Article

Documentation of Peripheral Auditory Function in Studies of the Auditory P300 Response

A Critical Review

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Abstract: A critical review was conducted to examine whether the peripheral hearing status of participants with neurological and psychological disorders was documented in published clinical studies of the auditory P300 response. Literature searches were conducted with three databases: PubMed, PsycINFO, and Scopus. Studies of participants with seven neurological or psychological disorders were included in the study. Each disorder was coupled with the main search phrase in separate searches on each database. Of the total 102 papers which met the inclusion criteria, the majority (64%) did not describe the peripheral hearing sensitivity of participants. In this review with studies that included participants at risk for hearing impairment, particularly age-related hearing loss, only a single publication adequately described formal hearing evaluation. Peripheral hearing status is rarely defined in studies of the P300 response. The inclusion of participants with a hearing loss likely affects the validity of findings for these studies. We recommend formal hearing assessment prior to inclusion of participants in studies of the auditory P300 response. The findings of this study may increase the awareness among researchers outside the field of audiology of the effects of peripheral hearing loss on the auditory P300.

Keywords: peripheral auditory function, auditory P300 response, event-related potentials, clinical application, neurological and psychological disorders

The auditory P300 response is an electrophysiological cognitive measure (Polich, 2007). The P300 response is typically observed as a positive peak occurring approximately 300 ms after the presentation of a target auditory stimulus randomly presented among frequent, non-target auditory stimuli in a test strategy referred to as the oddball paradigm (Picton, 1992; Polich, 2007). Latency of the auditory P300 response reflects auditory neural activity related to information discrimination and processing speed, whereas amplitude reflects the attention and working memory abilities (Polich, 1986; Polich & Heine, 1996).

For over 50 years, the auditory P300 response has widely been studied and applied clinically for a variety of neurological and psychological disorders, such as schizophrenia, dementia, Alzheimer disease, and depression (Cui et al., 2009; Frodl et al., 2002; Hall, 2015; Karaaslan et al., 2003; Pedroso et al., 2012; Picton, 1992). Research findings confirm differences in auditory P300 response amplitude and latency reported in individuals with these disorders (Polich, 1991, 2004; Roth & Cannon, 1972). For example, individuals with a diagnosis of schizophrenia typically yield reduced P300 amplitudes (Jeon & Polich, 2003). The auditory P300 response can also be applied as an objective measure of central auditory function in persons with suspected auditory processing disorder (APD) (Reis et al., 2015). Increased latency and decreased amplitude of the auditory P300 response in individuals with APD are associated with deficits in auditory attention, auditory memory, discrimination, integration, and information processing (Jirsa & Clontz, 1990).

Multiple subject factors such as age, gender, peripheral hearing sensitivity, and certain medications may also influence the P300 response (Melynyte et al., 2018; Picton, 1992; Pollock & Schneider, 1992; Puttabasappa et al., 2017). There is evidence of larger P300 amplitudes in females versus males, likely due to hormonal and anatomical differences (Melynyte et al., 2018). Advancing age with age-related hearing impairment is also associated with prolonged latencies and reduced amplitudes (Pollock & Schneider, 1992). The effect of advanced age alone on

the auditory P300 response shows an increase in latencies due to auditory maturation associated with advancing age in adults while hearing loss causes an increase in latency and a decrease in amplitude (Puttabasappa et al., 2017; Reis et al., 2015). The degree of hearing loss is also a factor in auditory P300 measurements (Reis et al., 2015). Although the auditory P300 response is typically not applied clinically in assessing peripheral auditory status, hearing sensitivity affects P300 recordings (Picton, 1992).

Peripheral hearing loss may compromise the clinical application of the P300 response in patients with neurological and psychological diseases and disorders. Hearing loss is not uncommon in participants in P300 studies. Studies focusing on disorders such as Alzheimer's disease and dementia often include elderly participants (Ralli et al., 2019). Target populations at risk for age-related hearing loss (Fjell & Walhovd, 2003). According to the World Health Organization (2019), a disabling hearing loss is expected in an estimated 25% of persons over 60 years of age. Recent studies have also shown that adults with hearing loss are at higher risk for developing dementia (Brewster et al., 2021; Loughrey et al., 2018; Thomson et al., 2017). Age-related hearing impairment is characterized by a gradual decrease in high-frequency hearing thresholds (Gates & Mills, 2005; Hall, 2014; Rigters et al., 2019; Salvi et al., 2018). High-frequency stimuli often used to elicit the auditory P300 response (Picton, 1992; Polich et al., 1996), increase the likelihood of age-related hearing impairment impacting the outcome of P300 response measurements. Failure to document and account for hearing sensitivity in participants of P300 studies may influence data analysis and even compromise the conclusions of studies.

We critically review publications describing auditory P300 findings in persons with neurological and psychological disorders to determine whether the hearing sensitivity of participants was formally evaluated, adequately described, and documented in the methods section of the papers.

Method

Research Design

A critical review was conducted through the review of published studies relating to the auditory P300 response being applied clinically for neurological and psychological disorders to investigate whether the peripheral hearing status of participants was accounted for and documented. A critical review aims to comprehensively research literature to critically review its quality (Grant & Booth, 2009).

Literature Search Strategy

PubMed, PsycINFO, and Scopus were searched to identify studies that met the inclusion criteria. Pubmed was searched using available Medical Subject Headings (MeSH) terms. As seven disorders were included in the study, each disorder was coupled with the main search phrase ("auditory P300") in separate searches on each database (e.g., "auditory P300 response" AND "schizophrenia"). A total of 21 searches were conducted across each one of the 3 databases (Table 1). The initial search resulted in a total of 278 articles.

Inclusion and Exclusion Criteria

The inclusion criteria were: (1) peer-reviewed published studies of the auditory P300 response used as a biomarker for selected psychological and neurological disorders, as a measurement of treatment progress, or as a predictor of genetic risk for such disorders; (2) study participants with disorders including schizophrenia, dementia, Alzheimer's disease, bipolar disorder, depressive disorder, traumatic brain injury, and auditory processing disorder. A pilot study with a review of literature published from 1990 to 2019 was conducted in 2019. The search terms consisted of the "auditory P300 response" combined with 25 different disorders to identify the most frequently occurring disorders in literature. The seven disorders with the most published literature available then were, therefore, included in the review; (3) English-language articles, and (4) articles published from 2000 to 2020. Our last literature search was conducted in August 2020.

Exclusion criteria were: (1) non-English-language publications; (2) publications that were not peer-reviewed; (3) papers describing studies of the visual P300 response but not the auditory P300 response; (4) non-clinical (animal) studies; (5) review articles; (6) pilot or preliminary studies, and (7) papers that did not describe amplitude and latency data for the P300 recordings.

Study Selection

After the initial search, the titles of all articles were reviewed, and duplicate articles were removed (Figure 1). Abstracts of the remaining 67 articles were reviewed, resulting in the exclusion of an additional 15 articles that did not meet the inclusion criteria or for which we could not obtain the entire article. The full text of the remaining 52 articles was then reviewed, of which a further 6 articles were excluded due to not completely meeting the inclusion or exclusion criteria.

A secondary search strategy was then conducted by reviewing the reference lists of the remaining 46 articles

Table 1. Databases and search strategies utilized

Search strategy		Seven phrases	Limiters	Number of articles
PsycINFO	Terms occurring in all fields	"auditory P300" AND "schizophrenia" "auditory P300" AND "dementia"	English journal articles published from 2000 to 2019	84
PubMed	MeSH terms relating to specific disorders and terms occurring in all fields	"auditory P300" AND "Alzheimer's disease" "auditory P300" AND "depression"	English journal articles published from 2000 to 2019	96
Scopus	Terms occurring in all fields	"auditory P300" AND "bipolar disorder" "auditory P300" AND "traumatic brain injury" "auditory P300" AND "auditory processing disorder"	English peer-reviewed journal articles published from 2000 to 2019	98

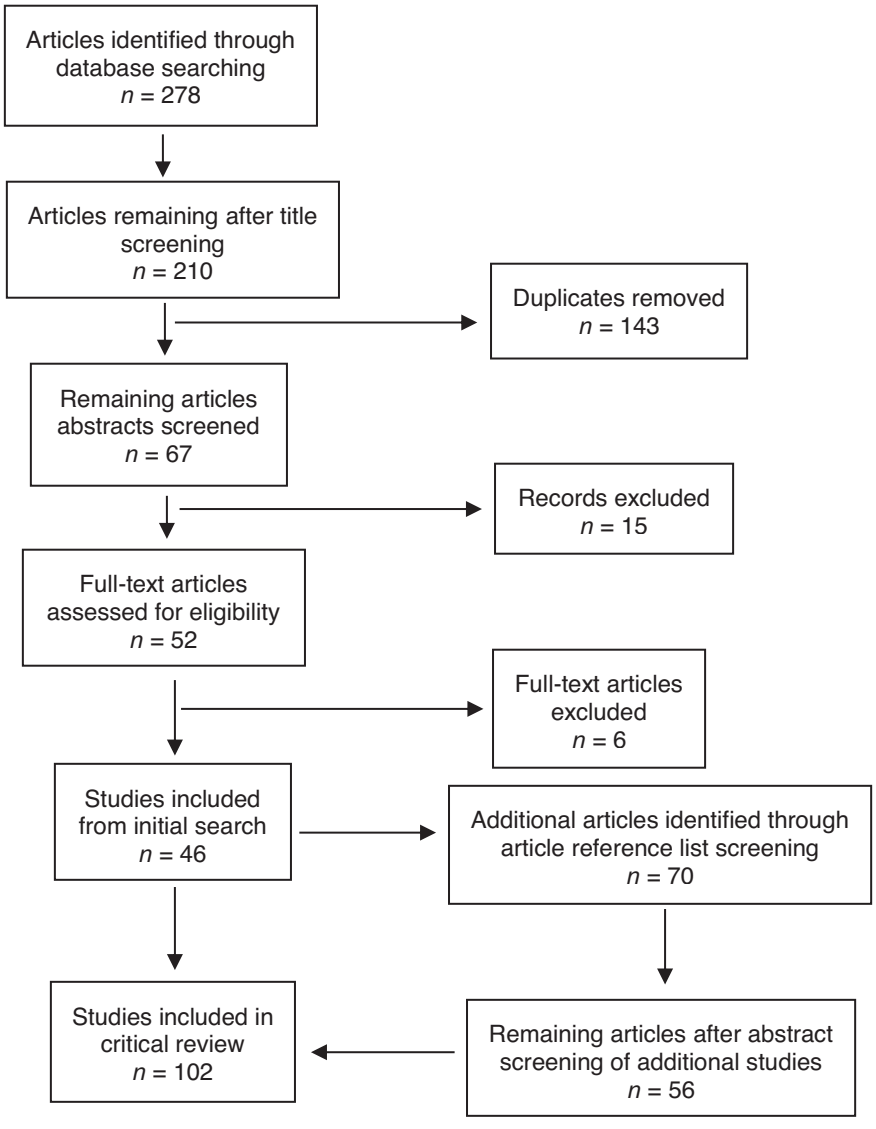

Figure 1. Data collection process.

from the initial search to ensure that all existing literature was considered. A total of 56 additional articles were identified and added, resulting in a total of 102 articles that were included in the review. To avoid selection bias, search strategies were established in advance. The first author reviewed the full text of all remaining articles, and any discrepancies were highlighted. The discrepancies were discussed among the authors. Articles were included in

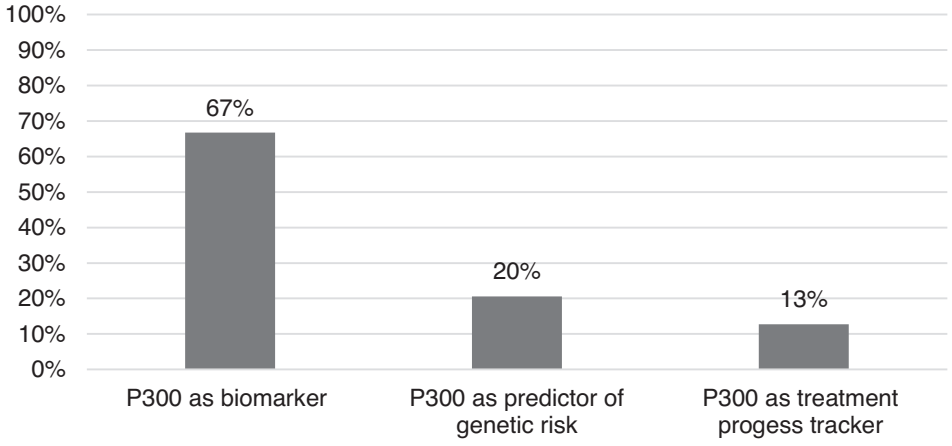

Figure 2. Main themes regarding the auditory P300 identified (n = 102).

the final selection only if a consensus was reached between three of the authors.

Data Extraction and Analysis

DistillerSR, a literature review software program, was utilized to aid in data extraction and analysis. Data extraction was completed with a close review of all selected publications. Quantitative data were collected from each study and descriptive data analysis was used to organize and analyze data collected from each study.

Results

Characteristics

Of the 102 studies included in the review, 61% were published over the years 2000–2009, whereas 39% were published from 2010 to 2020. Participant ages across the studies ranged from 8 to 90 years. Two studies included participants younger than 18 years of age, and 43 studies (42%) included some participants above the age of 50 years. The number of participants varied across studies, with the lowest being an N of 10 and the highest an N of 1,790. Most studies (93%) included male and female participants, with 7% male-only participants.

All but one of the studies (99%) was published in psychology, psychiatry, or neurology-related journals. The one exception, a study of the P300 response in participants with APD, was published in an audiology journal. Three main study themes were identified across studies (Figure 2).

Papers included in the review reported P300 findings for seven disorders included in the initial database search or combinations of these disorders. The distribution of disorders investigated across studies is presented in Table 2.

Table 2. Different disorders investigated across included studies (n = 102)

Disorder(s) investigated	Percentage of studies
Schizophrenia	60
Psychosis	14
Alzheimer's disease/Dementia	5
Bipolar disorder	5
Depression	4
Schizophrenia and psychosis	4
Psychosis and depression	2
Schizophrenia and bipolar disorder	2
Schizophrenia and Alzheimer's disease	1
Psychosis and bipolar disorder	1
Bipolar depression	1
Auditory processing disorder	1

The two most prevalent disorders investigated across included studies were schizophrenia, psychosis, or a combination of these disorders (n = 80; 78%). In addition to the auditory P300 response, 43% of studies (n = 44) also included other electrophysiological assessments, such as the N100, N200, and P200 components, as well as the visual P300 response.

Description of Peripheral Auditory Status of Participants

Most studies did not describe participants' peripheral hearing status, such as hearing sensitivity (64%; n = 65). Among papers that did mention peripheral hearing status, the methods used to assess hearing differed considerably (Figure 3).

Of the 37 studies (36%) that did account for hearing sensitivity, most (70%; n = 26) excluded participants based on self-reported hearing loss. However, only two of these

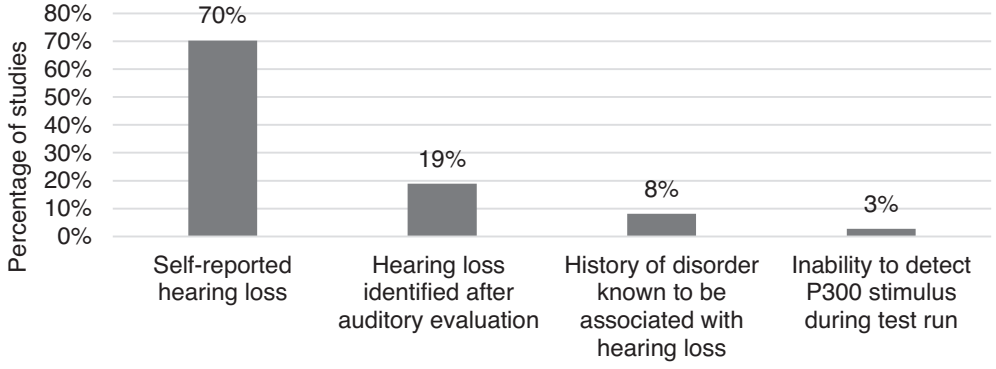

Figure 3. Criteria utilized regarding peripheral hearing status of participants (n = 37).

studies (8%) described the degree of self-reported hearing loss that warranted the exclusion of participants. Of the studies that excluded participants based on self-reported hearing loss, 4 (15%) indicated that only "normal hearing" participants were included, whereas 22 studies (85%) excluded participants who reported hearing impairments. Of the total number of studies that considered hearing sensitivity, three excluded participants based on the presence of other unspecified physical disorders associated with hearing loss and one participant excluded who could not perceive the auditory P300 stimulus tone during a trial run of the assessment.

Of all the articles reviewed, seven papers (7%) described the evaluation of peripheral hearing sensitivity of participants. However, among these seven papers, only one specified that a comprehensive audiological assessment was conducted to identify participants with hearing impairment. One paper reported that a 500 Hz tuning fork was employed to test hearing. The remaining five papers failed to mention how hearing status was assessed.

Another study conducted two experiments with two different participant groups. Peripheral hearing sensitivity was noted only for participants in the first experiment. Finally, the authors of one paper among those included in the review acknowledged that the failure to assess peripheral hearing sensitivity was a limitation of their study (Iwanami et al., 2002).

P300 Frequency and Stimulus Intensity

Most papers (96%) described the intensity levels of stimuli that elicit the auditory P300 response stimulus. One paper indicated that normal hearing sensitivity was confirmed with "1,000 kHz" tones (Light et al., 2015). This is presumably a typographical error or an error in terminology because 1,000 kHz is a frequency of 1,000,000 Hz. Four papers included in the review failed to describe the intensity level of stimuli that elicit the auditory P300 response. The authors of one paper erroneously indicated that the stimulus intensity was at 480 dB. Six other papers stated that the stimuli were presented within the range of 43–75 dB, which referenced the participant's subjective hearing threshold for the stimulus. All papers that specified P300 test parameters reported stimulus intensity levels between 55 and 90 dB. Most studies (59%) presented a P300 target stimulus of 1,000 or 2,000 Hz and non-target stimuli of 1,500 and 1,000 Hz. The remaining studies utilized other (rare) target versus frequent (non-target) frequency combinations, whereas 3% of studies provided no details on stimulus frequency.

Participant Age and Hearing Sensitivity

Almost two-thirds of the studies (64%) that did not account for hearing sensitivity included participants at risk for age-related hearing loss, namely participants above 50 years of age. Table 3 summarizes age and hearing status and the stimulus parameters of frequency and intensity for studies that included participants aged 50 years and older.

Among studies that included participants 50 years of age and older, three (7%) elicited the auditory P300 response with stimuli 43 or 50 dB above the participants' subjective hearing threshold but did not evaluate the participant's hearing status. Thirty-three studies (77%) utilized target (rare) stimuli presented at a higher frequency than the non-target (frequent) stimulus. Some of these studies (n = 16) also included one or more stimuli at a frequency of 2,000 Hz or higher. None of the papers listed hearing status as a factor in the analysis of P300 recordings.

Discussion and Conclusion

The auditory P300 response is widely investigated and applied clinically in selected neurological and psychological

Table 3. Audiometric documentation in studies that included participants 50 years of age and older

Author(s) & year	Number of participants	Age range (years)	Mean age	Documentation of hearing status	Stimulus intensity (dB)	Stimulus frequency (Hz)
Bachiller et al. (2015)	69	Not indicated	T group: 40.37; C group: 33.65	No mention of hearing status	90	T: 500, NT: 2,000
Bestelmeyer et al. (2009)	E1: 27 twin pairs; E2: 75	Not indicated	E1: T group (MZ twins): 34.1; T group (DZ twins): 33.8; E2: T group (SZ): 41.5; T group (BPD): 49.5; C group: 37.4	E1: Excluded participants based on self-reported hearing impairment	70	T: 2,000, NT: 1,000
Bonanni et al. (2010)	119	Not indicated	T group (AD): 71.7; T group (DLB): 69.9; C group: 72.0	No mention of hearing status	75	T: 500, NT: 1,000
Bramon et al. (2005)	110	T group: 25–56; T group (relatives): 18–70; C: 18–70	T group: 35.8; T group (relatives): 51.0; C group: 42.4	No mention of hearing status	80	T: 1,500, NT: 1,000
Chang et al. (2006)	38	45–63	T group: 57,3	Excluded participants based on self-reported hearing impairment	80	T: 2,000, NT: 750
Decoster et al. (2012)	332	14.4–64.2	T group: 32.4	No mention of hearing status	70	T: 1,470, NT: 800
Ford et al. (2001)	78	19–63	T group (SZ): 37.3; T group (epilepsy with SZ): 34.7; T group (epilepsy without SZ): 41.4; C group: 38	No mention of hearing status	80	T: 1,000, NT: 500
Ford et al. (2008)	43	Not indicated	T group: 39.19; C group: 37.29	No mention of hearing status	80	T: 1,000, NT: 500
Hall et al. (2007) **[Hall, Rijsdijk, Kalidindi, et al. or Hall, Schulze, Picchioni, et al. Please clarify]**	94 twin pairs	Not indicated	T group (twins – discordant): 41.8; T group (twins – concordant): 40.3; C group (MZ): 33.3; C group (DZ): 40.2	Excluded participants based on self-reported hearing impairment	43 above threshold	T: 1,500, NT: 1,000
Hall et al. (2007) **[Hall, Rijsdijk, Kalidindi, et al. or Hall, Schulze, Picchioni, et al. Please clarify]**	25 twin pairs; 77 other	T group (twins – concordant): 23–64; T group (twins – discordant): 23–52; C group (MZ): 19–56; C group (DZ): 20–58	T group (twins – concordant): 41.5; T group (twins = discordant): 31.6; C group (MZ): 33.1; C group (DZ): 40.2	Excluded participants based on self-reported hearing impairment	43 above threshold	T: 1,500, NT: 1,000
Hall et al. (2009)	94 twin pairs; 70 other	Not indicated	T group (BPD): 42.34; T group (parents): 43.31; T group (siblings): 42.84; C group: 37.14	Excluded participants based on self-reported hearing impairment	80	T: 1,500, NT: 1,000
Iwanami et al. (2000)	29	Not indicated	T group: 34.7	No mention of hearing status	75	T: 2,000, NT: 1,000
Iwanami et al. (2001)	10	Not indicated	T group: 36.6	No mention of hearing status	75	T: 2,000, NT: 1,000
Jahshan et al. (2012)	109	18–60	T group (BPD): 45.2.5; T group (SZ): 45.6; C group: 39.5	No mention of hearing status	85	1,000
Karaaslan et al. (2003)	56	T group: 19–51 C group: 20–48	T group: 35.63; C group: 34.30	No mention of hearing status	Not indicated	T: 2,000, NT: 1,000
Katada et al. (2003)	13	70–88	T group: 78.0	No mention of hearing status	70	T: 2,000, NT: 1,000
Kim et al. (2014)	88	Not indicated	T group: 33.91: C group: 34.74	Evaluated hearing sensitivity – auditory functioning was examined using a 512-Hz tuning fork	85	T: 1,500, NT: 1,000

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Table 3. (Continued)

Author(s) & year	Number of participants	Age range (years)	Mean age	Documentation of hearing status	Stimulus intensity (dB)	Stimulus frequency (Hz)
Kimble et al. (2000)	30	28–70	T group (relatives): 44.1; C group: 43.7	No mention of hearing status	97	T: 1,500, NT: 1,000
Korostenskaja et al. (2005)	26	T group: 18–55; C group: 23–55	T group: 31.9; C group: 34.7	No mention of hearing status	60	T: 1,000, NT: 2,000
Lebedeva & Orlova (2001)	60	T group (parents): 30–65; T group (siblings/children): 17–35; C group 1: 30–68; C group 2: 18–38	T group (parents): 51.8; T group (siblings/children): 24.9; C group 1: 49.3; C group 2: 26.0	Excluded participants based on self-reported hearing impairment	60	T: 1,000, NT: 2,000
Light et al. (2015)	1,790	Not indicated	T: group 46.25; C group: 38.63	Evaluated hearing sensitivity, an unspecified hearing test was conducted to ensure a > 40 dB hearing threshold bilaterally at 1000 Hz	85	1,000
Mathalon et al. (2000)	70	T group: 27–55; C group: 22–60	T group: 38.7; C group: 42.8	Excluded participants based on self-reported hearing impairment	80	T: 1,000, NT: 500
Mathalon & Ford (2002)	20	T group: 22–54; C group: 32–67	T group: 40.5; C group: 50.1	No mention of hearing status	86	T: 1,000, NT: 500
Mathalon et al. (2010)	59	T group (SZ): 22–56; T group (affective): 21–55; C group: 23–59	T group (SZ): 39.95; T group (affective): 36.46; C group: 37.29	No mention of hearing status	80	T: 1,000, NT: 500
O'Donnell et al. (2004)	49	18–65	T group (BPD): 39.6; T group (SZ): 40.8; C group: 37.8	Excluded participants based on self-reported hearing impairment	86	T: 1,500, NT: 1,000
O'Donoghue et al. (2014)	97	18–60	T group 1: 41; T group 2: 47.8; T group 3: 40.2; C group 1: 38.8; C group 2: 41.1; C group 3: 40.2	No mention of hearing status	80	T: 1,500, NT: 1,000
Ozgürdal et al. (2008)	166	Not indicated	T group (prodromal): 26.11; T group (FE): 26.39; T group (chronic SZ): 37.96; C group: 27.78	No mention of hearing status	83	T: 1,000, NT: 500
Perlman et al. (2015)	136	16–60 (at first admission)	T group (SZ): 44.29; T group (psychosis): 43.98; C group: 45.80	No mention of hearing status	75	Not mentioned
Pokryszko-Dragan et al. (2003)	26	56–77	T group: 68.6	No mention of hearing status	70	T: 2,000, NT: 1,000
Preskorn et al. (2014)	21	18–55	T group (medication 1): 51.4; T group (medication 2): 43.1; T group (placebo): 40.0	No mention of hearing status	50 above threshold	T: 1,000, NT: 500
Röschke & Wagner (2003)	42	Not indicated	T group: 39; C group: 38.1	Excluded participants based on self-reported hearing impairment	80	T: 2,000, NT: 1,500
Schulze et al. (2008)	117	18–60	T group: 43.3; T group (relatives): 43.2; C group: 40.2	No mention of hearing status	80	T: 1,500, NT: 1,000
Shin et al. (2010)	59	Not indicated	T group: 36.8; T group (SPD): 39.2; C group: 36.4	No mention of hearing status	86	T: 1,500, NT: 1,000

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Table 3. (Continued)

Author(s) & year	Number of participants	Age range (years)	Mean age	Documentation of hearing status	Stimulus intensity (dB)	Stimulus frequency (Hz)
Sumi et al. (2001)	97	T group: 60–84; C group: 60–77	T group (SZ): 65.5; T group (AD): 69.6; C group: 68.5	Excluded based on a history of disorders known to be related to hearing loss	70	T: 1,000, NT: 2,000
Thomas et al. (2001)	140	T group: 58–73; C group: 57–78	T group: 65.0; C group: 67.5	No mention of hearing status	75	T: 2,000, NT: 500
Turetsky et al. (2015)	1,236	Not indicated	T group: 43	Evaluated hearing sensitivity, an unspecified hearing test was conducted to ensure a > 40 dB hearing threshold bilaterally at 1,000 Hz	Not indicated	T: 1,500, NT: 1,000
Urretavizcaya et al. (2003)	81	Not indicated	T group: 55.6; C group: 52.9	Excluded participants based on self-reported hearing impairment	75	T: 6,000, NT: 2,000
Van Der Stelt et al. (2005)	62	T group (HR): 15–30; T group (RO SZ): 17–25; T group (chronic): 18–51; C group (younger): 19–25; C group (older): 24–57	T group (HR): 22.1; T group (RO SZ): 21.3; T group (chronic): 37.5; C group (younger): 22.5; C group (older): 34.1	Excluded participants based on self-reported hearing impairment	85	T: 1,064, NT: 1,000
Wang et al. (2010)	44	T group: 16–57; C group: 17–52	T group: 28.63; C group: 32.88		80	T: 1,500, NT: 1,000
Winterer et al. (2001) **[Winterer, Egan, et al. or Winterer, Mulert, et al. Please clarify]**	138	18–60	T group: 37.0; T group (siblings): 36.9; C group: 35.2	No mention of hearing status	80	T: 1,500, NT: 1,000
Winterer et al. (2001) **[Winterer, Egan, et al. or Winterer, Mulert, et al. Please clarify]**	43	Not indicated	T group: 36.27; C group: 34.16	No mention of hearing status	65	T: 1,000, NT: 2,000
Winterer et al. (2003)	270	18–60	T group: 36.8; T group (siblings): 37.0; C group: 34.9	No mention of hearing status	80	T: 1,500, NT: 1,000
Younger et al. (2005)	254	Not indicated	T group: 38.1; C group: 38.0	No mention of hearing status	80	T: 1,000, NT: 2,000

Note. AD = Alzheimer's disease; DLB = dementia with Lewy Bodies; MZ = monozygotic; DZ = dizygotic; SZ = schizophrenia; BPD = bipolar disorder; HR = high risk; RO = recent onset; FE = first episode; SPD = schizotypal personality disorder; T = test; C = control; T = target stimulus; NT = non-target stimulus.

disorders. Usually, P300 response latency and amplitude are analyzed in participants suspected of or diagnosed with these disorders (Hall, 2015; Picton, 1992). Hearing loss influences the amplitude and latency of the auditory P300 response (Picton, 1992; Reis et al., 2015). It is likely that the inclusion of participants with peripheral hearing loss has affected the P300 results of some of these published studies and, therefore, the conclusions drawn from data analysis.

We found that authors of studies exploring the application of the auditory P300 response being clinically applied for neurological and psychological disorders do not consistently account for the peripheral hearing sensitivity of participants. Over 90% of studies of the auditory P300 response did not include an evaluation or a description of participant hearing status, and participants with hearing impairments were not excluded from these studies. The lack of documentation of hearing status was most troublesome for studies with participants over 50 years of age and at greater risk of age-related hearing loss. These studies accounted for 42% of the articles reviewed. Decreased auditory P300 amplitudes and prolonged latencies are characteristic of persons with hearing loss (Pollock & Schneider, 1992; Reis et al., 2015). In addition, the degree and configuration of the hearing loss may differentially influence the P300 response for frequent (non-target) versus rare (target) stimuli. Furthermore, it is possible that participants with hearing loss may not completely hear or fully understand instructions for the required P300 task. Unrecognized or inadequately described hearing loss in participants in P300 studies may confound the neurophysiological assessment of higher-level auditory and cognitive function.

The relatively small proportion of studies that took hearing status into account relied on self-reports of hearing difficulty. There is a general agreement that self-reported hearing impairment and actual hearing status based on pure-tone hearing assessment are not well correlated (Choi et al., 2019; Nondahl et al., 1998; Valete-Rosalino & Rozenfeld, 2005). The inclusion or exclusion of participants in auditory P300 studies based on self-reported hearing status is not recommended. Rather, participant hearing status is best defined with accepted methods and procedures for hearing assessment, such as pure tone audiometry conducted by a licensed audiologist or validated automated audiometer software (Hall, 2014).

Less than 10% of the reviewed studies evaluated participant hearing sensitivity, and only two publications documented how the hearing was assessed. Five studies did not indicate how the hearing was assessed but stated that hearing thresholds were below 40 dB at 1,000 Hz. None of the studies specified how the hearing was assessed or the skill level or training of personnel conducting the assessment.

Remarkably, the authors of only one study evaluated hearing sensitivity using a comprehensive diagnostic audiological test battery to exclude participants with any degree of hearing loss (Mattsson et al., 2019). The article was published in the *International Journal of Audiology*. A hearing assessment conducted in an isolated sound room included pure tone audiometry, tympanometry, acoustic reflexes, otoscopic examination, word recognition score testing, and auditory brainstem response (ABR or BAER) measurements. Unfortunately, no information was provided on the clinical credentials of the person(s) who conducted the assessments. In this study (Mattsson et al., 2019), participants with hearing thresholds greater than 20 dB were excluded. Clinical practice guidelines call for formal assessment of the peripheral auditory status of children and adults who undergo diagnostic evaluation for APD with behavioral or electrophysiological procedures (*American Academy of Audiology Practice Guidelines* [Musiek et al., 2010]).

We hope this paper will increase awareness of the importance of adequately documenting peripheral hearing status and establish a greater appreciation of the effects of peripheral hearing sensitivity on the auditory P300 response among P300 researchers. We recommend regular documentation of the peripheral hearing status of participants in all studies of the auditory P300, including those conducted by researchers from the disciplines of neurology, psychology, and psychiatry. Our review also suggests a role for hearing health care professionals in the peer-review process prior to publishing manuscripts on the P300 being clinically applied for neurological and psychological disorders.

References

Bachiller, A., Lubeiro, A., Díez, Á., Suazo, V., Domínguez, C., Blanco, J. A., Ayuso, M., Hornero, R., Poza, J., & Molina, V. (2015). Decreased entropy modulation of EEG response to novelty and relevance in schizophrenia during a P300 task. *European Archives of Psychiatry and Clinical Neuroscience, 265*(6), 525–535. https://doi.org/10.1007/s00406-014-0525-5

Bestelmeyer, P. E. G., Phillips, L. H., Crombie, C., Benson, P., & St. Clair, D. (2009). The P300 as a possible endophenotype for schizophrenia and bipolar disorder: Evidence from twin and patient studies. *Psychiatry Research, 169*(3), 212–219. https://doi.org/10.1016/j.psychres.2008.06.035

Bonanni, L., Franciotti, R., Onofrj, V., Anzellotti, F., Mancino, E., Monaco, D., Gambi, F., Manzoli, L., Thomas, A., & Onofrj, M. (2010). Revisiting P300 cognitive studies for dementia diagnosis: Early dementia with lewy bodies (DLB) and Alzheimer's disease (AD). *Clinical Neurophysiology, 40*(5–6), 255–265. https://doi.org/10.1016/j.neucli.2010.08.001

Bramon, E., McDonald, C., Croft, R. J., Landau, S., Filbey, F., Gruzelier, J. H., Sham, P. C., Frangou, S., & Murray, R. M. (2005). Is the P300 wave an endophenotype for schizophrenia? A meta-analysis and a family study. *NeuroImage, 27*(4), 960–968. https://doi.org/10.1016/j.neuroimage.2005.05.022

Brewster, K. K., Hu, M. C., Wall, M. M., Brown, P. J., Zilcha-Mano, S., Roose, S. P., Stein, A., Golub, J. S., & Rutherford, B. R. (2021). Age-related hearing loss, neuropsychological performance, and incident dementia in older adults. *Journal of Alzheimer's Disease, 80*(2), 855–864. https://doi.org/10.3233/JAD-200908

Chang, M. Z., Zhang, W. P., Zhao, Y. X., Wu, H. Q., & Xiang, L. (2006). Value of P300 detection in evaluating cognitive impairment of patients with silent cerebral infarction and depression. *Chinese Journal of Clinical Rehabilitation, 10*(14), 174–176.

Choi, J. E., Moon, I. J., Baek, S. Y., Kim, S. W., & Cho, Y. S. (2019). Discrepancies between self-reported hearing difficulty and hearing loss diagnosed by audiometry: Prevalence and associated factors in a national survey. *BMJ Open, 9*(4), Article e022440. https://doi.org/10.1136/bmjopen-2018-022440

Cui, Y., Liu, F., Zhang, X., Tang, P., Liu, P., Zhang, B., & Liu, J. (2009). Auditory P300 in the patients with traumatic brain injury. *Fa Yi Xue Za Zhi, 25*(1), 19–23.

Decoster, J., De Hert, M., Viechtbauer, W., Nagels, G., Myin-Germeys, I., Peuskens, J., van Os, J., & van Winkel, R. (2012). Genetic association study of the P300 endophenotype in schizophrenia. *Schizophrenia Research, 141*(1), 54–59. https://doi.org/10.1016/j.schres.2012.07.018

Fjell, A. M., & Walhovd, K. B. (2003). Effects of auditory stimulus intensity and hearing threshold on the relationship among P300, age, and cognitive function. *Clinical Neurophysiology, 114*(5), 799–807. https://doi.org/10.1016/S1388-2457(03)00030-0

Ford, J. M., Mathalon, D. H., Kalba, S., Marsh, L., & Pfefferbaum, A. (2001). N1 and P300 abnormalities in patients with schizophrenia, epilepsy, and epilepsy with schizophrenialike features. *Biological Psychiatry, 49*(10), 848–860. https://doi.org/10.1016/S0006-3223(00)01051-9

Ford, J. M., Roach, B. J., Hoffman, R. S., & Mathalon, D. H. (2008). The dependence of P300 amplitude on gamma synchrony breaks down in schizophrenia. *Brain Research, 1235*, 133–142. https://doi.org/10.1016/j.brainres.2008.06.048

Frodl, T., Meisenzahl, E. M., Müller, D., Holder, J., Juckel, G., Möller, H. J., & Hegerl, U. (2002). P300 subcomponents and clinical symptoms in schizophrenia. *International Journal of Psychophysiology, 43*(3), 237–246. https://doi.org/10.1016/S0167-8760(01)00182-9

Gates, G. A., & Mills, J. H. (2005). Presbycusis. *Lancet, 366*(9491), 1111–1120. https://doi.org/10.1016/S0140-6736(05)67423-5

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal, 26*(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Hall, J. W. III (2014). *Introduction to audiology today* (1st ed.). Pearson.

Hall, J. W. III (2015). *eHandbook of auditory evoked responses*. Kindle Direct Publishing.

Hall, M. H., Rijsdijk, F., Kalidindi, S., Schulze, K., Kravariti, E., Kane, F., Sham, P., Bramon, E., & Murray, R. M. (2007). Genetic overlap between bipolar illness and event-related potentials. *Psychological Medicine, 37*(5), 667–678. https://doi.org/10.1017/S003329170600972X

Hall, M. H., Rijsdijk, F., Picchioni, M., Schulze, K., Ettinger, U., Toulopoulou, T., Bramon, E., Murray, R. M., & Sham, P. (2007). Substantial shared genetic influences on schizophrenia and event-related potentials. *American Journal of Psychiatry, 164*(5), 804–812. https://doi.org/10.1176/ajp.2007.164.5.804

Hall, M. H., Schulze, K., Rijsdijk, F., Kalidindi, S., McDonald, C., Bramon, E., Murray, R. M., & Sham, P. (2009). Are auditory P300 and duration MMN heritable and putative endophenotypes of psychotic bipolar disorder? A Maudsley bipolar twin and family study. *Psychological Medicine, 39*(8), 1277–1287. https://doi.org/10.1017/S0033291709005261

Iwanami, A., Kato, N., Kasai, K., Kamio, S., Furukawa, S.-I., Fukuda, M., Nakagome, K., Araki, T., Okajima, Y., Isono, H., & Kamijima, K. (2002). P300 amplitude over temporal regions in schizophrenia. *European Archives of Psychiatry and Clinical Neuroscience, 252*(1), 1–7. https://doi.org/10.1007/s004060200000

Iwanami, A., Okajima, Y., Isono, H., Shinoda, J., Kasai, K., Hata, A., Fukuda, M., Nakagome, K., & Kamijima, K. (2001). Effects of risperidone on event-related potentials in schizophrenic patients. *Pharmacopsychiatry, 34*(2), 73–79. https://doi.org/10.1055/s-2001-15181

Iwanami, A., Okajima, Y., Kuwakado, D., Isono, H., Kasai, K., Hata, A., Nakagome, K., Fukuda, M., & Kamijima, K. (2000). Event-related potentials and thought disorder in schizophrenia. *Schizophrenia Research, 42*(3), 187–191. https://doi.org/10.1016/s0920-9964(99)00132-2

Jahshan, C., Wynn, J. K., Mathis, K. I., Altshuler, L. L., Glahn, D. C., & Green, M. F. (2012). Cross-diagnostic comparison of duration mismatch negativity and P3a in bipolar disorder and schizophrenia. *Bipolar Disorders, 14*(3), 239–248. https://doi.org/10.1111/j.1399-5618.2012.01008.x

Jeon, Y. W., & Polich, J. (2003). Meta-analysis of P300 and schizophrenia: Patients, paradigms, and practical implications. *Psychophysiology, 40*(5), 684–701. https://doi.org/10.1111/1469-8986.00070

Jirsa, R. E., & Clontz, K. B. (1990). Long latency auditory event-related potentials from children with auditory processing disorders. *Ear and Hearing, 11*(3), 222–232. https://doi.org/10.1097/00003446-199006000-00010 **[author: doi ok?]**

Karaaslan, F., Gonul, A. S., Oguz, A., Erdinc, E., & Esel, E. (2003). P300 changes in major depressive disorders with and without psychotic features. *Journal of Affective Disorders, 73*(3), 283–287. https://doi.org/10.1016/S0165-0327(01)00477-3

Katada, E., Sato, K., Sawaki, A., Dohi, Y., Ueda, R., & Ojika, K. (2003). Long-term effects of donepezil on P300 auditory event-related potentials in patients with Alzheimer's disease. *Journal of Geriatric Psychiatry and Neurology, 16*(1), 39–43. https://doi.org/10.1177/0891988702250561

Kim, D.-W., Shim, M., Kim, J.-I., Im, C.-H., & Lee, S.-H. (2014). Source activation of P300 correlates with negative symptom severity in patients with schizophrenia. *Brain Topography, 27*(2), 307–317. https://doi.org/10.1007/s10548-013-0306-x

Kimble, M., Lyons, M., O'Donnell, B., Nestor, P., Niznikiewicz, M., & Toomey, R. (2000). The effect of family status and schizotypy on electrophysiologic measures of attention and semantic processing. *Biological Psychiatry, 47*(5), 402–412. https://doi.org/10.1016/S0006-3223(99)00184-5

Korostenskaja, M., Dapsys, K., Siurkute, A., Maciulis, V., Ruksenas, O., & Kähkönen, S. (2005). Effects of olanzapine on auditory P300 and mismatch negativity (MMN) in schizophrenia spectrum disorders. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 29*(4), 543–548. https://doi.org/10.1016/j.pnpbp.2005.01.019

Lebedeva, I. S., & Orlova, V. A. (2001). Features of auditory P300 in relatives of schizophrenic patients. *Human Physiology, 27*(3), 283–293. https://doi.org/10.1023/A:1010961603716

Light, G. A., Swerdlow, N. R., Thomas, M. L., Calkins, M. E., Green, M. F., Greenwood, T. A., Gur, R. E., Gur, R. C., Lazzeroni, L. C., Nuechterlein, K. H., Pela, M., Radant, A. D., Seidman, L. J., Sharp, R. F., Siever, L. J., Silverman, J. M., Sprock, J., Stone, W. S., Sugar, C. A., & Turetsky, B. I. (2015). Validation of mismatch negativity and P3a for use in multi-site studies of schizophrenia: Characterization of demographic, clinical, cognitive, and functional correlates in COGS-2. *Schizophrenia Research, 163*(1–3), 63–72. https://doi.org/10.1016/j.schres.2014.09.042

Loughrey, D. G., Kelly, M. E., Kelley, G. A., Brennan, S., & Lawlor, B. A. (2018). Association of age-related hearing loss with cognitive function, cognitive impairment, and dementia: A systematic review and meta-analysis. *JAMA Otolaryngology: Head and Neck Surgery, 144*(2), 115–126. https://doi.org/10.1001/jamaoto.2017.2513

Mathalon, D. H., & Ford, J. M. (2002). The long and the short of it: Influence of interstimulus interval on auditory P300 abnormalities in schizophrenia. *Clinical EEG and Neuroscience, 33*(3), 125–135. https://doi.org/10.1177/155005940203300309

Mathalon, D. H., Ford, J. M., & Pfefferbaum, A. (2000). Trait and state aspects of p300 amplitude reduction in schizophrenia: A retrospective longitudinal study. *Biological Psychiatry, 47*(5), 434–449. https://doi.org/10.1016/S0006-3223(99)00277-2

Mathalon, D., Hoffman, R., Watson, T., Miller, R., Roach, B., & Ford, J. (2010). Neurophysiological distinction between schizophrenia and schizoaffective disorder. *Frontiers in Human Neuroscience* **[Author: please check and approve the volume and article ID added]** 3, Article 70. https://doi.org/10.3389/neuro.09.070.2009

Mattsson, T. S., Lind, O., Follestad, T., Grøndahl, K., Wilson, W., Nicholas, J., Nordgård, S., & Andersson, S. (2019). Electrophysiological characteristics in children with listening difficulties, with or without auditory processing disorder. *International Journal of Audiology, 58*(11), 704–716. https://doi.org/10.1080/14992027.2019.1621396

Melynyte, S., Wang, G. Y., & Griskova-Bulanova, I. (2018). Gender effects on auditory P300: A systematic review. *International Journal of Psychophysiology, 133*(August), 55–65. https://doi.org/10.1016/j.ijpsycho.2018.08.009

Musiek, F. E., Baran, J. A., James Bellis, T., Chermak, G. D., Hall, J. W. III, Professor, C., Keith, R. W., Medwetsky, L., Loftus West, K., Young, M., Nagle, S., & Volunteer, S. (2010). ***[author: please add publisher]*** *American Academy of Audiology clinical practice guidelines: Diagnosis, treatment and management of children and adults with central auditory processing.*

Nondahl, D., Cruickshanks, K., Wiley, T., Tweed, T., Klein, R., & Klein, B. (1998). Accuracy of self-reported hearing loss. *Audiology, 37*(5), 295–301. https://doi.org/10.1016/j.jaci.2012.05.050

O'Donnell, B. F., Vohs, J. L., Hetrick, W. P., Carroll, C. A., & Shekhar, A. (2004). Auditory event-related potential abnormalities in bipolar disorder and schizophrenia. *International Journal of Psychophysiology, 53*(1), 45–55. https://doi.org/10.1016/j.ijpsycho.2004.02.001

O'Donoghue, T., Morris, D. W., Fahey, C., Da Costa, A., Moore, S., Cummings, E., Leicht, G., Karch, S., Hoerold, D., Tropea, D., Foxe, J. J., Gill, M., Corvin, A., & Donohoe, G. (2014). Effects of ZNF804A on auditory P300 response in schizophrenia. *Translational Psychiatry, 4*, Article e345. https://doi.org/10.1038/tp.2013.115

Ozgürdal, S., Gudlowski, Y., Witthaus, H., Kawohl, W., Uhl, I., Hauser, M., Gorynia, I., Gallinat, J., Heinze, M., Heinz, A., & Juckel, G. (2008). Reduction of auditory event-related P300 amplitude in subjects with at-risk mental state for schizophrenia. *Schizophrenia Research, 105*(1–3), 272–278. https://doi.org/10.1016/j.schres.2008.05.017

Pedroso, R. V., Fraga, F. J., Corazza, D. I., Andreatto, C. A. A., de Melo Coelho, F. G., Costa, J. L. R., & Santos-Galduróz, R. F. (2012). P300 latency and amplitude in alzheimer's disease: A systematic review. *Brazilian Journal of Otorhinolaryngology, 78*(4), 126–132. https://doi.org/10.1590/S1808-86942012000400023

Perlman, G., Foti, D., Jackson, F., Kotov, R., Constantino, E., & Hajcak, G. (2015). Clinical significance of auditory target P300 subcomponents in psychosis: Differential diagnosis, symptom profiles, and course. *Schizophrenia Research, 165*(2–3), 145–151. https://doi.org/10.1016/j.schres.2015.04.013

Picton, T. W. (1992). The P300 wave of the human event-related potential. *Journal of Clinical Neurophysiology, 9*(4), 456–479. https://doi.org/10.1097/00004691-199210000-00002

Pokryszko-Dragan, A., Słotwiński, K., & Podemski, R. (2003). **[Author: please check and approve the page range added]** Modality-specific changes in P300 parameters in patients with dementia of the Alzheimer type. *Medical Science Monitor, 9*(4), CR130–CR134.

Polich, J. (1986). Attention, probability, and task demands as determinants of P300 latency from auditory stimuli. *Electroencephalography and Clinical Neurophysiology, 63*(3), 251–259. https://doi.org/10.1016/0013-4694(86)90093-3

Polich, J. (1991). P300 in clinical applications: Meaning, method, and measurement. *American Journal of EEG Technology, 31*(3), 201–231. https://doi.org/10.1080/00029238.1991.11080373

Polich, J. (2004). Clinical application of the P300 event-related brain potential. *Physical Medicine and Rehabilitation Clinics, 15*(1), 133–161. https://doi.org/10.1016/S1047-9651(03)00109-8

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*(10), 2128–2148. https://doi.org/10.1016/j.clinph.2007.04.019

Polich, J., Ellerson, P. C., & Cohen, J. (1996). P300, stimulus intensity, modality, and probability. *International Journal of Psychophysiology, 23*(1–2), 55–62. https://doi.org/10.1016/0167-8760(96)00028-1

Polich, J., & Heine, M. R. D. (1996). P300 topography and modality effects from a single-stimulus paradigm. *Psychophysiology, 33*(6), 747–752. https://doi.org/10.1111/j.1469-8986.1996.tb02371.x

Pollock, V. E., & Schneider, L. S. (1992). P3 from auditory stimuli in healthy elderly subjects: Hearing threshold and tone stimulus frequency. *International Journal of Psychophysiology, 12*(3), 237–241. https://doi.org/10.1016/0167-8760(92)90062-G

Preskorn, S. H., Gawryl, M., Dgetluck, N., Palfreyman, M., Bauer, L. O., & Hilt, D. C. (2014). Normalizing effects of EVP-6124, an alpha-7 nicotinic partial agonist, on event-related potentials and cognition: A proof of concept, randomized trial in patients with schizophrenia. *Journal of Psychiatric Practice, 20*(1), 12–24. https://doi.org/10.1097/01.pra.0000442935.15833.c5

Puttabasappa, M., Rajanna, M., Jaisinghani, P., & Shukla, S. (2017). Auditory P300 in typical individuals: Age and gender effect. *International Journal of Health Sciences and Research, 7*(May), 2249–9571.

Ralli, M., Gilardi, A., Di Stadio, A., Severini, C., Antonio Salzano, F., Greco, A., & de Vincentiis, M. (2019). Hearing loss and Alzheimer's disease: A review. *International Tinnitus Journal, 23*(2), 79–85. https://doi.org/10.5935/0946-5448.20190014

Reis, A. C. M. B., Frizzo, A. C. F., de Lima Isaac, M., Garcia, C. F. D., Funayama, C. A. R., & Iório, M. C. M. (2015). P300 in individuals with sensorineural hearing loss. *Brazilian Journal of Otorhinolaryngology, 81*(2), 126–132. https://doi.org/10.1016/j.bjorl.2014.10.001

Rigters, S. C., Van Der Schroeff, M. P., Papageorgiou, G., Baatenburg De Jong, R. J., & Goedegebure, A. (2019). Progression of hearing loss in the ageing population: Repeated auditory measurements in the Rotterdam study. *Audiology and Neurotology, 23*(5), 290–297. https://doi.org/10.1159/000492203

Röschke, J., & Wagner, P. (2003). A confirmatory study on the mechanisms behind reduced P300 waves in depression. *Neuropsychopharmacology, 28*(Suppl 1), S9–S12. https://doi.org/10.1038/sj.npp.1300139

Roth, W. T., & Cannon, E. H. (1972). Some features of the auditory evoked response in schizophrenics. *Archives of General Psychiatry, 27*(4), 466–471. https://doi.org/10.1001/ARCHPSYC.1972.01750280034007

Salvi, R., Ding, D., Jiang, H., Di Chen, G., Greco, A., Manohar, S., Sun, W., & Ralli, M. (2018). Hidden age-related hearing loss and hearing disorders: Current knowledge and future directions. *Hearing, Balance and Communication, 16*(2), 74–82. https://doi.org/10.1080/21695717.2018.1442282

Schulze, K. K., Hall, M. H., Mcdonald, C., Marshall, N., Walshe, M., Murray, R. M., & Bramon, E. (2008). Auditory P300 in patients with bipolar disorder and their unaffected relatives. *Bipolar Disorders, 10*(3), 377–386. https://doi.org/10.1111/j.1399-5618.2007.00527.x

Shin, Y. W., Krishnan, G., Hetrick, W. P., Brenner, C. A., Shekhar, A., Malloy, F. W., & O'donnell, B. F. (2010). Increased temporal variability of auditory event-related potentials in schizophrenia and schizotypal personality disorder. *Schizophrenia Research, 124*(1–3), 110–118. https://doi.org/10.1016/j.schres.2010.08.008

Sumi, N., Harada, K., Fujimoto, O., Taguchi, S., Ohta, Y., Nan-no, H., Hanatani, T., & Takeda, M. (2001). Inter-peak latency of auditory event-related potentials (P300) in cases of aged schizophrenia and Alzheimer-type dementia. *Psychogeriatrics, 1*(1), 64–68. https://doi.org/10.1111/j.1479-8301.2001.tb00074.x

Thomas, A., Iacono, D., Bonanni, L., D'Andreamatteo, G., & Onofrj, M. (2001). Donepezil, rivastigmine, and vitamin E in Alzheimer's disease: A combined P300 event-related potentials/neuropsychologic evaluation over 6 months. *Clinical Neuropharmacology, 24*(1), 31–42. https://doi.org/10.1097/00002826-200101000-00007

Thomson, R. S., Auduong, P., Miller, A. T., & Gurgel, R. K. (2017). Hearing loss as a risk factor for dementia: A systematic review. *Laryngoscope Investigative Otolaryngology, 2*(2), 69–79. https://doi.org/10.1002/lio2.65

Turetsky, B. I., Dress, E. M., Braff, D. L., Calkins, M. E., Green, M. F., Greenwood, T. A., Gur, R. E., Gur, R. C., Lazzeroni, L. C., Nuechterlein, K. H., Radant, A. D., Seidman, L. J., Siever, L. J., Silverman, J. M., Sprock, J., Stone, W. S., Sugar, C. A., Swerdlow, N. R., Tsuang, D. W., & Light, G. (2015). The utility of P300 as a schizophrenia endophenotype and predictive biomarker: Clinical and socio-demographic modulators in COGS-2. *Schizophrenia Research, 163*(1–3), 53–62. https://doi.org/10.1016/j.schres.2014.09.024

Urretavizcaya, M., Moreno, I., Benlloch, L., Cardoner, N., Serrallonga, J., Menchón, J. M., & Vallejo, J. (2003). Auditory event-related potentials in 50 melancholic patients: Increased N100, N200 and P300 latencies and diminished P300 amplitude. *Journal of Affective Disorders, 74*(3), 293–297. https://doi.org/10.1016/s0165-0327(02)00016-2

Valete-Rosalino, C. M., & Rozenfeld, S. (2005). Auditory screening in the elderly: Comparison between self-report and audiometry. *Brazilian Journal of Otorhinolaryngology, 71*(2), 193–200. https://doi.org/10.1016/s1808-8694(15)31310-0

Van Der Stelt, O., Lieberman, J. A., & Belger, A. (2005). Auditory P300 in high-risk, recent-onset and chronic schizophrenia. *Schizophrenia Research, 77*(2–3), 309–320. https://doi.org/10.1016/j.schres.2005.04.024

Wang, J., Tang, Y., Li, C., Mecklinger, A., Xiao, Z., Zhang, M., Hirayasu, Y., Hokama, H., & Li, H. (2010). Decreased P300 current source density in drug-naive first episode schizophrenics revealed by high density recording. *International Journal of Psychophysiology, 75*(3), 249–257. https://doi.org/10.1016/j.ijpsycho.2009.12.005

Winterer, G., Egan, M. F., Rädler, T., Coppola, R., & Weinberger, D. R. (2001). Event-related potentials and genetic risk for schizophrenia. *Biological Psychiatry, 50*(6), 407–417. https://doi.org/10.1016/s0006-3223(01)01072-1

Winterer, G., Egan, M. F., Rädler, T., Sanchez, C., Jones, D. W., Coppola, R., & Weinberger, D. R. (2003). P300 and genetic risk for schizophrenia. *Archives of General Psychiatry, 60*(11), 1158–1167. https://doi.org/10.1001/archpsyc.60.11.1158

Winterer, G., Mulert, C., Mientus, S., Gallinat, J., Schlattmann, P., Dorn, H., & Herrmann, W. M. (2001). P300 and LORETA: Comparison of normal subjects and schizophrenic patients. *Brain Topography, 13*(4), 299–313. https://doi.org/10.1023/A:1011184814194

World Health Organization. (2019). *Deafness and hearing loss*. WHO. https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss

Younger, W-Y.Y., Tai-Jui, C., Ming-Chao, C., Shih-Jen, T., & Tien-Wen, L. (2005). Effect of age and global function score on schizophrenic p300 characteristics. *Neuropsychobiology, 51*(1), 45–52. https://doi.org/10.1159/000082855

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