

Mascaramento clínico: aplicabilidade dos métodos platô e otimizado na pesquisa dos limiares auditivos***

Clinical masking: applicability of plateau and optimized methods in hearing thresholds testing

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Abstract

Background: many situations may raise difficulties when obtaining hearing thresholds for each ear separately. These situations demand the use of masking. The plateau method has been used for more than four decades. Nevertheless, in 2004 a different masking protocol was suggested, called the optimized method, to replace the plateau method in specific cases. Aim: to evaluate the feasibility of two clinical masking methods, plateau and optimized, in the testing of hearing thresholds. Method: participants of this study were 40 individuals aged 15 to 65 years, with either unilateral or bilateral hearing losses. All participants underwent air and bone conduction pure tone audiometry for both ears, with and without the use of the two masking methods, considering unilateral, bilateral, symmetrical and bone-only patterns. Results: there was no statistically significant difference between the two masking methods for obtaining the air conduction hearing thresholds considering the tested situations. However, there was a higher percentage difference for the symmetrical pattern in the air conduction retest situation. There was a statistically significant difference between the plateau and optimized methods regarding the bone conduction thresholds for the symmetrical and bone-only patterns. Conclusion: the plateau method can be used for all patterns and the optimized method is the most effective for unilateral and bilateral patterns. Therefore, it is important for the audiologist to have the knowledge about the application of both masking methods in order to obtain more reliable results.

Key Words: Hearing; Audiometry; Auditory Threshold; Masking.

Resumo

Tema: na audiometria tonal liminar (ATL) algumas situações dificultam a obtenção dos limiares auditivos para cada orelha separadamente, havendo a necessidade do mascaramento. O método Platô, é o mais utilizado há mais de quatro décadas. Em 2004, foi sugerido um protocolo de mascaramento em que o método Otimizado substituiria o Platô, em casos específicos. Objetivo: analisar a aplicabilidade dos métodos Platô e Otimizado, na pesquisa dos limiares auditivos. Método: participaram deste estudo 40 indivíduos, de 15 a 65 anos, com perda auditiva unilateral ou bilateral. Foi realizada a ATL por via aérea (VA) e via óssea (VO), para ambas as orelhas, sem e com a utilização do mascaramento, segundo os padrões unilateral, bilateral, simétrico e somente-ósseo. Resultados: não houve diferença estatisticamente significativa entre os dois métodos para a obtenção dos limiares por VA, para os padrões avaliados. Contudo, houve um maior percentual de diferença para o padrão simétrico, durante reteste de VA. Houve diferença estatisticamente significativa entre os métodos Platô e Otimizado, para a obtenção dos limiares por VO, para os padrões: simétrico e somente-ósseo. Conclusão: o Método Platô pode ser utilizado para todos os padrões e o Otimizado é mais eficaz para os padrões unilateral e bilateral. Desta forma, é necessário que o audiólogista saiba diferenciar os melhores casos para a aplicação de um dos dois métodos e assim, obter resultados fidedignos.

Palavras-Chave: Audição; Audiometria; Limiar Auditivo; Mascaramento.

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Introduction

In pure tone audiometry (PTA), some situations make the obtaining of hearing thresholds for each ear separately, demanding the use of masking.

Masking has been defined as the lowering of a sound perception made through the introduction of a noise to avoid the occurrence of contralateral hearing, allowing the determination of hearing threshold for each ear independently¹⁻³.

Although some book have been published in Brazil, it's possible to evidence the lack of studies about this theme within the last decades, hindering a deeper knowledge of this issue^{1,3-4}. With the advent of electroacoustic and electrophysiological hearing assessment, the studies related to basic hearing assessment are being even more extinguished.

Perhaps the search for further knowledge regarding this specific procedure wouldn't be necessary if all aspects related to it had been explored and if this difficulty of some people, students or professionals, in using masking were not observed. Despite the clinical experience moves towards similar practices, some masking methods are out of clinic and of the teaching as formal, valid procedures.

The Plateau Method⁵ has been the most used in audiometric practice for the last four decades. However, it's considered by some professionals and researchers a long-lasting and of difficult applicability method^{2,6-8}.

The Optimized Method, which is similar to the Plateau, (however faster and of easier applicability, for using a smaller number of masking increments in obtaining the hearing threshold), is based on air conduction thresholds (AC) in the tested ear (TE) to calculate the initial masking level. The Plateau Method is based on the AC thresholds in the nontest ear (NTE)⁷.

A masking protocol in which the Optimized Method would substitute Plateau Method in some situations has been suggested. In order to make it happen, four patterns were defined, based on the audiometric configuration obtained without masking; they are: unilateral, bilateral, symmetrical and bone-only⁸.

Herewith, the aim of this study was to analyze the applicability of Plateau and Optimized Methods, in the research of hearing thresholds.

Method

The study was carried out at Centro de Prevenção e Reabilitação de Deficiências (CEPRED), Salvador - BA, from November 2006 to April 2007 and sanctioned by Comitê de Ética em Pesquisa da Pontifícia Universidade Católica (PUC/SP), under protocol 043/2006.

408 data files were analyzed to compose the sample of this study. People aged from 15 to 65, living in Salvador city, with unilateral or bilateral hearing loss, compatible with the patterns: unilateral (the thresholds without the masking indicate unilateral conductive hearing loss, there is an apparent gap on the TE); bilateral (the NTE's AC thresholds, without the masking, are, at least, 25dB better than the TE's AC thresholds); symmetrical (the AC thresholds, without the masking, are equal - symmetrical - or show a deviation of less than 20 dB); bone-only (there is only the need of masking for bone conduction thresholds of one or both ears)⁸.

Medical profiles which presented notes regarding non-systematic or inconsistent answers, observed during the audiologic assessment, performed at Serviço de Saúde Auditiva, were excluded.

Having this, 41 individuals were selected to be submitted to the procedures. Out of these one was excluded because a collapse of the ear canal was detected. So, the sample of the study was made up of 40 individuals.

The procedures adopted were: otoscopy, immitance audiometry and pure tone audiometry (PTA) through AC and BC, with and without masking using the two methods: Plateau and Optimized. An Interacoustics AD229E audiometer was used, with TDH-39 supra-aural earphones, for the emission of the acoustic stimulus through AC and bone B-71 vibrator for the emission of acoustic stimulus through BC and AZ-7, Interacoustics middle ear analyzer.

The otoscopy aimed to eliminate any obstruction which could impair the procedures and the immitance audiometry was used to complete the audiologic assessment.

Before applying the masking for the PTA, it was necessary to perform a biological calibration of the narrow band masking noise, aiming to verify the effectiveness of the noise for the pure tone masking.

The study of case for the biological calibration was composed of 10 individuals, normal listeners. For the selection of those, hearing thresholds were

obtained through AC, in both ears, totalizing 20 ears. Following, pure tone noise was applied through AC, ipsilateral, on the ear with better thresholds, for each individual, in the frequencies of 1000, 2000, 4000 and 500 Hz, in this sequence. The tone was presented in intensities of 30, 50 and 70 dBHL and the noise in increments of 5 dB, observing the intensity of noise needed in order to make the tone not audible in each frequency⁹. The average value obtained was lower than 5 dB, confirming the effectiveness of the masking noise.

From that on, pure tone audiometry (PTA) was applied to the 40 individuals selected for the study. The hearing thresholds were obtained through AC and BC in frequencies of 500, 1000, 2000 and 4000 Hz, for both ears, without masking. After that, the necessity of masking was analyzed based on the minimum interaural attenuation level of 40 dB for retesting through AC and of 0 dB through BC^{2,10-19}.

A masking process was applied, using Plateau and Optimized methods, following the same stages for the retesting of the thresholds through AC and BC, as described⁷⁻⁸.

Plateau Method:

1. Thresholds were measured through AC and BC, without masking, for each ear.
2. The necessity of masking was analyzed.
3. The initial masking level was introduced 10dB beyond the hearing threshold through AC of the NTE and the hearing threshold through AC or BC retested.
4. The masking level was increased in 10 dB and the threshold retested.
5. When the masking level was increased twice (interval of 20dB) with no changes to the threshold, the real hearing threshold was obtained.

Optimized Method:

1. For each ear, hearing thresholds were measured through AC and BC.
2. The necessity of masking was analyzed.
3. The masking level was introduced 10dB below the AC threshold for the TE and the AC or BC threshold retested.
4. The threshold variance was determined according to the masking noise.
5. The masking level was increased in an amount equal to the variance of the threshold and retested.
6. In case in which there was an improvement in the threshold or in which it remained the same, the real

hearing threshold was determined. When there was alteration in the threshold (worsening), steps 5 and 6 were repeated.

Plateau and Optimized methods were applied alternately.

The data were analyzed for each pattern: unilateral, bilateral, symmetrical and bone-only, looking for possible differences between the hearing thresholds, with the applying of the contralateral masking for Plateau and Optimized methods, during PTA.

The real hearing threshold was considered for the Plateau Method, when the threshold remained the same after two increments of masking noise of at least 20 dB, reaching the plateau region: interval of masking between two points, corresponding to the lowest effective masking level and the maximum allowed^{5,7,20-21}. For the Optimized method, it was considered real threshold when this reached the plateau region, with the application of the expected masking level. The initial masking level is generally bigger than the AC threshold for the NTE, enough to change the threshold and reach the plateau region⁷⁻⁸.

For this study, it was considered significant when the difference between the hearing thresholds obtained was bigger than or equal to 10 dB, based on the fact that pure tone audiometry is a psychoacoustic evaluation and the answers may vary.

Two factors could influence the real values of threshold: the variability of the test and the central masking. The measurement of the threshold may vary typically in more or less 5 dB. Besides that, the central masking can increase the hearing threshold for an average of 5 dB⁷.

The effect of central masking was alleged to be a factor which affects the decisions related to the masking in audiometry, especially through bone conduction¹³.

Although the change in the threshold produced by the masking is around 5 dB, there is considerable variability among individuals¹.

For the statistic analysis of the results, the software R 2.0.1 and the Wilcoxon Statgraphics Plus v. 1.4 were used, adopting 5% for the rejection of the nullity hypothesis. For the comparison of the data, it was considered statistically significant difference value ≥ 0.05 .

Minimum and maximum numbers of necessary increments were flagged during the performing of the masking for retest of the thresholds through AC and BC, for the patterns: unilateral, bilateral,

and compared according to the methods (Plateau and Optimized). Increments of 10 dB were defined for the application of Plateau Method, despite retest (AC and BC), as referred5.

Results

Considering the patterns described in literature8, the distribution of the population is shown in Table 1.

Table 2 presents the results regarding the deviation between the hearing thresholds obtained through AC using both masking methods, considering the patterns, individually.

The biggest deviation found for the retesting for AC was of 10 dB, corresponding to 2.5% of the thresholds tested (bilateral and symmetrical patterns).

Table 3 presents the results regarding the deviation between the hearing thresholds through BC, using both methods, considering the patterns, individually.

The deviation observed for retest for BC vary from 10 to 30 dB, being: 2.6% (10 dB); 2.6% (15 dB); 0.5% (20 dB); 1% (25 dB); 1% (30 dB), considering the retest of the thresholds for bilateral, symmetrical and bone only patterns.

The minimum and maximum number of masking increments needed in order to one obtain the hearing thresholds through AC and BC, was also analyzed, considering unilateral and bilateral patterns, in which similar hearing thresholds were obtained for a higher percentage of frequencies assessed, using both masking methods (Plateau and Optimized).

It was verified that minimum number of three increments was necessary for the retest for AC, for unilateral pattern, considering Plateau Method and of one increment for Optimized Method; for bilateral pattern it was necessary one increment for Plateau Method and one for Optimized Method.

Regarding the maximum number of increments for the masking through AC, six increments were needed for Plateau Method and two for the Optimized Method for each pattern (unilateral and bilateral).

Regarding the minimum number of increments for retest of BC it was necessary: three increments for Plateau Method and one for Optimized Method (unilateral pattern); one increment for Plateau Method and one for Optimized Method (bilateral pattern).

Concerning the maximum number of increments, for the retest of BC, it was necessary: seven increments for Plateau Method and two for

Optimized Method (unilateral pattern); nine increments for Plateau Method and three for Optimized Method (bilateral pattern).

It was verified that despite the test, AC or BC, the Optimized test has used a smaller number of increments for the masking performance.

TABLE 1. Distribution of individuals according to the patterns of classification.

Patterns*	N	Frequency(%)
unilateral	10	25
bilateral	14	35
symmetrical	8	20
bone-only	8	20
TOTAL	40	100

*Unilateral: thresholds without masking point out a conductive unilateral hearing loss (there is an apparent gap in the TE); Bilateral: the AC thresholds, without masking, of the NTE are, at least, 25dB better than the AC thresholds of the TE; Symmetrical: AC thresholds, without masking, are equal (symmetrical), or with a deviation smaller than 20 dB; Bone-only: there was a necessity of masking only for the BC thresholds, in one or both ears.

TABLE 2. Deviation between Plateau and Optimized Methods, for unilateral, bilateral and symmetrical (AC), individually.

deviation (p=1.0000) Unilateral	N= 38	%
no deviation (0 and 5)	38	100.0
deviation (above 5)	0	---
deviation (p=0.3173) bilateral	N=51	%
no deviation (0 and 5)	50	98.0
deviation (above 5)	1	2.0
deviation (p=0.1573) symmetrical	N= 33	%
no deviation (0 and 5)	31	93.9
deviation (above 5)	2	6.1

N= number of observations P- Value (Wilcoxon Test)

TABLE 3. Deviation between Plateau and Optimized Methods, for unilateral, bilateral, bone-only and symmetrical (BC), individually.

deviation (p=1.0000) Unilateral	N=40	%
no deviation (0 and 5)	40	100.0
deviation (above 5)	0	---
deviation (p=0.3173) bilateral	N=53	%
no deviation (0 and 5)	52	98.1
deviation (above 5)	1	1.9
deviation (p=0.0047) symmetrical	N= 53	%
no deviation (0 and 5)	45	84.9
deviation (above 5)	8	15.1
deviation (p=0.0143) bone-only	N= 47	%
no deviation (0 and 5)	41	87.2
deviation (above 5)	6	12.8

N= number of observations P- Value (Wilcoxon Test)

Discussion

Comparing the results obtained using Plateau and Optimized Methods and presented in TABLE 2, we verified there was no statistically significant difference between the methods for the obtaining of the thresholds through AC for the evaluated patterns (unilateral, bilateral and symmetrical). It is important to remember that the bone-only pattern was not evaluated because there is no need of masking through AC for this pattern⁸.

Table 3 showed a statistically significant difference between Plateau and Optimized methods in the determination of the thresholds through BC, for symmetrical and bone-only patterns.

According to the data presented in Tables 2 and 3, it was verified that there was a higher percentage of similarities than differences considering the patterns evaluated.

The higher percentage of differences was observed for the symmetrical pattern (AC and BC). This result is compatible with the literature, which states that the application of the method is not suitable for the symmetrical pattern once the AC thresholds, without masking, would be equal (symmetrical) or with difference lower than 20 dB; this would lead to the introduction of a initial masking level (10 dB lower than the AC threshold of the TE), inaudible to the NTE, not enough intensity for the masking⁸.

By this mean, it would be more appropriate to use Plateau Method for this symmetrical pattern⁸. However, it is important to emphasize that, even though Plateau Method is more indicated, there were situations in this study in which over masking was observed, being, then, difficult to determine the hearing threshold safely, agreeing with the literature^{8,22}. As for the Optimized method, the initial level was not able to mask the NTE, being it sometimes non-audible, as mentioned⁸.

The Optimized Method would be better used when the thresholds without masking met the requirement for the patterns: unilateral and bilateral, that is compatible with this study where we observed a lower percentage of difference between the masking methods for these patterns⁸.

The determination of real hearing threshold occurs when the masking noise is within the Plateau region, what must happen for both methods. The hearing threshold would probably be similar, then, no matter the masking method used⁷.

Regarding the number of masking noise increments needed for the retest of the thresholds (AC and BC), considering unilateral and bilateral patterns in which similar hearing thresholds were obtained for a higher percentage of frequencies tested, it was verified that the Optimized method used a smaller number of increments for the masking, despite of the test (AC or BC), what considerably reduced the evaluation time.

This data agrees with the literature that states that Optimized Method is similar to Plateau, however it's presented aiming to be faster and easier to be applied, because of the use of less increments to reach the real hearing threshold, what would reduce the time of the test⁷⁻⁸.

During this study, when using the Optimized Method and presenting a masking level of high intensity it was necessary to be careful, during some moments in order to avoid discomfort to the patient.

This can happen because the Optimized Method specifies a large increase in the masking level which can produce a masking level over 80 dB HL. When this happens it is recommended to consider small increases in the masking level to identify the plateau⁷⁻⁸.

Therefore, both masking methods presented advantages and disadvantages; the audiologist should be aware of this in order to choose the method consciously, to obtain reliable results during the audiometric assessment. Certainly, other studies will be necessary, allowing new discussions.

Conclusion

Plateau Method can be used for all patterns and Optimized Method is more effective for unilateral and bilateral patterns. Hence, it is necessary that the audiologist knows how to choose the best cases for the use of one of the methods and then obtain reliable results.

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