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Brazilian Portuguese Hearing in Noise Test (HINT): different interpretation criteria for individuals' responses

Hearing in Noise Test (HINT) em português brasileiro: critérios de interpretação de respostas

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Keywords

Hearing
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ABSTRACT

Introduction: The ability to recognize the sounds of speech enables an efficient communication. This ability must always be considered when communication disorders are evaluated. In this study, sentences of the Hearing in Noise Test (HINT), originally developed in English and adapted to Brazilian Portuguese, were used to evaluate speech recognition in silence and in the presence of noise. Although this test can be an important clinical tool, it is noticed that it has not been used in audiological clinical practice in Brazil. One possible reason is the lack of standardization of some aspects of the test, including the methods adopted to analyze the patient's answers. **Purpose:** The aim of this study was to analyze different judgment criteria of individuals' answers during sentence recognition thresholds measurement using the HINT in Brazilian Portuguese. **Methods:** The study was conducted with 30 young adults (three groups of 10 people), between 18 and 25 years old, of both genders, with normal hearing. HINT sentences were adapted to Brazilian Portuguese and speech recognition thresholds were determined in the presence of noise by using three judgment criteria published in Brazilian literature. A single variation analysis was performed to compare the average threshold between the three groups. The maximum error probability to reject the null hypothesis was 5%. **Results:** The mean and standard deviations of thresholds, respectively, were: 59.90 ± 1.43 dB SPL; 59.60 ± 0.53 dB SPL and 59.95 ± 0.6 dB SPL. There was no statistically significant difference between the means (F = 0.398; p> 0.05). **Conclusion:** Regardless the judging criteria used, results obtained in all groups were equivalent.

Descritores

Audição
Compreensão
Percepção da Fala
Ruído
Testes de Discriminação da Fala

RESUMO

Introdução: A capacidade em perceber os sons da fala possibilita ao ser humano comunicar-se de forma eficiente. Esse aspecto deve ser considerado na avaliação dos distúrbios da comunicação humana. O *Hearing in Noise Test* (HINT) foi adaptado para o português brasileiro e faz uso de sentenças para avaliar o reconhecimento de fala em silêncio e na presença de ruído competitivo. O teste pode ser uma ferramenta clínica importante, embora não se observe o uso do HINT na prática clínica audiológica no Brasil. Um dos motivos dessa ausência pode estar relacionado com a falta de padronização em alguns aspectos do teste, incluindo o julgamento de respostas apresentadas durante sua aplicação. **Objetivo:** Analisar os diferentes critérios de julgamento de respostas obtidas de indivíduos submetidos à pesquisa de limiares de reconhecimento das sentenças do HINT em português brasileiro. **Método:** A pesquisa foi realizada com 30 adultos jovens (três grupos de 10 pessoas), entre 18 e 25 anos, de ambos os gêneros, com audição normal. Os indivíduos foram submetidos ao teste de reconhecimento de sentenças em presença de ruído competitivo com uso de sentenças do HINT, adaptado para o português brasileiro. Foram determinados limiares de reconhecimento de sentenças na presença de ruído, através da utilização de três critérios de julgamento publicados na literatura brasileira. Foi realizada uma análise de variação única para comparar as médias dos limiares entre os três grupos. A probabilidade máxima de erro para rejeitar a hipótese nula foi de 5%. **Resultados:** As médias e os desvios padrão dos limiares de reconhecimento de sentenças, respectivamente, foram: 59,90 dB NPS ± 1,43; 59,60 dB NPS ± 0,53 e 59,95 dB NPS ± 0,6. Não houve diferença, estatisticamente significativa, entre as médias (F=0,398; p>0,05). **Conclusão:** Independentemente do critério de julgamento utilizado, as respostas obtidas de indivíduos submetidos à pesquisa de limiares de reconhecimento de sentenças na presença de ruído, foram semelhantes.

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INTRODUCTION

Speech understanding enables human beings to efficiently communicate with each other and is fundamental for social integration. Thus, this ability is one of the most important aspects in the assessment of the hearing function, as it may allow the observation of the receptive communicative function, providing information on how individuals interact in everyday listening situations[1].

Situations of communication between people are permeated by competitive noise in various daily activities. Research has shown that even people with normal hearing may have speech perception altered by everyday environmental noise[2].

The tests that make up the basic audiological assessment do not reflect faithfully the ability to understand speech in social situations, as they are performed in listening occasions in which the background noise is not part of the purpose of such tests. Thus, the information obtained from the basic audiological assessment on the performance of individuals in real life conditions are limited[3].

In this scenario, among many speech listening tests in the presence of noise, the *Hearing in Noise Test* (HINT) is one that verifies the individual's performance on speech recognition in silence and in the presence of background noise. This is, therefore, appropriate to assess more realistic situations and close to listening in daily life.

This instrument contains 12 lists with 20 sentences presented to the individual, in the presence or absence of background noise, and then the individual is asked to repeat what he was told. The percentages of right and/or threshold answers of recognition of sentences are determined. Thus, the HINT can provide more detailed information about hearing functional capacity by assessing sentence recognition ability in noisy environments[3]. In this sense, this test can be a valuable tool for professionals because, besides simulating situations of everyday life, contributes to formulating more accurate audiological diagnoses[4].

Studies with different populations in Brazil have increasingly demonstrated the relevance of the use of HINT adapted to Brazilian Portuguese in audiology, but performances of the judging criteria used to interpret it have not yet been compared. Studies with HINT adapted to Brazilian Portuguese have revealed a variety of judging criteria used by researchers[5-7], and this may hinder its use in clinical practice.

The criterion of Bevilacqua et al.[5] considers that the change of one definite or indefinite article, or even the addition of words without changing the meaning of the sentence, should not be counted as an error. According to the criterion proposed by Danieli[6], the occurrence of reversal in the order of the sentence, provided this does not compromise its meaning, or the change of tense without changing the meaning, should be evaluated as correct answers. In the criterion used by Advíncula et al.[7], any word omitted or not correctly repeated should be computed as an error. These three forms of judgment of responses of individuals under test are described in detail in the literature.

In this scenario, the present study aimed to analyze the different criteria for judgment of responses obtained from individuals undergoing sentence recognition threshold research with the HINT in Brazilian Portuguese.

METHODS

Participants were 30 young adults of both genders, recruited among students and staff of the Federal University of Pernambuco, aged 18-25 years (mean 21.2 years). All were native Brazilian Portuguese speakers and had normal hearing (pure-tone thresholds ≤ 20 dB HL at the octave frequencies from 250 to 8000 Hz in the test ear). No individual reported history of otologic or neurologic disease. All agreed to participate in the study by signing the Informed Consent (IC). This is a cross-sectional study with quantitative approach. The tests were conducted between July 2014 and December 2014 at the Audiology Laboratory of the Department of Speech Language and Hearing Sciences of the Federal University of Pernambuco.

Participants were randomly allocated into three groups, each with 10 participants. In each group, responses were evaluated based on different judgment criteria: Bevilacqua et al.[5], Danieli[6] and Advíncula et al.[7].

The speech stimuli used in this research were the sentences listed in the Brazilian Portuguese version of the HINT[5]. This version of the HINT consists of 12 lists with 20 sentences each, recorded by a native male speaker. The sentences were originally recorded in the *House Research Institute* (HRI), USA. Background noise had the same frequency spectrum of the original sentences (*speech-shaped noise*) and was presented at a fixed intensity of 65 dB SPL.

Speech stimuli and competitive noise were sent via digital signal processing platform (RZ6, Tucker-Davis Technologies); and under the control of a computer that ran a Matlab ™ Custom *script* by means of a Sennheiser HD580, headset on the right ear or the better ear when the thresholds between the ears varied by more than 5 dB.

All subjects underwent examination of tonal and vocal audiometry to verify normalcy of hearing. Then, a speech recognition test in the presence of background noise was held using the sentences of the Brazilian Portuguese version of the HINT, monoaurally presented. For the sentence recognition test in the presence of steady noise, subjects were tested in a sound-treated booth and instructed to repeat each sentence the way it was perceived. Outside the booth, the researcher monitored the oral response of the individual through headphones attached to a microphone positioned inside the booth. As each sentence was presented to the individual, the text of the sentence would be simultaneously presented on the computer screen in front of the experimenter, with all the words highlighted in a shaded rectangle sensitive to marking. The researcher used the computer's *mouse* to mark the words that were omitted or incorrectly reproduced. However, for the proposed adaptive procedure, the sentence was given an overall score of "correct" or "incorrect". To obtain these scores, three different judging criteria were used[5-7], precisely one criterion for each group of participants.

Sentence recognition thresholds in the presence of steady noise were measured using an adaptive *two-down/one-up* procedure which converges to 71% of accuracy[8]. In this procedure, after two

correct sentences, the level of presentation of the next sentence would be reduced by 2 dB; and after one incorrect sentence, the level of presentation of the next sentence would be increased by 2 dB. The estimation range of the threshold continued until 6 reversions toward the threshold level. The estimated threshold is calculated as the average of the four final levels (intensities) of the reversion. Three threshold estimates were obtained for each participant. The final threshold was calculated as the average of three estimates obtained. Lists were randomly chosen and individuals would not listen to the sentences more than once in order to eliminate variables related to the learning phenomenon.

Data were processed and analyzed using the SPSS software (*Statistical Package for Social Sciences*). Measures of central tendency and dispersion were calculated for continuous variables (age, average tritone and average threshold) and proportions for the nominal variable (gender). After checking normality of the average response threshold of the three groups by the Kolmogorov-Smirnov test, an analysis of variance (ANOVA) was carried out to compare them by F test. The maximum error probability for rejecting the null hypothesis was 5%.

The research is part of a study entitled *Temporal masking and speech recognition in the aging auditory system: US-BRAZIL* and was approved by the American ethics committee under the number 11-1113 and the National Research Ethics Commission (CONEP) under number 233/2012.

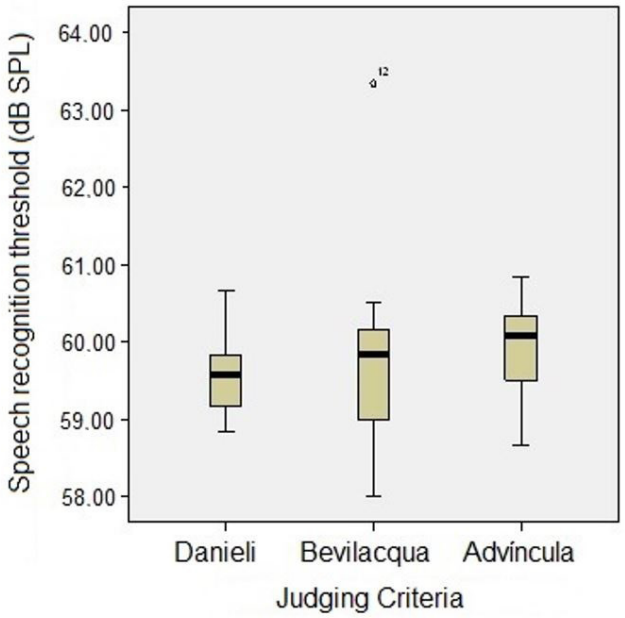
RESULTS

The sample of 30 individuals consisting of students and employees of the Federal University of Pernambuco, had a mean age of 21.2 ± 2.41 years, ranging between 18 and 25 years. Approximately 83% (n = 25) were female. The average tritone was 11.13 ± 5.12 dB HL and ranged from 0 (zero) to 18 dB HL.

Measures of central tendency were analyzed for the response thresholds to HINT according to the three criteria analyzed (Figure 1).

Threshold values of responses to HINT, according to Bevilacqua et al.[5] criterion, were observed to vary between 58 and 63.33 dB SPL, with a mean of 59.90 dB SPL and standard deviation of ± 1.43 dB. As for Danieli[6] criterion, thresholds varied between 58.83 and 60.67 dB SPL, with a mean of 59.60 dB SPL and standard deviation of ± 0.53 dB. When Advíncula et al.[7] criterion was adopted, there was a variation of thresholds between 58.67 and 60.83 dB SPL, with a mean of 59.95 dB SPL and standard deviation of ± 0.61 dB.

The Kolmogorov-Smirnov ($p > 0.05$) test showed that the average threshold values had normal distribution. The ANOVA test showed no statistically significant difference between average response thresholds to HINT obtained according to the three criteria analyzed - Bevilacqua et al.[5], Danieli[6] and Advíncula et al.[7] ($p > 0.05$).



Caption: F test (between groups) = 0.398; p> 0.05
Figure 1. Comparison between average threshold of responses to the HINT according to the judging criteria

DISCUSSION

Any audiological test in clinical practice should have its procedures standardized for implementation and analysis. As noted earlier, three judging criteria for the Brazilian version of the *Hearing in Noise Test* (HINT) have been developed. The possibility of difference between the average thresholds of responses to the HINT arising from this diversity of judging criteria could compromise the use of this instrument. The absence of a unified criterion for judging HINT responses in the Brazilian Portuguese version could hinder the insertion of the HINT in clinical audiology.

This study showed no difference between the three judging criteria for HINT responses used in Brazil: Bevilacqua et al.[5], Danieli[6] and Advíncula et al.[7]. In this sense, considering the lack of a consensus among authors in relation to evaluation of sentences, different average thresholds of responses to the HINT were expected from the three judging criteria, but this was not observed in the present investigation.

One aspect to be discussed is that speech recognition tests in noise use different scoring methods[†]. In the method of keywords (*keyword scoring)*, the participant needs only correctly repeat the key words of the sentence. For example, in the sentence: "My father sold the ranch" (see Appendix A: List 1, Sentence 12), only the words 'my' 'father' 'sold' and 'ranch' are counted as hits when correctly repeated. The other words are ignored. Another way to score these types of test is when every word in the sentence is analyzed (*word scoring)*; i.e., the individual undergoing the test must correctly repeat the entire sentence. In both methods, the test result is calculated based on the number of keywords or sentence words used[9,10].

When considering the judging criteria used in this study, it is clear that the Advíncula et al.[7] criterion fits in the method

[†] The term 'scoring method' is used herein to refer to the type of calculation used to obtain a given result. Therefore, this differs from the term 'judgment criteria' used herein, which refers to what should be considered error or hit.

word scoring, because all the words are computed in this case. Following this reasoning, it can be said that the other criteria discussed here are similar to the *keyword scoring* method, considering only how to calculate the answers, because keywords in Bevilacqua et al.[5] and Danieli[6] are not determined to be computed. However, in these last two methods, not all the words need to be correctly reproduced. Some words, if omitted or distorted, are not judged as errors.

Another method is the *sentence scoring* employed by Plomp and Mimpenn[11]. In this method, if at least one word is not correctly repeated by the individual, the whole sentence is computed as error.

Some studies compare these scoring methods. Versfeld et al.[12] showed that for the German speech in noise test developed by Plomp and Mimpen[11], the sentence recognition threshold was lower when employing *word scoring* than *sentence scoring*. People performed better when all the words would be counted as a hit (or error) instead of sentences. Terband and Drullman[13] found similar effects when comparing the *keyword scoring* and the *sentence scoring* methods. People performed better when the keywords were counted as a hit (or error) instead of sentences. It must be noted that these studies were not performed with versions of the *Hearing In Noise Test,* but with other speech recognition tests in the presence of noise.

In this scenario, the literature seems to point to scoring methods based on the number of correct words, whether keywords or all words of the sentence. Thus, the three judging criteria studied here are in line with what the literature indicates as scoring method.

Another aspect that needs to be highlighted is that a speech recognition tests can generally be carried out in two ways: search for the threshold or percentage of correct answers. In the first case, the result will always be a measure of intensity (decibel) and in the second case, in percentage (%). As explained earlier, we have opted for the determination of speech recognition thresholds in the present study. Thus, the discussion of the present results should not be extrapolated to results of research studies in which percentage of speech recognition in the presence of background noise was determined. Studies have shown that speech recognition thresholds through adaptive procedures are different from those obtained using the method of constant stimuli intensity (percentage of correct answers), even when the two methods show the same target probabilities for correct answers[14-16].

The results of this study reinforce the idea that any of the analyzed judging criteria can be used as standard in the application of the Brazilian version of HINT. Before using the test in clinical practice, however, some recommendations are opportune, given the limitations of this work. Similar studies determining the percentage of correct answers, rather than thresholds, should be carried out.

Another important detail in the analysis is the focus on only one aspect of HINT: its linguistic material (and how this is used in the test). The development of similar research with the application of HINT in all its dimensions is necessary. In this sense, therefore, the Brazilian version of the test still needs more scientific investment in order that its use becomes consolidated in clinical practice.

CONCLUSION

The results showed that, regardless of the judging criterion adopted, similar answers were obtained from patients evaluated for sentence recognition threshold of the Brazilian Portuguese version of the *Hearing In Noise Test*. This opens the possibility for application of this test in audiological clinic, but it is still necessary to evaluate other test criteria before clinical recommendation.

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Author contributions

RCM principal investigator, preparation of the research, development of the schedule, literature review, data collection and analysis, paper writing, submission and procedures for publication of the paper; DCM supervisor, preparation of the research, development of the schedule, data analysis, paper writing correction, approval of the final version; FAP and KPA collaborating researchers, literature review, collection and analysis of data, writing and final review of the paper; SMSG co-supervisor, preparation of the research, development of the schedule, data analysis, paper writing correction, approval of the final version.

Appendix A. Lists of the Hearing In Noise Test (HINT) - Brazilian Portuguese version

LIST 1	LIST 2	LIST 3
1. Mal dá pra assistir televisão.	1. A mamãe está dormindo.	1. Tomei banho frio hoje cedo.
2. Vou acordar bem cedo.	2. Eu ficarei com ela.	2. Perdi a hora outra vez.
3. A torneira tá pingando.	3. O menino tem um amigo.	3. A manga está muito verde.
4. Tem gente me esperando.	4. A menina gritou de susto.	4. O cachorro fugiu de casa.
5. Perdi o dado do jogo.	5. O menino derrubou o suco.	5. Eu convidei muitas crianças.
6. Minha irmã comprou pão.	6. A escada era vermelha.	6. Eu chamei a ambulância.
7. O homem pegou o dinheiro.	7. Eu gosto de televisão.	7. O sorvete de creme está bom.
8. A fábrica fechou ontem.	8. Não sei qual era a história.	8. O pássaro voou alto.
9. Meus vizinhos dormem cedo.	9. Eu irei ao parque amanhã.	9. Preciso terminar a casa.
10. Meu filho nasceu hoje cedo.	10. A pilha acabou rápido.	10. Eles nadarão no mar.
11. Minha mãe foi para casa.	11. Eles ficarão no banco.	11. Minha amiga mora perto.
12. O meu pai vendeu o sítio.	12. Os homens usarão calças.	12. Meu pai tem um sítio.
13. O moço bateu o carro.	13. A casa terá um jardim.	13. Eu nadei na piscina.
14. A chuva destruiu as casas.	14. O motorista me esperou muito.	14. Eu me lembrei da história.
15. Não temos lugar para descanso.	15. O sorvete derreteu logo.	15. Eu não vou ao aniversário.
16. Na feira tem frutas boas.	16. Ela bateu o pé na porta.	16. O barco afundou no rio.
17. O professor trabalhou ontem.	17. O frango está cozido.	17. Os preços aumentaram muito.
18. Ele não gosta de música.	18. Ela chamou a filha.	18. A casa ficará pronta.
19. A chuva derrubou o telhado.	19. Os bombeiros conversaram.	19. O jornal caiu na rua.
20. É o prédio mais velho da praça.	20. Vou tomar banho quente.	20. A novela será bonita.
LIST 4	LIST 5	LIST 6
1. O homem parou o carro.	1. O menino jogou a água.	1. Passei meu cartão de ponto.
2. Eu sempre busco pão.	2. Eu peguei a bicicleta.	2. Eu estou muito cansado.
3. Ela não toma café com leite.	3. Você fez um bom trabalho.	3. A menina brinca de bonecas.
4. Quero doze cervejas da “brama”.	4. Ele se vestiu de palhaço.	4. É hora de dormir.
5. Tá chovendo muito forte.	5. Você me empurrou com força.	5. O cachorro comerá carne.
6. O meu pai comprou roupa para mim.	6. O menino brincou na areia.	6. Não vi televisão hoje.
7. É meio perigoso andar sozinho.	7. Fiquei sentado no chão.	7. A novela já terminou.
8. Naquela fábrica não tem vaga.	8. Eu olhei pela janela.	8. O carrossel já vai rodar.
9. Ela ficou com medo.	9. A novela terminará logo.	9. Vou mudar pra outra casa.
10. O leite estava na mesa.	10. A minha letra é feia.	10. Quero ir embora agora.
11. Visitei meus amigos.	11. A criança bateu a cabeça.	11. Eu caí da bicicleta.
12. Eu ganhei um pirulito.	12. Tem gente gritando lá fora.	12. Eu estava com um amigo.
13. Eu tomei banho ontem.	13. O almoço vai sair tarde.	13. Minha irmã quase chorou.
14. Não vamos falar alto.	14. Ela não gosta de escrever.	14. A garrafa estava na caixa.
15. Minha avó irá à praia.	15. Fui à festa do meu amigo.	15. Os tomates estavam verdes.
16. A mamãe conversa com ele.	16. Meu pai viajou de carro.	16. O cachorro brincou com o osso.
17. Eu brinquei em casa.	17. Minha mãe não ficou brava.	17. As tesouras estão na mesa.
18. Estou cansado hoje.	18. O homem dirigiu bem.	18. Ela perdeu seu cartão de crédito.
19. O menino riu da piada.	19. O moço se casará com ela.	19. A equipe jogará bem.
20. Eles escutaram o barulho.	20. O menino quebrou o copo.	20. Os jovens estão dançando.

Appendix A. Continued...

LIST 7	LIST 8	LIST 9
1. Os brinquedos estão no chão.	1. Eu procurei meu irmão.	1. O meu pai jogou bola.
2. A mamãe está sozinha.	2. Ela não chegou muito tarde.	2. A gente andou na roda gigante.
3. Era uma bela tarde.	3. Nesse fim de semana ele folga.	3. Meu irmão empurrou o carro.
4. As folhas caíam no chão.	4. Fui chamado pra trabalhar.	4. A minha tia tem um filho.
5. Tenho reunião às oito.	5. Tem gente batendo na porta.	5. A menina tropeçou na pedra.
6. Vou inventar uma história.	6. Eu não bebo no serviço.	6. Meu pai virá aqui hoje.
7. Quero duas latas de cerveja.	7. A roupa no varal já secou.	7. O menino chorou muito.
8. Quero trabalhar muito mais.	8. Vai ter churrasco lá em casa.	8. Sábado é bom para feijoada.
9. Não vou comprar ovos.	9. Minha mulher tá grávida.	9. A médica tem muitas consultas.
10. Empilhei quatro caixas.	10. A gente brincou na praça.	10. As meninas estão tristes.
11. Cheguei cedo no trabalho.	11. O cachorro rasgou a toalha.	11. Eu entendi a professora.
12. O avô contou uma história.	12. Eu irei à piscina.	12. Não gosto de poesias.
13. O estudante dormiu aqui.	13. Meu pai pegou um peixe.	13. Eu fiz uma poesia para você.
14. A mulher desmaiou na sala.	14. Eu só sei escrever meu nome.	14. Comerei logo.
15. Ele precisa voltar ao país.	15. Eu vou ao médico depois.	15. As crianças ganharam brinquedos.
16. A primavera é bela.	16. Eu comprei o presente dele.	16. Mamãe ligou no restaurante.
17. O amor não é só sensação.	17. Eu venderei meu carro.	17. Muito sabão mancha a roupa.
18. A vida é muito curta.	18. O uniforme já rasgou.	18. Os tomates acabaram cedo.
19. Eles deixaram eu brincar.	19. A carta caiu no chão.	19. Não aprendi a lição.
20. Eu estava escondida.	20. Vou viajar no fim do ano.	20. Meu pai pagou o aluguel.

LIST 10	LIST 11	LIST 12
1. Ainda não tomei meu café.	1. Ela tinha muitos presentes.	1. Ele caiu da árvore.
2. Ele rasgou a camisa nova.	2. Quero comer ovo frito.	2. A cachorrinha não é brava.
3. O estacionamento é longe.	3. O torcedor gritou no jogo.	3. Vou comprar um rádio na loja.
4. Perdi os meus documentos.	4. A criança tomou chuva.	4. O pastelzinho da feira é jóia.
5. O bebê só chora à noite.	5. Ele comeu peixe assado.	5. Preciso fazer a barba.
6. O ladrão levou o dinheiro.	6. A menina canta bonito.	6. No fim de semana tem jogo.
7. Vai lá em casa tomar sol.	7. O aluno acertou a questão.	7. Vai ter churrasco domingo.
8. Vamos chegar bem cedo.	8. Os cavalos fugiram hoje.	8. Hoje eu tô morrendo de fome.
9. Eu tô feliz aqui no alto.	9. Esse refrigerante tá quente.	9. Você ganhou um jogo.
10. Já começou a trabalhar de carro.	10. Só bebi duas cervejas.	10. A senhora fez café para você.
11. Gosto de conversar na rua.	11. O churrasco acabou logo.	11. Tô muito atrasado hoje.
12. A menina ganhou uma boneca.	12. A loja vendeu com desconto.	12. Sua blusa está na cadeira.
13. O empregado limpa o chão.	13. O menino pedia socorro.	13. O jogador fez muita falta.
14. Ela cortará a carne.	14. Ela desfila com roupas da moda.	14. Andei até o ponto de ônibus.
15. A comida está cara.	15. Meu marido chega tarde.	15. Não pude trabalhar hoje.
16. Preciso falar com você.	16. A estudante mora longe.	16. Eu brinquei com ele.
17. Eu também desenhei bem.	17. A torcida verá o jogo.	17. Brinquei na minha avó.
18. Ele perdeu o boné ontem.	18. O motorista bateu o carro.	18. As crianças estão perdidas.
19. Ele tava com pressa pra sair.	19. Ele pagou sua conta em dia.	19. A professora tem roupa chique.
20. Já vou pagar o aluguel.	20. Eles queriam batatas.	20. Uma casa foi construída.