prolongada quando comparada com os jovens. Na presença do ruído, a latência média do P300 é prolongada, em ambos os grupos.
Palavras-chave: Envelhecimento; Potenciais Relacionados a Eventos, P300; Ruído.

Resumen
Introduction: Understanding speech is more difficult in noisy environments and tends to degrade even further with aging. Hearing in noise is a complex process that requires multiple systems, including cognition, which can be assessed through the P300 auditory potential. It is widely believed that speech perception worsens in noise, but this performance varies between individuals, even with similar pure-tone audiograms. Objective: To analyze whether P300 latency and amplitude differ significantly between older and younger adults in quiet and noise. Method: This systematic review searched for observational studies comparing the differences in P300 latency and amplitude results between older and younger adults in quiet and noise, without language or date restrictions, in the following databases: MEDLINE, ScienceDirect, Scopus, Web of Science, SciELO, Cochrane Central, Embase, LILACS, and Circumpolar Health Bibliographic. Results: The search on the databases found 21,727 results, of which 302 titles were selected. Of these, 61 were excluded due to repeated titles, leaving 241 abstracts to be read. Then, 40 full texts were selected. Next, 37 articles were excluded for not meeting the eligibility criteria, leaving 3 articles eligible. Conclusion: The elderly presented a prolonged mean P300 latency in silence compared to the young. In the presence of noise, the mean P300 latency was prolonged in both groups.
Palabras clave: Envejecimiento; Potenciales Relacionados con Eventos, P300; Ruido.

1. Introduction

Effective communication depends heavily on our ability to understand speech in the most varied listening conditions in our daily lives. Speech comprehension becomes increasingly difficult in noisy environments and tends to degrade even further with age (Billings & Madsen, 2018; Karunathilake et al., 2023).

Older people often complain of difficulty hearing in environments with background noise, a finding that is not solely attributed to presbycusis (Pichora-Fuller, 2003; McCullagh & Shinn, 2018). Greater listening challenges, such as with interfering background noise, are known to require more cognitive resources to understand speech (Rönnberg et al., 2013).

Hearing in noise is a complex process that requires the use of multiple systems, including cognition (Anderson et al., 2013; Helfer & Freyman, 2014). Hearing in noise and cognition are subject to decline due to aging. However, the underlying age-related changes in the cortical processing of auditory stimuli in noise are not yet fully understood (McCullagh & Shinn, 2018).

The relationships between brain and behavior can be better understood if the electrophysiological test includes measures of cognitive function (e.g., the oddball paradigm, which requires cognitive processes such as working memory) and a measure of selective attention (which results in the positive P300 peak). This paradigm typically involves attention to a rare stimulus that appears between other frequent stimuli (Decker, 2025) and has been used by researchers to understand the relationship between brain and behavioral measures and to characterize the function of the auditory system in speech-in-noise tests (Billings & Madsen, 2018; Farwell & Donchin, 1988; Sellers & Donchin, 2006).

Although the literature widely indicates that speech perception worsens in noise, such performance (like speech comprehension in quiet) varies between individuals, even with similar pure-tone audiograms (Billings & Madsen, 2018; Dirks et al., 1982).

Thus, this systematic review aimed to verify older people's P300 responses in quiet and noise, triggered by an auditory oddball paradigm, to answer the research question: "Do older adults have different P300 potential responses in noise than younger adults?", aiming to analyze whether the P300 latency and amplitude differed significantly between older and younger adults in quiet and noise.

The aim of this study is to analyze whether P300 latency and amplitude differ significantly between older and younger adults in quiet and noise.

2. Methodology

A systematic literature review was carried out, quantitative in nature in relation to the number of articles and qualitative in relation to the discussions (Pereira et al., 2018) regarding the number of articles selected and qualitative in relation to the discussion on the articles.

This systematic literature review of observational studies aimed to answer the following research question: “Do older adults have different P300 potential responses in noise than younger adults?”. Based on this question, the review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement – PRISMA (Moher et al., 2009). A protocol was published in the Prospero database (http://www.crd.york.ac.uk/PROSPERO) under registration number: CRD42023477966.

Search strategy

The strategy included descriptors (DECs and MeSH) and free terms based on the first two PICO elements (Population, Interest, Context) in the title, as follows: (Senile OR Age-related OR Aged OR Aging OR Ageing Effect OR Ageing OR Older) AND (Event-Related Potentials, P300 OR P300 OR P3 OR Oddball paradigm OR Long latency OR Late potential) AND (Noise OR Signal-To-Noise Ratio OR Din OR Clatter). The complete strategy is found Chart 1.

Chart 1 - Literature search strategy used for all databases.

Medline (via PubMed) *#1 E #2 E #3* *#1 (senile) OR (Age-related) OR (Aged) OR (Aging) OR (Ageing Effect) OR (Ageing) OR (older) OR (50 years) OR (60 years) OR (65 years) OR (70 years)* *#2 (Event-Related Potentials, P300) OR (P300) OR (P3) OR (Oddball paradigm) OR (long latency) OR (late potential)* *#3 (noise) OR (Signal-To-Noise Ratio) OR (din) OR (clatter)* *SciELO / Science Direct /LILACS/CENTRAL/OpenGrey.eu and other databases* *(senile OR Age-related OR Aged OR Aging OR Ageing Effect OR Ageing OR older) AND (Event-Related Potentials, P300 OR P300 OR P3 OR Oddball paradigm OR long latency OR late potential) AND (noise OR Signal-To-Noise Ratio OR din OR clatter)*

Source: Research data (2025).

Searches were conducted between March and December 2024 and reviewed in January 2025. The following electronic bibliographic databases were searched: MEDLINE, Scientific Electronic Library Online (SciELO), Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, Latin American and Caribbean Health Sciences Literature (LILACS), Science Direct, Scopus, Web of Science, and Circumpolar Health Bibliographic Database (CHBD). Grey literature was searched on OpenGrey.eu, DissOnline.de, The New York Academy of Medicine, and ResearchGate. Protocols were searched at ClinicalTrials.gov. The researchers did not manually search the articles included in the review or contact experts in the field to avoid the risk of citation bias (Sterne et al., 2008).

Eligibility criteria

The inclusion criteria were observational studies, with a group of older adults aged 45 years or older, who had performed the auditory P300 potential in quiet and noise, who had normal hearing at 250 to 1000 Hz and thresholds below 55 dB HL in frequencies up to 6000 Hz, and with a control group of normal-hearing younger adults at 250 to 6000 Hz, in similar procedural conditions to the test group. The review included studies with at least a title and/or abstract in English, but with no restriction on language or publication date.

The exclusion criteria were studies whose participants had changes in central auditory processing and confirmed psychiatric and/or neurological changes with diagnosis. Duplicate articles in different databases were also excluded.

Data extraction

Two researchers conducted the review, who independently sought to identify titles and abstracts that met the inclusion criteria, extracted from electronic databases. Selection discrepancies were resolved by consensus. They retrieved and analyzed the full texts of these potentially eligible studies. The outcome sought in the studies was the latency and amplitude results of the P300 potential evoked by pure tone or speech, having used an oddball paradigm, in quiet and noise, with samples of young and older adults. Besides the outcome data, the researchers extracted the authors' names, title, year of publication, country, age ranges of the groups, and equipment. They created a standard data storage form based on the Cochrane model (Higgins et al., 2016).

Method for assessing risk of bias

The risk of bias was assessed according to the recommendations of the Newcastle-Ottawa manual and scale, adapted for cross-sectional observational studies. Two researchers independently assessed the quality of the studies, and disagreements were resolved by consensus. The maximum score to be achieved was 10 points, and the items assessed on the scale were: 1) Representativeness of the sample; 2) Sample size; 3) Management of non-responses; 4) Determination of exposure (risk factor); 5) Comparability, to investigate whether individuals in different groups of results were comparable, based on the study design or analysis, control of confounding factors; 6) Evaluation of results; and 7) Statistical test (Chart 2).

Chart 2 - Newcastle-Ottawa Scale (adapted) for assessing the quality of cross-sectional studies.

Selection: *(Maximum 5 stars)*
1. Sample representativeness:
a) Truly representative of the mean in the target population. (All subjects or random sampling).*
b) Somewhat representative of the mean in the target population. (Non-random sampling).*
c) Group of selected users.
d) Description of the sampling strategy.
2. Sample size:
*a) Justified and satisfactory.**
b) Not justified.
3. Non-responses:
*a) Comparability between responses and non-responses is established and the response rate is satisfactory.**
b) The response rate is not satisfactory or the comparability between responses and non-respondents is unsatisfactory.
c) Description of the response rate or the characteristics of responses and non-responses.
4. Ascertainment of exposure (risk factor):
*a) Validated measuring tool.***
*b) Non-validated measuring tool, but the tool is available or described.**
c) Description of measuring tool.
Comparability: *(Maximum 2 stars)*
1. Objects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
*a) The study takes into account the most important factor (select one).**
*b) The study controls for any additional factors.**
Outcome: *(Maximum 3 stars)*
1. Assessment of the outcome:
*a) Independent blind assessment.***
*b) Record linkage.***
*c) Self report.**
d) No description.

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2. Statistical test: *a) The statistical tests used to analyze the data are clearly described and appropriate, and the measure of association is presented, including confidence intervals and the probability level (p-value).** *b) The statistical test is not appropriate, not described, or incomplete.*
This scale was adapted from the Newcastle-Ottawa Quality Assessment Scale for cohort studies to assess the quality of cross-sectional studies for the systematic review, "Are health workers' intentions to vaccinate related to their knowledge, beliefs, and attitudes? A systematic review".

Source: Research data (2025).

Method for data analysis

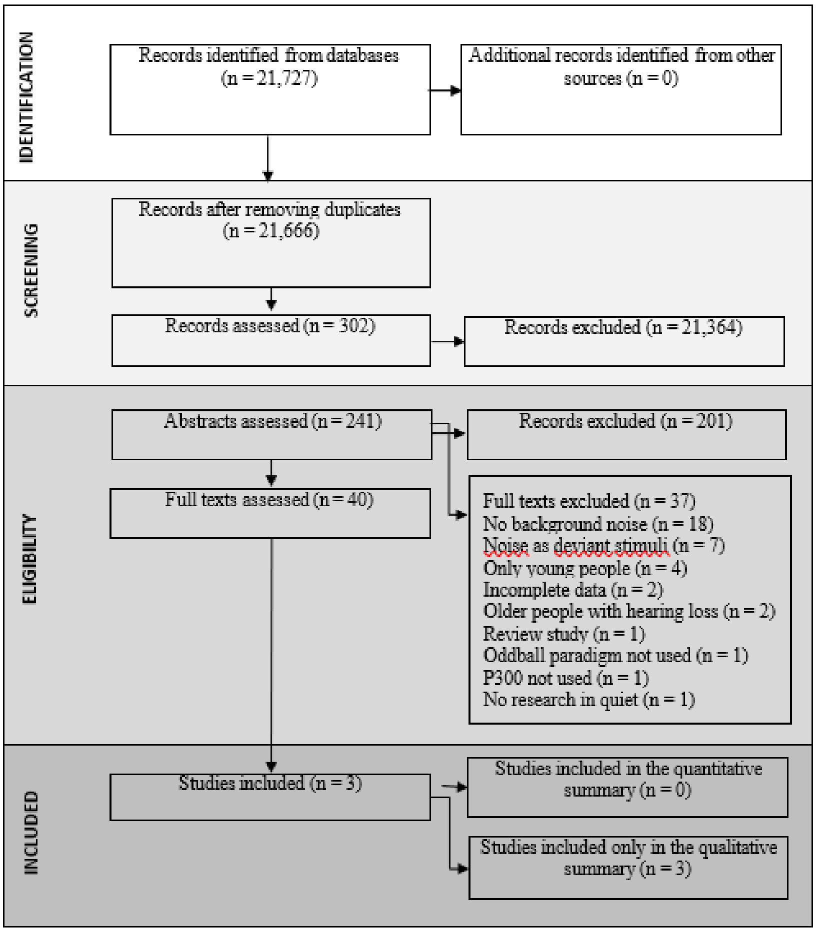
The data from eligible studies that met the inclusion and exclusion criteria defined in the study methodology were presented descriptively in tables and charts.

3. Results and Discussion

Studies included in the review

The flowchart illustrating the search and selection of studies is shown in Figure 1. The search in the said databases found 21,727 results, of which 302 relevant titles were selected. Of these, 61 were excluded because they were duplicates, leaving 241 abstracts to be read. Then, 40 full texts were selected for reading. Next, 37 articles were excluded because they did not meet the eligibility criteria. Therefore, three full texts were included in the qualitative analysis.

Figure 1 - Flowchart of article search and selection.



Source: Research data (2025).

The characteristics of the studies included in the review are described in Table 1, the characteristics of the parameters to evoke the P300 in these studies are described in Table 2, and the description of the study objectives, results, and conclusions are described in Table 3.

Table 1 - Characteristics of the studies included in the review.

Authors	Year	Country	Task	Device/Method	N in the young adults' group	N in the older adults' group
Kestens et al.	2023	Belgium	Pressing a button	Neuron Spectrum 5	19 (MA = 24.79 years SD = 3.14)	20 (MA = 58.90 years SD = 5.84)
McCullah and Shinn	2018	USA	Mentally counting rare stimuli	Intelligent Hearing Systems (IHS) SmartEP	20 (MA = 21.1 years SD = 2.7)	15 (MA = 66.4 years SD = 4.6)
Bertoli et al.	2005	Switzerla nd	Pressing a button	Neuroscan QuickTrace	10 (MA = 26.2 years; ranging from 20 to 38 years)	10 (MA = 67.5 years (ranging from 61 to 81 years)

MA – mean age
SD – standard deviation

Source: Research data (2025).

Table 2 - Characteristics of the parameters to evoke the P300 in the eligible studies.

Authors	Noise	SNR	Stimulus	Stimulus intensity	Paradigm	Transducer
Kestens et al.	Noise in the form of speech	+4 and -2 dB	Flemish monosyllabic number words – "one" (/e:n/ in Flemish) and "three" (/dri:/ in Flemish) as standard and deviant stimuli, respectively	65 dB SPL	Oddball (80% frequent and 20% rare)	Stimulus and background noise were presented in a free field through a loudspeaker, positioned at 0º azimuth, 90 cm from the participant.
McCullah and Shinn	White noise	+20, +10, and 0 dB	500 Hz (frequent) and 1000 Hz (deviant)	50 dB SL in response to the behavioral pure-tone threshold	Oddball (80% frequent and 20% rare)	Stimulation through an ER-3A earphone with open-fit hearing aid domes, and noise presented through a speaker positioned at 0º azimuth, 42 cm from the participants' nose
Bertoli et al.	Digitally recorded speech babble	0 dB in the contralate ral ear	1000 Hz (frequent) and three deviant stimuli differing at 64, 32, and 16 Hz.	70 dB SPL	Oddball (deviants occurred between standard stimuli with a probability of 0.15 in a pseudorandomize d sequence, with at least three standard stimuli preceding each deviant)	Pure tone stimuli were presented to the right ear and noise to the left ear via ER3 insert headphones.

SNR – signal-to-noise ratio
SD – standard deviation

Source: Research data (2025).

Table 3 - Description of the objectives, results, and conclusions of the included studies.

Authors	Objective	Result	Conclusion
Kestens et al.	To explore the P3b (hereafter referred to as P300) as a physiological measure of the engagement of cognitive systems that contribute to listening effort.	The mean P300 latency differed statistically significantly between listening conditions (F(2.61.037) = 190.822, p < 0.001). A Bonferroni-corrected post hoc analysis showed a significantly prolonged P300 latency for the unfavorable noise condition compared to the favorable one (EDM = 0.112 ms, 95% CI [0.083; 0.140], p < 0.001) and silent condition (EDM = 0.223 ms, 95% CI [0.195; 0.251], p < 0.001). Furthermore, a significantly prolonged P300 latency was observed for the favorable noise condition compared to the silent condition (EDM = 0.111 ms, 95% CI [0.086; 0.136], p < 0.001). The main effect of age group showed that there was a statistically significant difference in mean P300 latency between age groups (F(1,33,324) = 18.521, p < 0.001), while older adults showed prolonged P300 latencies (EDM = 0.052 ms, 95% CI [0.027; 0.076], p < 0.001). There was no statistically significant interaction between listening condition and age group on P300 latency (F(2.61.037) = 2.311, p = 0.108). Furthermore, the main effect of listening condition on P300 amplitude was statistically significant (F(2.60.595) = 13.022, p < 0.001). Bonferroni-corrected post-hoc analysis showed statistically significant larger P300 amplitudes in the unfavorable than in the favorable noise condition (EDM = 4.150 µV, 95% CI [1.979; 6.320], p < 0.001) and the quiet condition (EDM = 3.950 µV, 95% CI [1.779; 6.120], p < 0.001). The main effect of age group revealed a statistically significant difference in P300 amplitudes (F(1.35.052) = 8.639, p = 0.006), showing significantly larger P300 amplitudes for young adults than older adults (EDM = 5.053 µV, 95% CI [1.563; 8.542], p = 0.006). No statistically significant interaction between listening condition and age group was observed on P300 amplitude (F(2.60.595) = 0.002, p = 0.998).	An increase in listening demand resulted in an increase in P300 amplitude and latency, which are thought to reflect the engagement of cognitive systems contributing to listening effort. These results are in line with contemporary models of listening cognitive effort. Because advancing age is associated with hearing loss and cognitive decline, more research is needed on the effects of all these variables on the P300 to better explore its utility as a measure of listening effort for clinical and research purposes.
McCullah and Shinn	To investigate age-related differences in the cognitive processing of auditory stimuli evoking the auditory P300 at multiple SNRs.	Latencies were significantly longer for the older adults' groups compared to the young [F (1.3) = 8.48, p = 0.01]; however, there were no significant group X listening condition interactions [F (1.3) = 0.65, p = 0.59]. There were no significant latency differences between the quiet and +20 SNR conditions (t = -2.20, p = 0.03), or the +20 and +10 SNR conditions (t = -0.86, p = 0.40). However, significantly longer P300 latencies occurred in the 0 SNR condition compared to the quiet condition (t = -5.99, p < 0.001) and in the 0 SNR condition compared to the +10 SNR condition (t = -4.77, p < 0.001). Amplitudes were not significantly different for the young group compared to the older adults' group [F (1.3) = 0.79, p = 0.38]. There were no significant group X listening condition interactions [F (1.3) = 0.50, p = 0.68].	The results of this study provide evidence that auditory cortical processing, regardless of age, is poorer at more difficult SNRs. However, it also demonstrates that older adults perform significantly worse than their younger counterparts. This supports the notion that there is some degree of age-related decline in the synchronous firing and transmission rate of auditory cortical neurons that contribute to the auditory P300. Further studies are needed to elucidate the impact of noise on auditory cortical processing across populations. Furthermore, although assessment of the ability to process in noise has focused primarily on behavioral measures, objective measures such as those described in this protocol need to be developed to provide additional means by which to assess processing in noise in clinical populations.

Bertoli et al.	To investigate the effects of age, age-related hearing loss, and distracting noise on auditory frequency discrimination in young and older listeners.	According to post hoc tests, the responses of subjects in the group of normal hearing older subjects and in the group of older subjects with hearing loss were delayed compared with those of the young group (N2b: $p < 0.0001$ and $p < 0.0004$, respectively; P3b: $p < 0.0001$ for both groups of older subjects). P3b latencies did not differ significantly between the two groups of older subjects ($p > 0.1$). The presentation of contralateral noise further delayed the P3b latency. This effect was similar for all three groups of subjects, as there was no interaction between subject groups and noise conditions. P3b amplitudes were significantly reduced in both subjects in the group of normal hearing older adults and in older adults with hearing loss compared with those in the young group ($p < 0.04$ and $p < 0.003$, respectively). Noise reduced P3b amplitudes significantly in all three groups. A significant interaction of subject group and stimulus deviation indicated that both young and normal hearing older subjects had increasing P3b amplitudes with increasing stimulus contrast, whereas in the data from older subjects with hearing loss, the degree of deviation had no effect on P3b amplitude.	Sensorineural hearing loss clearly impairs frequency discrimination and speech perception in noise. Aging, in relatively normal hearing older adults and those with hearing loss, is associated with pronounced changes in the later ERP cognitive components, reflecting a decrease in inhibitory control of irrelevant stimuli, a decreased sensitivity of automatic discrimination of pre-attentive stimuli, and a more effortful and delayed stimulus evaluation. These results support current concepts of presbycusis, suggesting a combination of peripheral, central auditory, and cognitive factors underlying older people's hearing difficulties.

SNR – signal-to-noise ratio
SD – standard deviation

Source: Research data (2025).

The study by Kestens et al. (2023) evoked the P300 by speech stimuli with SNR +4 and -2 dB. Their results are descriptive and report that after a Bonferroni-corrected post hoc analysis, the P300 latency was significantly prolonged for the unfavorable noise condition compared to the favorable one (estimated mean difference [EMD] = 0.112 ms, 95% CI [0.083; 0.140], $p < 0.001$) and quiet (EMD = 0.223 ms, 95% CI [0.195; 0.251], $p < 0.001$). The P300 latency was significantly prolonged in the favorable noise condition than in quiet (EMD = 0.111 ms, 95% CI [0.086; 0.136], $p < 0.001$).

The mean P300 latency was statistically significantly different between age groups (younger and older adults) ($F[1,33,324] = 18.521$, $p < 0.001$), showing that older adults had prolonged P300 latencies (EMD = 0.052 ms, 95% CI [0.027; 0.076], $p < 0.001$). There was no statistically significant difference between listening condition (SNR +4 and -2 dB) and age group (older and younger adults) in P300 latency ($F[2,61,037] = 2.311$, $p = 0.108$).

P300 amplitudes, after Bonferroni corrected post-hoc analysis, were statistically greater and significant in the unfavorable noise condition than in the favorable one (EMD = 4.150 μV, 95% CI [1.979; 6.320], $p < 0.001$) and in the silent condition (EMD = 3.950 μV, 95% CI [1.779; 6.120], $p < 0.001$). The P300 amplitude was statistically significantly different between older and younger adults ($F[1,35,052] = 8.639$, $p = 0.006$), with significantly larger P300 amplitudes in younger than in older adults (EMD = 5.053 μV, 95% CI [1.563; 8.542], $p = 0.006$). No statistically significant interaction in P300 amplitude occurred between listening condition (SNR +4 and -2 dB) and age group (younger and older adults) ($F[2,60,595] = 0.002$, $p = 0.998$).

The study by McCullagh and Shinn (2018) evoked the P300 with pure-tone stimuli with SNR +20, +10, and 0 dB. The description of the results points out that the latencies were significantly higher among older people than the younger ones ($F[1,3] = 8.48$, $p = 0.01$). However, the groups (younger and older adults) did not interact significantly with the listening condition (SNR +20, +10, and 0 dB) ($F[1,3] = 0.65$, $p = 0.59$). They did not find significant differences in latency between the quiet and SNR +20 conditions ($t = -2.20$, $p = 0.03$), or the SNR +20 and +10 conditions ($t = -0.86$, $p = 0.40$). However, P300 latencies were significantly longer in the 0 SNR condition than in quiet ($t = -5.99$, $p < 0.001$) and in the 0 SNR condition than in the +10 SNR condition ($t = -4.77$, $p < 0.001$). P300 amplitudes were not significantly different between the younger and older groups (F[1,3] = 0.79, p = 0.38). The groups (younger and older adults) did not interact significantly with the listening condition (SNR +20, +10, and 0 dB) (F[1,3] = 0.50, p = 0.68).

The study by Bertoli et al. (2005) evoked the P300 with pure-tone stimuli with SNR 0 dB. The descriptive results of the study reveal that after post hoc tests, the responses of the group of normal-hearing older adults and hearing-impaired older adults were delayed compared to those of the younger group (N2b: $p < 0.0001$ and $p < 0.0004$, respectively; P3b: $p < 0.0001$ for both groups of older adults). The P3b latencies did not differ significantly between the two groups of older adults ($p > 0.1$). Presenting contralateral noise further delayed the P3b latency similarly in all three groups, as there was no interaction between groups (normal-hearing younger and older adults and hearing-impaired older adults) and noise condition (SNR 0).

P3b amplitudes were significantly reduced in normal-hearing older people and hearing-impaired older adults compared with the younger group ($p < 0.04$ and $p < 0.003$, respectively). Noise reduced P3b amplitudes significantly in all three groups. Normal-hearing younger and older adults had increasing P3b amplitudes with increasing stimulus contrast, whereas in hearing-impaired older adults, the degree of deviation had no effect on P3b amplitude.

Assessment of the risk of bias

The quality analysis of the included articles Bertoli et al. (2005), McCullagh and Shinn (2018), and Kestens et al. (2023), and consequently the risk of bias, is shown in Table 4.

Table 4 - Quality of included articles, according to the Newcastle-Ottawa quality assessment scale.

Authors	Sample representativeness	Sample size justified[a]	Non-response rate	Ascertainment of exposure	Comparability	Outcome assessment	Appropriate statistical test	Final assessment[b]
Kestens et al.	Not representative	Yes	Yes	Validated tool	Yes	Self report	Yes	7/10
McCullah and Shinn	Not representative	Yes	Yes	Validated tool	Yes	Self report	Yes	7/10
Bertoli et al.	Not representative	Yes	Not cited	Validated tool	Yes	Self report	Yes	6/10

Results presented as points obtained/maximum score.
[a] Minimum criterion of $n \geq 30$ (central limit theorem).
[b] Maximum rating of 10 stars

Source: Research data (2025).

All included studies were observational cross-sectional studies. The final assessment ascribed one study with a quality percentage of 60% (6/10) and two with the maximum score of 70% (7/10). All of them conformed to the central limit theorem, with samples equal to or greater than 30 subjects. However, none of them performed calculations to estimate the sample size. All studies selected groups based on convenience. All used validated tools for data collection and comparability between the control and the older adults' group in quiet and noise. None of the studies described latency and amplitude values but displayed their data through figures. All studies evaluated the results through self report. Finally, all studies used appropriate statistical tests.

Discussion

The few articles found reveal the need for further studies to elucidate the impact of noise on auditory cortical processing in older adults – particularly the P300 auditory potential, as a physiological measure of the cognitive system that contributes to research on listening effort.

Older adults' mean P300 latency was prolonged in quiet when compared with younger adults in all eligible studies (McCullagh & Shinn, 2018; Bertoli et al., 2005; Kestens et al., 2023). Longer P300 latencies in older adults may indicate their slower cognitive performance. Anderer et al. (2003) report reduced information processing speed as a key contributor to age-related memory loss.

Researchers (Peters, 2002; Gaal et al., 2007) attribute older people' prolonged P300 latency to slowed processing and/or increased inhibition, suggesting age-related declines in the synchronous firing and transmission rate of auditory cortical neurons that contribute to the P300 potential (Goodin et al., 1978).

McCullagh and Shinn (2018) explain that P300 latency can be attributed to stimulus processing rather than response processing. Hence, the increased latencies in older adults compared to younger adults suggest that older adults take longer to classify stimuli.

Successful communication in difficult listening environments depends on how well the auditory system encodes and extracts signals of interest from other competing acoustic information (Billings & Madsen, 2018). Another common finding across all studies was significantly prolonged P300 latencies in noise compared with responses in quiet in older and younger adults. Similar results were also found in other studies (Polich et al., 1985; Obert & Cranford, 1990; McCullagh et al., 2012), which identified increased mean P300 latencies in the presence of background noise, revealing a greater effort of the cortex to process sounds in the face of competing noise in younger and older adults.

Kestens et al. (2023) researched noise in favorable and unfavorable conditions (SNR +4 and -2 dB) and observed that regardless of the SNR she researched, noise delays P300 latency when compared to quiet.

Another piece of evidence found in the studies is the lack of differences in P300 latency between older and younger adults in the different listening conditions (SNR). It is known that P300 latency has been related to the time of mental processing (Kok, 2001; Picton, 2010), and the observed P300 latency prolongations with background noise may reflect slower cognitive processing in more demanding listening conditions, which occurred in both age groups (older and younger adults) in the present study.

There was no consensus of P300 amplitude results in quiet among the eligible studies. Bertoli et al. (2005) reported that the P300 amplitude was reduced in the older people's group, compared to the younger group. This corroborates the study by Kestens et al. (2023), which observed a greater P300 amplitude in younger adults than in older adults. McCullagh and Shinn (2018) did not identify differences in amplitude between older and younger adults.

Regarding amplitude in noise, Kestens et al. (2023) and McCullagh and Shinn (2018) found no differences between older and younger adults in the different listening conditions researched: quiet, SNR +4, and SNR -2dB; and quiet, SNR +20, +10, and 0dB, respectively. This evidence suggests that the amount of neural substrate responding synchronously did not change significantly with increasing age in the interaction with noise. Researchers (Salisbury et al., 2002) explain that the lack of change in P300 amplitude in noise may reflect a contraction between the increased allocation of resources required for increased task complexity and the reduced information transfer in noise.

Bertoli, Smurzynki, and Probst (2005) observed that the P300 amplitude in noise (SNR 0 dB) decreased in older and younger adults. Unlike the other two studies, the researchers used three deviant stimuli and observed that the P300 amplitude increased with the increase in stimulus contrast in normal-hearing young and older adults. An increase in the P300 amplitude in the most challenging listening conditions may reflect an increase in the listening effort exerted by the listener since the P300 is related to attention and working memory (Kok, 2001; Picton, 2010).

4. Conclusion

A common finding in all eligible studies in this systematic review was that the mean P300 latency in quiet is prolonged when compared with younger people. The mean P300 latency is prolonged in noise when compared with quiet in older and younger adults. The mean P300 latency in different SNRs studied did not differ between older and younger adults. There was no consensus among the eligible articles on the P300 amplitude results in quiet and noise between older and younger adults.

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