UNIVERSIDADE FEDERAL DE MINAS GERAIS

Faculdade de Medicina

Programa de Pós-Graduação em Saúde da Criança e do Adolescente

CAMILA GUIMARÃES MENDES

Estudo experimental sobre o efeito do estímulo musical na atenção de crianças e adolescentes com tdah e com desenvolvimento típico

Belo Horizonte, Minas Gerais, Brasil

2022

CAMILA GUIMARÃES MENDES

ESTUDO EXPERIMENTAL SOBRE O EFEITO DO ESTÍMULO MUSICAL NA ATENÇÃO DE CRIANÇAS E ADOLESCENTES COM TDAH E COM DESENVOLVIMENTO TÍPICO

Tese apresentada ao Programa de Pós-Graduação em Ciências da Saúde – Saúde da Criança e do Adolescente da Faculdade de Medicina da Universidade Federal de Minas Gerais como requisito para a obtenção do título de Doutor.

Linha de pesquisa: Distúrbios do neurodesenvolvimento

Doutoranda: Camila Guimarães Mendes

Orientadora: Profª. Dra. Débora Marques de Miranda

Belo Horizonte, Minas Gerais, Brasil

2022

Mendes, Camila Guimarães.
M538e Estudo experimental sobre o efeito do estímulo musical na Atenção de Crianças e Adolescentes com TDAH e com desenvolvimento típico [recursos eletrônicos]. / Camila Guimarães Mendes. - - Belo Horizonte: 2022.
144f.: il.
Formato: PDF.
Requisitos do Sistema: Adobe Digital Editions.

Orientador (a): Débora Marques de Miranda.
Área de concentração: Ciências da Saúde da Criança e do Adolescente.
Tese (doutorado): Universidade Federal de Minas Gerais, Faculdade de Medicina.

1. Música. 2. Atenção à Saúde. 3. Transtorno do Deficit de Atenção com Hiperatividade. 4. Criança. 5. Dissertação Acadêmica. I. Miranda, Débora Marques de. II. Universidade Federal de Minas Gerais, Faculdade de Medicina. III. Título.

NLM: WB 550

Bibliotecário responsável: Fabian Rodrigo dos Santos CRB-6/2697

UNIVERSIDADE FEDERAL DE MINAS GERAIS
FACULDADE DE MEDICINA - CENTRO DE PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE
SAÚDE DA CRIANÇA E DO ADOLESCENTE

FOLHA DE APROVAÇÃO

ESTUDO EXPERIMENTAL SOBRE O EFEITO DO ESTÍMULO MUSICAL NA ATENÇÃO DE CRIANÇAS E ADOLESCENTES COM TDAH E COM DESENVOLVIMENTO TÍPICO

CAMILA GUIMARÃES MENDES

Tese de Doutorado defendida no dia 05 de agosto de 2022, como requisito parcial para a obtenção do grau de Doutora em CIÊNCIAS DA SAÚDE, pelo Programa de Pós-Graduação em Ciências da Saúde-Saúde da Criança e do Adolescente e **aprovada** pela Comissão Examinadora designada pelo Colegiado do Programa de Pós-Graduação supramencionado da Universidade Federal de Minas Gerais constituída pelos seguintes Professores Doutores: Débora Marques de Miranda - Orientadora (UFMG), Isabela Maria Magalhães Lima (UFSJ), Maíra Ferreira do Amaral (UFTM), Emmanuely Macedo Santana de Nardin (PUC-MG), Jonas Jardim de Paula (UFMG) e Renato Tocantins Sampaio (UFMG).

Belo Horizonte, 05 de agosto de 2022.

Documento assinado eletronicamente por **Jonas Jardim de Paula**, **Servidor(a)**, em 05/08/2022, às 13:05, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Debora Marques de Miranda**, **Professora do Magistério Superior**, em 05/08/2022, às 14:03, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Renato Tocantins Sampaio**, **Professor do Magistério Superior**, em 08/08/2022, às 11:55, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Maíra Ferreira do Amaral**, **Usuário Externo**, em 09/08/2022, às 09:51, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Isabela Maria Magalhães Lima**, **Usuária Externa**, em 09/08/2022, às 10:59, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Emmanuely Macedo Santana De Nardin**, **Usuária Externa**, em 09/08/2022, às 20:11, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

A autenticidade deste documento pode ser conferida no site https://sei.ufmg.br/sei/controlador_externo.php?acao=documento_conferir&id_orgao_acesso_externo=0, informando o código verificador **1656526** e o código CRC **4A888F41**.

AGRADECIMENTOS

Á Deus, que sempre esteve à frente de todos os meus planos e por ter me dado forças para chegar até aqui e passar por todas as etapas deste trabalho.

À minha família, que sempre me apoiou e acreditou no meu potencial, dando suporte em todas as minhas necessidades e me dando sempre carinho, mesmo na distância

À minha orientadora, mestre e amiga Débora Miranda que trabalhou junto comigo me dando todo apoio e suporte na elaboração deste trabalho e por todo seu ensinamento.

Aos professores Danielle Costa e Jonas Jardim, que tanto me auxiliaram nas decisões quanto às análises estatísticas e demais pontos

importantes para melhoria deste trabalho! Obrigada pela paciência e disposição!

A todos os funcionários, professores, diretora e especialmente à coordenadora pedagógica Thaís, da Escola Municipal Dinorah Magalhaes Fabri que abriram todas as portas necessárias para que eu pudesse realizar a pesquisa com os seus alunos. Obrigada pela acolhida e suporte durante esse processo!

Aos demais colegas do grupo NITIDA, em especial o Dr. Antônio e residentes, que atenderam os pacientes com TDAH durante esse tempo e me auxiliaram no que fosse necessário para verificar os critérios de elegibilidade para o estudo e realizar a pesquisa durante os dias de atendimento.

A todos os familiares, crianças e adolescentes, que participaram desse estudo, especialmente aqueles que abriram as portas de suas casas, ainda em meio à pandemia do COVID-19. Obrigada pela acolhida e por confiarem em mim!

Ao meu marido Marcus que me acompanhou todo esse tempo com muita paciência e por todo seu companheirismo!

Por fim, a todos os meus amigos, até aqueles que conheci nesse último ano, e que de alguma forma contribuíram para a finalização dessa etapa tão importante da minha vida!

Caminhante, não há caminho, o caminho se faz ao andar (António Machado)

Resumo

OBJETIVO: Este estudo teve o objetivo de avaliar experimentalmente o efeito da escuta musical no desempenho de crianças com Transtorno do Déficit de Atenção com Hiperatividade (TDAH) e crianças com desenvolvimento típico (DT) em uma tarefa atencional (Attention Network Test – ANT). **METODOLOGIA:** Trata-se de um estudo de desenho experimental, com o protocolo registrado pelo Registro Brasileiro de Ensaios Clínicos (U1111-12589039). A amostra foi composta por 76 meninos de 10 a 12 anos, sendo 34 com TDAH e 42 sem o diagnóstico de TDAH, pareados em idade, sexo e nível socioeconômico. Ambos os grupos realizaram o ANT (versão para crianças) submetidos a duas condições experimentais aleatorizadas: com música (MU) e sem música (SMU). O desfecho avaliado foi a eficiência das redes atencionais (alerta, orientação e conflito) e a taxa geral de erros cometidos durante a realização da tarefa. Para caracterização da amostra foram aplicados os questionários Child Behavior Checklist 6-18 (CBCL/6-18), o Swanson Nolandand Pelham-IV (SNAP IV) e o Critério de Classificação Econômico Brasil (CCEB). Todas as crianças realizaram também o Conner's Continuous Performance Test (CCPT), que caracteriza o comportamento atencional da criança. Análises de variância (ANOVA) de medidas repetidas foram realizadas para avaliar o efeito da condição experimental (MU versus SMU) em cada grupo e o efeito do diagnóstico de TDAH. Os erros de comissões e omissões obtidos pela medida de atenção basal no CCPT foram incluídos como covariantes durante as análises. **RESULTADOS:** As análises mostraram que não houve diferença significativa entre os grupos e entre as condições experimentais com relação às redes atencionais, porém ambos os grupos tiveram a taxa de erros geral reduzida quando realizaram o ANT na condição com música. Os resultados sugerem que a música afetou o número de erros cometidos durante a tarefa de atenção, porém não houve um efeito direto nas redes atencionais. Dessa forma, aparentemente não há uma melhora na atenção das crianças induzida pela escuta de música. **CONCLUSÃO:** Quando as crianças ouvem música durante a realização de tarefas que requerem atenção, elas podem se sentir mais motivadas e ficarem mais engajadas na tarefa, podendo levar a um menor número de erros cometidos. Nossos dados não são conclusivos uma vez que ampliação da amostra ainda se mostra necessária.

Palavras-chave: música, atenção, TDAH, crianças

ABSTRACT

OBJECTIVE: This study aimed to experimentally evaluate the effect of listening to music on the performance of children with Attention Deficit Hyperactivity Disorder (ADHD) and typically development (TD) children in an attentional task (Attention Network Test - ANT). **METHODOLOGY:** This is an experimental design study, with the protocol registered by the Brazilian Registry of Clinical Trials (U1111-12589039). The sample consisted of 76 boys aged 10 to 12 years, 34 with ADHD and 42 without a diagnosis of ADHD, matched for age, sex and socioeconomic status. Both groups performed the ANT (children's version) submitted to two randomized experimental conditions: with music (MU) and non-music (NMU). The evaluated outcome was the efficiency of the attentional networks (alert, orientation and conflict) and the general rate of errors made during the task. To characterize the sample, the Child Behavior Checklist 6-18 (CBCL/6-18), the Swanson Nolandand Pelham-IV (SNAP IV) and the Brazilian Economic Classification Criteria (CCEB) were applied. All children also performed the Conner's Continuous Performance Test (CCPT), which characterizes the child's attentional behavior. Repeated measures analyzes of variance (ANOVA) were performed to assess the effect of the experimental condition (MU versus SMU) on each group and the effect of the ADHD diagnosis. The commission errors and omissions obtained by the CCPT baseline care measure were included as covariates during the analyses. **RESULTS:** The analyzes showed that there was no significant difference between the groups and between the experimental conditions regarding attentional networks, however both groups had a reduced overall error rate when they performed the ANT in the condition with music. The results suggest that music affected the number of errors made during the attention task, but there was no direct effect on attentional networks. Thus, apparently there is no improvement in children's attention induced by listening to music. **CONCLUSION:** When children listen to music while performing tasks that require attention, they may feel more motivated and become more engaged in the task, which may lead to fewer mistakes. Our data are not conclusive since a sample enlargement is still necessary.

Keywords: music, attention, ADHD, children

LISTA DE FIGURAS

LISTA DE TABELAS

ARTIGO 1

METODOLOGIA

ARTIGO 3

SUMÁRIO

1. INTRODUÇÃO

O Transtorno do Déficit de Atenção com Hiperatividade (TDAH) é um dos transtornos comportamentais mais comuns da infância, afetando cerca de 7,6% da população infantil no Brasil (Polanczyk, 2007). É uma condição de saúde caracterizada por níveis prejudiciais de déficit de atenção, impulsividade e hiperatividade, que podem persistir até a vida adulta (American Psychiatric Association, 2013). Comumente as funções executivas estão deficitárias no TDAH (ex. memória operacional, planejamento e organização, flexibilidade cognitiva, atenção e impulsividade cognitivas, entre outras) (Willcutt et al., 2005) que são funções essenciais para a conclusão de tarefas do cotidiano e relacionadas a aprendizagem que exigem concentração e esforço.

Segundo Barkley (1997), muitos desses prejuízos no TDAH poderiam ser explicados por um déficit no controle inibitório, ou seja, na dificuldade de o indivíduo frear uma resposta automática, impulsiva, diante de uma tarefa que requer uma resposta que exige um maior esforço cognitivo. Por outro lado, elas também poderiam estar associadas a um déficit na regulação de estado (Sergeant, 2004; Martella et al., 2020) que seria a alocação de esforço extra para a criança sustentar o desempenho em uma tarefa com uma taxa de estímulos alta. Essa taxa maior de estímulos, em geral, aumentaria o estado de alerta (capacidade de sustentar a atenção), no entanto, diante de longos intervalos da sua apresentação poderia levar a uma hipoativação do sistema de alerta, culminando na dificuldade em somar o esforço necessário para ajustar o desempenho adequadamente às exigências da tarefa (Sergeant, 2004;Sergeant, 2000). Como o processamento de estímulos irá depender em parte do seu atual estado de alerta, é possível que crianças com TDAH se beneficiem de estímulos que aumentem o estado de alerta e consequentemente melhorem o desempenho da tarefa a ser realizada (Söderlund et al., 2007).

Alguns estudos têm demonstrado que ouvir música durante a realização de tarefas de matemática, pode melhorar significativamente o desempenho dessas crianças, o que não ocorre necessariamente com crianças com desenvolvimento típico (Abikoff et al., 1996; Greenop & Kann, 2007). Esses estudos defendem a premissa de que crianças com TDAH se beneficiam do uso de estímulos externos para melhorar seu desempenho, o que pode ser endossado pelo Modelo Cognitivo-Energético que sugere que esse estímulo aumentaria o estado de alerta dessas crianças (Sergeant, 2000). No entanto, ainda existem poucas avaliações experimentais, e entre os existentes a ausência de controles e a ampla variedade metodológica que limita as generalizações.

Pelham e colaboradores (2011) mostraram que o efeito no comportamento e na conclusão de atividades acadêmicas dentro de sala de aula de crianças com e sem TDAH foi variável com tipo de distrator ao qual foram expostas (vídeo versus música). Em relação à música, ambos os grupos não foram afetados negativamente, enquanto a presença de vídeos pareceu exacerbar as diferenças entre os grupos, tendo o grupo TDAH se mostrado mais afetado negativamente pela presença desse tipo de distrator. Sobretudo, dentro do mesmo grupo de indivíduos houve melhora do desempenho nas tarefas na presença de música para alguns, enquanto outros pioraram, sugerindo que possa haver outros fatores relacionados às individualidades desse grupo (Pelham et al., 2011).

Segundo Posner et al., a atenção envolve três redes que possuem diferentes funções: alerta (fase de alerta) e vigilância (geral estado de ativação do sistema cognitivo); orientação (alocação do foco da atenção visual para uma área relevante); e controle executivo (habilidade para controlar nosso próprio comportamento para alcançar determinados objetivos ou resolver conflitos diante de respostas alternativas) (Posner & Petersen, 1990). Os sistemas de alerta e orientação estão associados a regiões frontal e parietal, no

hemisfério direito, enquanto o controle executivo está associado a regiões do cíngulo anterior e córtex pre-frontal lateral (Fan et al., 2002). O entendimento de como essas habilidades são afetadas pela música poderia trazer implicações importantes para intervenção com essa população, sendo de relevância para professores em sala de aula que lidam com essas crianças, bem como para os familiares no dia a dia.

Até o momento evidências sugerem que ouvir música durante uma tarefa de atenção pode melhorar o desempenho, principalmente se tratando de canções preferidas pelo ouvinte e sem letra (Mendes et al., 2021). Em se tratando do TDAH, hipotetiza-se que o mesmo ocorra, considerando o potencial motivador da música e a possibilidade de ativação do sistema de alerta dessas crianças (Sergeant, 2000; Salimpoor et al., 2009). Dessa forma, pretendemos avaliar o efeito do estímulo musical nas redes atencionais descritas por Posner e Peterson (1990) através do Attention Network Test (ANT), que é uma adaptação de paradigmas experimentais de estímulo-reação que possibilita investigar o estado da alerta e orientação da atenção encoberta por pistas (estímulo visual que antecede o alvo), bem como estimar a interferência da informação alvo em conflito (Fan. et al., 2002).

Esta Tese obedeceu à resolução 03/2010 do Programa de Pós-Graduação em Ciências da Saúde – Saúde da Criança e do Adolescente da Faculdade de Medicina da Universidade Federal de Minas Gerais (UFMG), sendo composta por essa introdução, uma revisão da literatura, os objetivos, a metodologia, os resultados, a discussão e as considerações finais. A revisão de literatura, e os resultados e discussão serão apresentados sob a forma de três artigos científicos, em versão inglesa, sendo o primeiro uma revisão de estudos sobre o efeito da música no desempenho de tarefas de atenção, o segundo um artigo de protocolo e o terceiro um artigo original.

1.2 Referências bibliográficas

Abikoff, H., Courtney, M. E., Szeibel, P. J., & Koplewicz, H. S. (1996). Abikoff 1996. *Journal of Learning Disabilities*, *29*(3), 238–246.

Achenbach, T. M., & Ruffle, T. M. (2000). The child behavior checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review*, *21*(8), 265–271. https://doi.org/10.1542/pir.21-8-265

Adólfsdóttir, S., Sørensen, L., & Lundervold, A. J. (2008). The attention network test: A characteristic pattern of deficits in children with ADHD. *Behavioral and Brain Functions*, *4*, 1–9. https://doi.org/10.1186/1744-9081-4-9

Amaravathi, T., Murugan, M., Subramanian, A., & Geetha, A. P. S. (2019). Attention deficit hyperactivity disorder. *Trends in Biosciences*, 214–221. https://doi.org/10.4324/9780203754818-11

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)* (5th ed).

Antshel, K. M., & Barkley, R. (2020). Attention deficit hyperactivity disorder. In *Handbook of Clinical Neurology* (1º ed, Vol. 174). Elsevier B.V. https://doi.org/10.1016/B978-0-444-64148-9.00003-X

Associação Brasileira de Empresas de Pesquisa (ABEP). ([s.d.]). *Dados com Base no Levantamento Sócio Econômico – IBOPE.* 2015. http://www.abep.org/new/criterioBrasil.aspx

Barkley, R. A. (1997). Behavioral Inhibition, Sustained Attention, and Executive Functions: Constructing a Unifying Theory of ADHD. In *Psychological Bulletin* (Vol. 121, Número 1). Routledge. https://doi.org/10.1037/0033-2909.121.1.65

Berger, A., & Posner, M. I. (2000). Pathologies of brain attentional networks. *Neuroscience and Biobehavioral Reviews*, *24*(1), 3–5. https://doi.org/10.1016/S0149-7634(99)00046-9

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., Wilens, T. E., Frazier, E., & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of Psychiatry*, *159*(1), 36–42. https://doi.org/10.1176/appi.ajp.159.1.36

Bordin IAS, Rocha MM, Paula CS, Teixeira MCTV, Achenbach TM, Rescola LA, S. E., Bordin, I. A., Rocha, M. M., Paula, C. S., Teixeira, M. C. T. V., Achenbach, T. M., Rescorla, L. A., & Silvares, E. F. M. (2013). Child Behavior Checklist (CBCL), Youth Self- Report (YSR) and Teacher's Report Form (TRF): an overview of the development of the original and Brazilian versions. *Cadernos de Saúde Pública*, *29*(1), 13–28. http://www.ncbi.nlm.nih.gov/pubmed/23370021%0Ahttp://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2013000500004&lng=pt&nrm=iso&tlng=en

Bradley, M., & Lang, P. J. (1994). Self-Assessment Manikin (SAM). *J.Behav.Ther. & Exp. Psychiat.*, *25*(1), 49–59.

Brown, T. E. (2008). ADD/ADHD and impaired executive function in clinical practice. *Current Psychiatry Reports*, *10*(5), 407–411. https://doi.org/10.1007/s11920-008-0065-7

Christiansen, H., Hirsch, O., Albrecht, B., & Chavanon, M. L. (2019). Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span. *Current Psychiatry Reports*, *21*(3), 16–18. https://doi.org/10.1007/s11920-019-1003-6

Conners, B. C. K. (2014). Conners ' Continuous Performance Test II (CPT II V . 5) Profile Report Client Name : Iago Oliveira. *Musician*, 1–15. https://www.pearsonclinical.co.uk/Psychology/ChildMentalHealth/ChildADDADHDBehaviour/ConnersContinuousPerformanceTestIIVersion5forWindows(CPTIIV5)/PDFReports/Profile.pdf

Conners, C. K. (2002). *Conners' continuous performance test for Windows*.

Costa, D. S., de Paula, J. J., Malloy-Diniz, L. F., Romano-Silva, M. A., & Miranda, D. M. (2019). Parent SNAP-IV rating of attention-deficit/hyperactivity disorder: accuracy in a clinical sample of ADHD, validity, and reliability in a Brazilian sample. *Jornal de Pediatria*, *95*(6), 736–743. https://doi.org/10.1016/j.jped.2018.06.014

Dalton, B. H., & Behm, D. G. (2007). Effects of noise and music on human and task performance: A systematic review. In *Occupational Ergonomics* (Vol. 7). IOS Press.

de Souza Almeida, R., Faria-Jr, A., & Klein, R. M. (2021). On the origins and evolution of the Attention Network Tests. *Neuroscience and Biobehavioral Reviews*, *126*(September 2020), 560–572. https://doi.org/10.1016/j.neubiorev.2021.02.028

Egermann, & Hauke. (2013). *Can parents influence children ' s music preferences and positively shape their development ? Dr Hauke Egermann*.

Fabio, R. A., & Urso, M. (2014). The analysis of Attention Network in ADHD, attention problems and typically developing subjects. *Life Span and Disability*, *17*(2), 199–221.

Fan, J., McCandliss, B. D., Sommer, T., & Raz, A., Posner, M. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. http://www.sacklerinstitute.org/users/jin.fan/publications/ANT.pdf

Greenop, K., & Kann, L. (2007). Extra-task stimulation on mathematics performance in children with and |PsyssA without ADHD. *South African Journal of Psychology*, *37*(2), 330–344.

Hall, C. L., Guo, B., Valentine, A. Z., Groom, M. J., Daley, D., Sayal, K., & Hollis, C. (2020). The Validity of the SNAP-IV in Children Displaying ADHD Symptoms. *Assessment*, *27*(6), 1258–1271. https://doi.org/10.1177/1073191119842255

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. *Music Perception*, *20*(2), 151–171. https://doi.org/10.1525/mp.2002.20.2.151

Ilieva, I. P., & Farah, M. J. (2019). Attention, Motivation, and Study Habits in Users of

Unprescribed ADHD Medication. *Journal of Attention Disorders*, *23*(2), 149–162. https://doi.org/10.1177/1087054715591849

Posner, G., Polanczyk, E. S.-B. (2020). Attention-deficit hyperactivity disorder. *Lancet*, *8*(6), 450–462. https://doi.org/10.1097/00004703-200312000-00013

Johnson, K. A., Robertson, I. H., Barry, E., Mulligan, A., Dáibhis, A., Daly, M., Watchorn, A., Gill, M., & Bellgrove, M. A. (2008). Impaired conflict resolution and alerting in children with ADHD: evidence from the Attention Network Task (ANT). *Journal of child psychology and psychiatry, and allied disciplines*, *49*(12), 1339–1347. https://doi.org/10.1111/j.1469-7610.2008.01936.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Markham, W. A., & Spencer, N. (2022). Factors that mediate the relationships between household socio-economic status and childhood Attention Deficit Hyperactivity Disorder (ADHD) in children and adolescents: A systematic review. *PLoS ONE*, *17*(3 March), 1–22. https://doi.org/10.1371/journal.pone.0262988

Martella, D., Aldunate, N., Fuentes, L. J., & Sánchez-Pérez, N. (2020). Arousal and Executive Alterations in Attention Deficit Hyperactivity Disorder (ADHD). *Frontiers in Psychology*, *11*(August), 1–7. https://doi.org/10.3389/fpsyg.2020.01991

Mattos, P., Serra-Pinheiro, M. A., Rohde, L. A., & Pinto, D. (2006). MTA-SNAP-IV em português para uso no Brasil. *Revista de Psiquiatria do Rio grande do Sul*, *28*(3), 290–297.

Mendes, C. G., Diniz, L. A., & Marques Miranda, D. (2021). Does Music Listening Affect Attention? A Literature Review. *Developmental Neuropsychology*, *46*(3), 192–212. https://doi.org/10.1080/87565641.2021.1905816

Morsink, S., Sonuga-Barke, E., Van der Oord, S., Van Dessel, J., Lemiere, J., & Danckaerts, M. (2021). Task-related motivation and academic achievement in children and adolescents with ADHD. *European Child and Adolescent Psychiatry*, *30*(1), 131–141. https://doi.org/10.1007/s00787-020-01494-8

Nigg, J. T. (2005). Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: The state of the field and salient challenges for the coming decade. *Biological Psychiatry*, *57*(11), 1424–1435. https://doi.org/10.1016/j.biopsych.2004.11.011

Pasquali, L., Wechsler, S., & Bensusan, E. (2002). Matrizes progressivas do Raven Infantil: um estudo de validação para o Brasil. *Aval. psicol*, 94–110.

Pelham, W. E., Waschbusch, D. A., Hoza, B., Gnagy, E. M., Greiner, A. R., Sams, S. E., Vallano, G., Majumdar, A., & Carter, R. L. (2011). Music and video as distractors for boys with ADHD in the classroom: Comparison with controls, individual differences, and medication effects. *Journal of Abnormal Child Psychology*, *39*(8), 1085–1098. https://doi.org/10.1007/s10802-011-9529-z

Pereira, C. S., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., & Brattico, E. (2011). Music and Emotions in the Brain: Familiarity Matters. *PLoS ONE*, *6*(11). https://doi.org/10.1371/journal.pone.0027241

Pizzo, R., Urben, S., Van Der Linden, M., Borradori-Tolsa, C., Freschi, M., Forcada-Guex, M., Hüppi, P., & Barisnikov, K. (2010). Attentional networks efficiency in preterm children. *Journal of the International Neuropsychological Society*, *16*(1), 130–137. https://doi.org/10.1017/S1355617709991032

Polanczyk, G. (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry*, *164*(6), 942. https://doi.org/10.1176/appi.ajp.164.6.942

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *International Journal of Epidemiology*, *43*(2), 434–442. https://doi.org/10.1093/ije/dyt261

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(February), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040. https://doi.org/10.1016/j.neuropsychologia.2003.12.012

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*(2), 257–264. https://doi.org/10.1038/nn.2726

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE*, *4*(10). https://doi.org/10.1371/journal.pone.0007487

Schellenberg, E. G., & Hallam, S. (2005). Music listening and cognitive abilities in 10- and 11-year-olds: the blur effect. *Annals of the New York Academy of Sciences*, *1060*, 202–209. https://doi.org/10.1196/annals.1360.013

Sergeant, J. (2004). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive?energetic model. *Biological Psychiatry*. https://doi.org/10.1016/j.bps.2004.09.010

Sergeant, Joseph. (2000). Sergeant.00 Modelo cognitivo energético.pdf. *Neuroscience and Biobehavioral Reviews*, *24*, 7–12.

Siti Norazah, S., Abdullah, N., Salleh, N., Renuka, J., Azlina, M., Abd Rahman, H., & Nor Azila, N. (2017). The Effects of Music on Cognitive Performance in Attention Deficit Hyperactive Disorder (ADHD) Children: A Systematic Review. *Asian Journal of Multidisciplinary Studies*, *5*(9), 11–17. http://www.adhd-federation.org/fileadmin/user_upload/Abstract_Review/2017/10_Oktober/Treatment/The_Effects_of_Music_on_Cognitive_Performance_in_ADHD_Children_-_A_Systematic_Review.pdf

Skalski, S., Pochwatko, G., & Balas, R. (2020). Impact of Motivation on Selected Aspects of Attention in Children with ADHD. *Child Psychiatry and Human Development*, *52*(4), 586–595. https://doi.org/10.1007/s10578-020-01042-0

Smith, Z. R., & Langberg, J. M. (2018). Review of the Evidence for Motivation Deficits in Youth with ADHD and Their Association with Functional Outcomes. *Clinical Child and Family Psychology Review*, *21*(4), 500–526. https://doi.org/10.1007/s10567-018-0268-3

Smith, Z. R., Langberg, J. M., Cusick, C. N., Green, C. D., & Becker, S. P. (2020). Academic Motivation Deficits in Adolescents with ADHD and Associations with Academic Functioning. *Journal of Abnormal Child Psychology*, *48*(2), 237–249. https://doi.org/10.1007/s10802-019-00601-x

Söderlund, G., Sikström, S., & Smart, A. (2007). Listen to the noise: Noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(8), 840–847. https://doi.org/10.1111/j.1469-7610.2007.01749.x

Wan, J., & Taatgen, N. (2018). The Influence of Music and Music Familiarity on Time Perception. *CogSci 2018*, 2657–2662.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/ hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Zajenkowski, M., Goryńska, E., & Winiewski, M. (2012). Variability of the relationship between personality and mood. *Personality and Individual Differences*, *52*(7), 858–861. https://doi.org/10.1016/j.paid.2012.01.007

2. REVISÃO DA LITERATURA

A revisão da literatura sobre os efeitos da música na atenção será exposta por meio de um artigo de revisão que teve como objetivo investigar como a escuta de estímulo musical afeta o desempenho de tarefas atencionais em uma amostra experimental. Cabe ressaltar, que o artigo 1, intitulado *"Does Music Listening Affect Attention? A Literature Review*" foi publicado em abril de 2021, na revista *Developmental Neuropsychology*.

2.1. Artigo 1

Title: Does Music Listening Affect Attention? A Literature Review

Authors: Camila Guimarães Mendes[a] *, Luiza Araújo Diniz[c], Débora Marques Miranda [a,b]

Institutional affiliation:

[a] Graduate Program in Children and Adolescent Health, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil, https://orcid.org/0000-0001-8176-814X;

[b] Department of Pediatrics, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil; https://orcid.org/0000-0002-7081-8401;

[c] School of Medicine, Federal University of Ouro Preto (UFOP), Belo Horizonte, MG, Brazil, https://orcid.org/0000-0002-5136-1418.

***Corresponding Author:**

Camila Guimarães Mendes, Universidade Federal de Minas Gerais, Avenida Prof. Alfredo Balena, 190 Santa Efigênia, 30130-100, Belo Horizonte, MG, Brazil. Email: camilagmbh@gmail.com.

DEVELOPMENTAL NEUROPSYCHOLOGY
https://doi.org/10.1080/87565641.2021.1905816

Does Music Listening Affect Attention? A Literature Review

Camila Guimarães Mendes[a], Luiza Araújo Diniz[b], and Débora Marques Miranda[a,c]

[a]Graduate Program in Children and Adolescent Health, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil; [b]School of Medicine, Federal University of Viçosa (UFV), Belo Horizonte, Brazil; [c]Department of Pediatrics, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil

ABSTRACT

This review focused on knowledge about the effects of music on attention. The revision was performed in compliance with the PRISMA protocol, being registered at Prospero under number CRD42020172933. Across reviewed studies, the music improved performance on attention tasks, either by listening or using it within a procedure to modulate mood and motivation. It is still difficult to generalize and compare the results because of methodology and study design diversity. Further studies are needed to increase knowledge about the effect of music effect, especially to evaluate if it might have any potential clinical use.

ARTICLE HISTORY
Received 11 August 2020
Revised 4 February 2021
Accepted 15 March 2021

Introduction

Attention facilitates selecting relevant information and allocating cognitive resources or processes necessary during everyday life (Cohen, 2014). This skill is evident from birth and continues to develop into young adulthood (e.g., 20-years-old) (Cohen, 2014). However, attention refers to a broad class of cognitive processes and a wide range of behavioral phenomena (Cohen, 2014). Individual resources (i.e., cognitive) influence both attention capacity and environmental factors (i.e., presence of reward or stimulation). In this sense, music has been investigated in the literature as an external factor capable of affecting cognitive tasks' performance (Dalton & Behm, 2007; Schwartz, Ayres, & Douglas, 2017).

Specific regions of the brain are implicated by music. Music affects processes related to memory, motor control, timing, language, emotion, and reward circuits, suggesting a possible involvement of dopaminergic pathways (Demarin, Bedekovic, Puretic, & Pasic, 2016; Salimpoor, Benovoy, Larcher, Dagher, Zatorre, & 2011). For example, when the listener listens to a piece of music, the brain's right and left hemispheres work together to process the melody and analyze the other musical elements (e.g., rhythm, pitch, and timbre) while the limbic system activates an emotional response (Hampton, 2007). Such has been growing evidence that music improves attention since music enhances arousal and increases motivation, potentially benefiting the learning process through emotional processes (Dalton & Behm, 2007; Husain, Thompson, & Schellenberg, 2002).

Listening to music was investigated as a potential help for children with learning difficulties and sustaining attention, such as children with ADHD and children with autism (Abikoff, Courtney, Szeibel, & Koplewicz, 1996; Greenop & Kann, 2007; Hallam, Price, & Katsarou, 2002; Lanovaz, Sladeczek, & Rapp, 2011). While in some studies, music was reported as a distractor that may deter the performance of specific tasks such as reading comprehension, memory processes (i.e., memorizing advertisements, specific memory tasks, and remembering texts read before) and driving performance (Etaugh & Michaels, 1975; Kämpfe, Sedlmeier, & Renkewitz, 2010; Treisman, 2006).

Previous reviews gathered a series of studies about the effect of music listening procedures on an individual's performance in general tasks (Dalton & Behm, 2007; Schwartz et al., 2017). However, yet

CONTACT Camila Guimarães Mendes camilagmbh@gmail.com Universidade Federal de Minas Gerais, Avenida Prof. Alfredo Balena, 190 Santa Efigênia, Belo Horizonte 30130-100, Brazil.

Disponível em:

https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Abstract

This review focused on knowledge about the effects of music on attention. The revision was performed in compliance with the PRISMA protocol, being registered at Prospero under number CRD42020172933. Across reviewed studies the music improved performance on attention tasks, either by listening or using it within a procedure to modulate mood and motivation. It is still difficult to generalize and compare the results because of methodology and study design diversity. Further studies are needed to increase knowledge about the effect of music effect, especially to evaluate if it might have any potential clinical use.

Keywords: attention, music listening, review

Introduction

Attention facilitates selecting relevant information and allocating cognitive resources or processes necessary during everyday life (Cohen, 2014). This skill is evident from birth and continues to develop into young adulthood (e.g., 20-years-old) (Cohen, 2014). However, attention refers to a broad class of cognitive processes and a wide range of behavioral phenomena (Cohen, 2014). Individual resources (i.e., cognitive) influence both attention capacity and environmental factors (i.e., presence of reward or stimulation). In this sense, music has been investigated in the literature as an external factor capable of affecting cognitive tasks' performance (Schwartz, Ayres, & Douglas, 2017; Dalton & Behm, 2007).

Specific regions of the brain are implicated by music. Music affects processes related to memory, motor control, timing, language, emotion and reward circuits, suggesting a possible involvement of dopaminergic pathways (Salimpoor, Benovoy, Larcher, Dagher, & 2011; Demarin, Bedekovic, Puretic, & Pasic, 2016). For example, when the listener listens to a piece of music, the brain's right and left hemispheres work together to process the melody and analyze the other musical elements (e.g., rhythm, pitch, and timbre) while the limbic system activates an emotional response (Hampton, 2007). Such has been growing evidence that music improves attention since music

enhances arousal and increases motivation, potentially benefiting the learning process through emotional processes (Husain, Thompson, & Schellenberg, 2002; Dalton & Behm 2007).

Listening to music was investigated as a potential help for children with learning difficulties and sustaining attention, such as children with ADHD and children with autism (Abikoff, Courtney 1996; Greenop & Kann, 2007; Hallam & Price, 1998; Lanovaz, Sladeczek, & Rapp, 2011). While in some studies, music was reported as a distractor that may deter the performance of specific tasks such as reading comprehension, memory processes (i.e., memorizing advertisements, specific memory tasks, and remembering texts read before) and driving performance (Etaugh & Michals, 1975; Kämpfe, Sedlmeier & Frank Renkewitz, 2010; Treisman, 2006).

Previous reviews gathered a series of studies about the effect of music listening procedures on an individual's performance in general tasks (Dalton & Behm 2007; Schwartz, 2017). However, yet the results were inconclusive and did not allow comparisons due to methodological and outcome differences. Thus, this study focused on understanding music's effects on a single outcome: attention.

Method

This study is registered at PROSPERO, under number CRD42020172933.

Search criteria

A systematic review was conducted in February 2020 with a guiding question: What is music's effect on the attention? For this, were used the following keywords: "music," "background music," and "attention," for search articles related to the topic. Mesh descriptors and keywords were used in English and were combined with operators AND and OR. Databases were PubMed, PsycINFO, Eric, and Scopus. The search strategies for each database are detailed (see Table 1). This review was conducted

according to the model of the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes – PRISMA (Shamseer, et al., 2015).

Table 1: Search strategies

Data Base	Search strategies
PubMed	Title/abstract: music OR background music AND attention
PsycINFO	Abstract: "music" OR Abstract: background music AND Abstract: attention AND Document Type: Journal Article
Eric	music OR background music AND attention
Scopus	ABS ("music" OR "background music" AND "attention") AND DOCTYPE (ar) AND (LIMIT-TO (EXACTKEYWORD , "Music") OR LIMIT-TO (EXACTKEYWORD , "Attention")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Portuguese"))

The inclusion criteria were: (1) studies if they involved any music listening procedure (i.e the manipulation of background music or listening to music); (2) at least one dependent variable assessed the participants' attention; (3) in English. There was no delimitation of a year of publication. Studies that addressed interventions using music, such as music therapy or art therapy were excluded, as well as the studies in which participants actively manipulated musical instruments (e.g., musical training studies). Because the term "attention" refers to many different behavioral and cognitive phenomena, was considered a valid effect on attention since some measure was used to assess the ability to focus, divide, or sustain mental effort during task performance (Zillmer, Spiers & Culbertson, 2007). The term "music" was considered as an organized sound that includes general elements that govern melody and harmony, rhythm, dynamics (i.e., loudness and softness), and the sonic qualities of timbre and texture (Goldman, 1961; Burton, 2015).

Screening procedure

The screening of studies was performed in pairs, including initial screening of abstracts and titles from the search independently to identify potential trials according to the inclusion and exclusion criteria. After selecting the articles eligible for full reading, the two authors discussed the results and reached a consensus of articles included to review. If no agreement was reached, a third author decided.

A unified neuropsychological model of attention (Cohen, 2014) was used to help group the measurement tools mentioned by the articles. The categories were as follows: (1) selective attention (when the task is to give preference to certain stimuli over others); (2) focused attention (when the task requires the selection abilities of the individual); and (3) sustained attention (when the task requires attentional persistence over a period of time) (Cohen, 2014). When a measure could group under multiple categories, it was placed under the domain that best describes its function.

Data extraction

Data extracted followed a standard form, including first author, year, country, study design, objectives, music listening procedures, study subject, measurement of attention, and main findings.

Risk of Bias (Quality) Assessment

The same review authors assessed the risk of bias in each included study using the Cochrane Collaboration's risk of bias tool (Higgins & Green, 2011).

Results

A total of 2940 articles were identified from the databases using the search strategy. Two additional references were hand-searched and included in this review. Two hundred and twenty-four duplicates were removed, and 2400 articles were assessed by title and abstract. Of these, 2296 reports were excluded because they did not fulfill the predetermined criteria. Hence, 104 papers were included and their full-text analyzed, of which 18 met inclusion criteria and one more hand-searched after full-text reading. Nineteen (N=19) studies were included in the review. A flow chart (Figure 1) of the process was made following the PRISMA statement (Shamseer, et al., 2015).

The participants and music listening procedures varied, so the focus remained on qualitative synthesis in this review. When the studies presented secondary outcomes that were not directly related to music and attention, the focus remained on presenting and discussing only the main findings according to this review's purpose.

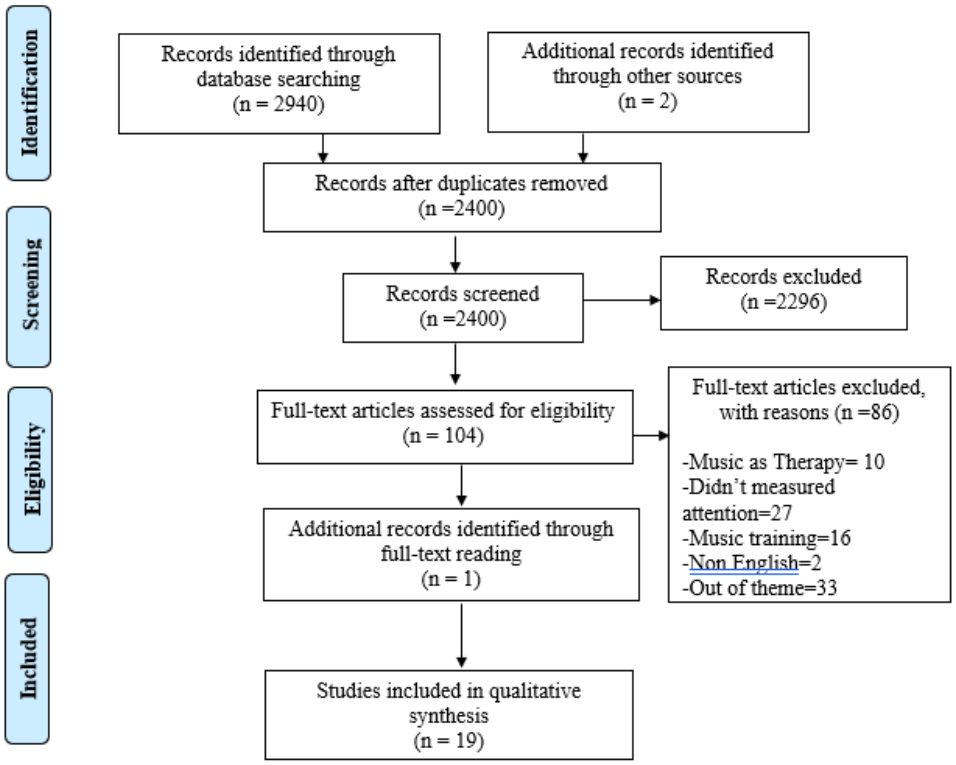


Figure 1 - Flow Diagram

Table 2 summarized the included studies grouped according to the measures of attention used for this study. Since the same measurement of selective attention was found in six of the included studies, the data was pooled together (Table 3). Thus, 13 studies grouped as outlined in what follows:

Selective attention (N=7): included studies that used the paradigm of attention blink, that consists in the task of rapid serial visual presentation (Xie, Miao, Zhang, & Tang, 2012; Ho, Mason, & Spence, 2007; Jefferies, Smilek, Eich, & Enns, 2008). This task involves participants identifying two target digits T1 and T2 (in their correct order of presentation) presented amongst a stream of distractor letters (Cohen, 2014). Also, some studies used Flanker tasks, such as the Attention Network Test (ANT) (designed to measure individual differences in alerting, orienting, and executive attention) (Rowe, Hirsh, & Anderson, 2006; Jiang, Scolaro, Bailey, & Chen, 2011; McConnell & Shore, 2011). The ANT is similar to that a single flanker task combined with cueing conditions

and of dissociation of effects associated with cueing and flanker conditions. The other flanker task used included one based on Eriksen and Eriksen's classic flanker task. Finally, one single study used the d2 Test (a cancellation test measures accuracy and speed in differentiating stimuli varying in visual detail) (Lipscomb & Society for Music Perception and Cognition., 2004).

Focused attention (N=3): included studies used tests that require working memory, and coding, mental arithmetic, and other effortful cognitive operations. The tests were: Digit Span (requires participants to repeat, in the same order, a string of numbers read to them) and Coding (requires to rapidly fill in empty boxes as with digits corresponding to each unique geometric shape are given to them) (Lake & Goldstein, 2011); Symbol digit modality testing (SDMT) (participants were asked to scan the coding key which consists of 9 symbols each paired with a number from 1-9 and write the number corresponding to each symbol) (Herlekar, & Siddangoudra, 2019); and Numeral Finding Test (finding of the object, elimination of unwanted object, and calculation of desired object figures within a given time frame) and Typo Revealing Test (memorizing power, retrieval capacity and finding of desired object figures) (Begum, et al., 2019).

Sustained attention (N=3): included studies which involved tests that measured sustained attention. A study used the Sustained Attention to Response Task (SART) (involves the rapid presentation of black numbers, 0-9, on a white background and requires the participants to response with a mouse click to every number except for the number 3) (Baldwin & Lewis, 2017). Another study used the Laboratory Temperament Assessment Battery (Lab-TAB) to measure the attention of children. The battery includes an episode task where the child should play freely with decorated cubes for 3 min (divided into 6-time intervals of 10s). Each time interval is scored for intensity of the facial interest, duration of observation, and manipulation. All scores were averaged to compute a

composite score of Sustained attention (Lejeune, et al., 2019). A study also used a single clinical neuropsychological assessment that assessed focused attention and sustained attention (Särkämö, et al., 2008).

Table 3 summarized six studies that used the same test to examine the attention. The Chu Attention Test is a standard evaluation tool frequently used in occupational therapy as a predictor of attention level in community services. The participants are asked to look at a series of scrambled codes and search for the symbol, "*," randomly distributed among 00 to 99 items within 10 minutes (Shih, Huang, & Chiang, 2009; Huang & Shih, 2011; Shih, Huang, & Chiang, 2012; Shih, Chen, Chiang, & Liu, 2015; Shih, Chien, & Chiang, 2016; Wu & Shih, 2019).

Table 2. Descriptive characteristics of included studies according the model of attention.

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
SELECTIVE ATTENTION									
1	Cristy Ho	2007	UK	Quasi experimental study	Investigate what influence, if any, the 'Mozart effect' would have on temporal attention using the visual AB task	The participants performed the Attentional Blink Task under three conditions: – Silence (no music) – Mozart forward condition (listening Mozart's Sonata, normally) – Mozart backward condition: listening Mozart in reverse.	N = 34 Female = 21 Male = 13 Age: 18–23	Attentional Blink (AB) Task	Accuracy to T2 on AB task: Mozart forward > Mozart backward > silence
2	Jefferies	2008	Canada	Quasi experimental study	Examine how the emotion-attention relationship is influenced by chances in mood valence and arousal state	Participants performed the AB task during the induction mood Sad (negative affect, low arousal) Calm (positive affect, low arousal) Anxious (negative affect, high arousal) Happy (positive affect, high arousal) Neutral (no induction procedure) Induction mood: listening to music and to generate thoughts consistent with induced mood, except in the neutral condition	N = 100	Attentional Blink (AB) Task	T2 accuracy on AB task: Sadness: highest levels Anxiety: lowest levels Calm and happy states (low and high arousal combined with positive affect): intermediate
3	Xie	2012	China	Quasi experimental study	To investigate the existence of the temporal component of Mozart effect, the influence of arousal or mood changing to AB when listening to Mozart Sonata	The participants performed the test listening Mozart Sonata for Two Pianos in D Major, K.448 Experiment 1: - Baseline: in silence (no music) – Mozart normal speed – Mozart fast speed Experiment 2: – Baseline: in silence (no music) – Mozart Major played in normal speed – Mozart Minor played in fast speed	EXP. 1: N = 26 Female = 12 Male = 14 Age: 21–27 EXP. 2: N = 29 Female = 13 Male = 16 Age: 21–24	Attentional Blink (AB) Task	Experiment 1: Accuracy of T2: Mozart Normal > silence Mozart fast < Mozart Normal Experiment 2: Accuracy of T2: Mozart Major and Mozart Minor < silence. Not significant.

(*Continued*)

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
4	Jiang	2011	China	Quasi experimental study	The present experiment aimed at determining the influence of inducing a specific mood on attentional networks	ANT before and after mood induction (listen to music and generate thoughts consistent with induced mood). Positive: listen to a Bach's Brandenburg Concerto No. 3 Negative: listen to Prokofiev's "Alexander Nevsky Neutral: reading a collection of facts about China	N = 36 Female = 25 Male = 11 Age = 18–24	Attention Network Test (ANT)	Alerting scores: negative mood > positive mood > neutral RT: negative > positive and neutral (under no cue and double cue condition) negative < positive and neutral mood under all cue conditions except the double-cue condition.
5	Mc Connell	2011	Canada	Randomized Controlled Trial (RCT)	To examine the combined effects of mood and arousal on a variety of attention measures.	STUDY 1: Answered the mood-arousal measures before and after listen to music for 10 min. Music: Mozart's sonata K. 448 varied in both tempo and mode STUDY 2: Perform the ANT test after listen the music for 10 min. Fast-major (n = 16); Slow-major (n = 16) Fast-minor (n = 17); Slow-minor (n = 15)	STUDY 1: N = 24 Female = 16 Male = 8 Age = M.19.7 STUDY 2: N = 66 Age = M.19.3 Female = 50 Male = 16	Attention Network Test (ANT)	Alerting scores: negative > positive (not significant) Flanker congruency effects (executive control): Arousal high: positive > negative. Arousal low: Emotional Valence did not influence the magnitude of the flanker effect.

(Continued)

Disponível em: https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
6	Darrow	2006	USA	Quasi experimental study	To determine if music compromises one's selective attention, and if music, affects music majors and non-music majors differently.	Participants took the d2 test both with the background music and without. The order of conditions was counterbalanced between subjects. Groups: music majors and nonmusic majors The music was specific to the individual participant.	N = 87	d2 Test	Music majors music first < non music condition Instrumental > with vocal More items under the music condition. Music majors > nonmusic majors under all conditions. Errors: Music major < Non music Items correctly: Music major > Non music Concentration: Music > non music
7	Rowe	2006	Canadá	Quasi experimental study	To examine if the increased cognitive flexibility and creative thinking associated with positive mood reflects a change in selective attention	All participants performed the tasks during each of induced affective states. Happy mood induction: listen to a Bach's Brandenburg Concerto 3 Sad mood induction: listen to Prokofiev's "Alexander Nevsky: Russia Under the Mongolian Yoke" Neutral: reading a collection of facts about Canada	N = 24 Female = 12 Male = 12	Flanker Task	Positive moods resulted in greater flanker interference relative to both sad and neutral moods
FOCUSED ATTENTION									

(Continued)

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
8	Lake	2011	EUA	Quasi experimental study	Examination the effect of listening music on attention in groups of older adults (mild cognitive impairtment and normal)	Perform to test of attention after listen to or not music for 10 min Group control (n = 12) Group patients (n = 12) Music: "Spring" movement of Four Seasons by Vivaldi (1990)	N = 12 amnestic mild cognitive impairment Female = 3 Male = 9 Age = M.74.3 N = 12 cognitively intact Female = 8 Male = 4 Age = M.66,1	Digit Span Coding	Digit Span Music x silence: no difference found. Music order (Music then Silence x Silence then Music): no difference found Test order (Version A then B x Version B then A) Coding Controls > patients Music x silence: no difference found. Music order (Music then Silence x Silence then Music): no difference found Test order (Version A then B x Version B then A)

(*Continued*)

Disponível em: https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
9	Herlekar	2019	Indian	Randomized Control Trial	To assess the effect of classical instrumental, background music on successive divided attention tests	- Form A – pre test, without music (all students) - Form B – during exposure to music/control. - Form C – during post test in all subjects, without music Indian/Malaysian: Music group (n = 30) Control group (n = 30): no music	N = 60 Indian Female = 15 Male = 15 Malaysian Female = 15 Male = 15 Age: 18–20	Symbol digit modality testing (SDMT)	Posttest (total and correct scores): Music group > Control group During music/rest: "Correct": Malaysian music > control Malaysian music > Indian music "Total": Malaysian music > control Malaysian music > Indian music Malaysian control: highest errors POSTTEST "Correct": Malaysian music > control Malaysian music > Indian music "Total": Malaysian music > control Malaysian music > Indian music

(Continued)

Disponível em: https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
10	Begum	2019	Bangladesh	Cross-Sectional	To examine the impact of soft, stimulating, and depressing songs on the attention of students.	Group1(Control): without any songs Group 2 (Soft): That's My Name (Akcent); Group 3 (Stimulating): Rain Over Me(Pitbull featuring Marc Anthony); Group 4 (Depressing): Broken Angel (Arash featuring Helena).	280 students Female = 125 Male = 155 Age: 18–25	Numeral Finding Test (NF test) Typo Revealing Test (TR test)	NF TEST and TR TEST: % attention Group 2 (soft song) > Group 1 (control) Group 3 (stimulating song) > Group 1 (control). Group 4 (depressing) < Group 1 (control). Among all groups lowest attention was reported by Group 4 and highest by Group 3. All results were statistic significant.
SUSTAINED ATTENTION									

(Continued)

Disponível em: https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
11	Baldwin	2016	USA	Quasi experimental study	To establish a database of popular music varying along the dimensions of tempo and valence and to examine the impact of music varying along these dimensions on restoring attentional resources following performance of a sustained attention to response task (SART) vigil.	Experiment 1: 80 popular songs ("top hits" lists) were sorted by the researchers to participants listen and evaluate the emotions inspired by music Experiment 2: 7 minute SART block, + an intervention + a second 7 minute SART block. Intervention group: positive fast/slow songs,, negative fast/slow songs, Control groups: no music 7 min. SART block, + 7 min. break (silence)/no break + second SART block.	Experiment 1: N = 69 Female:48 Male: 21 Age: M.21.59 Experiment 2: N = 89 Female = 65 Male = 24 Age = M. 20.73	Sustained Attention to Response Task (SART)	Misses after the intervention: Positive slow songs condition showed significant reduction Negative conditions or no break conditions showed significant increases Music preference: Like the music less = tended to have increased misses no matter which group they were Moderately like the music = the misses were more similar based on their group.
12	Lejeune	2018	Switzerland	Randomized Controlled Trial (RCT)	To evaluate long-term effects of music listening on cognitive and emotional development in preterm children by comparing them to a preterm control group with no previous music exposure and to a full-term group at 12 and 24 months.	Preterm-music (n = 23): listened to music during 8 min with headphones, from gestational age of 33 weeks until hospital discharge or term-equivalent age. 5 times/week agree with the state of wakefulness (e.g helping the baby to wake up). Preterm-control (n = 17): without music Full-term (n = 17): no previous music exposure	N = 44 (17 full-term and 27 preterm). Age = 12–24 months	Laboratory Temperament Assessment Battery (Lab-TAB)	No difference found for sustained attention

(Continued)

Table 2. (Continued).

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
13	Sarkamo	2007	Finland	Randomized Controlled Trial (RCT)	To determine whether regular selfdirected music listening during the first months after middle cerebral artery (MCA) stroke can enhance the recovery of cognitive functions and mood.	Listen to music or narrated audio books (minimum 1 h per day) for 2 months while still in the hospital or at home. Music group (n = 18): their own favorite music in any musical genre Language group (n = 19): narrated audio books on cassette selected by the patients from a collection of the Finnish Celia library for the visually impaired. Control group (n = 17): without listening material	N = 54 Music group: M.56.1 years Language group: M.59.3 years Control: M.61.5 years	Clinical neuropsychological assessment	Focused attention and verbal memory: Music group > Language group and Control Group Depressed, confuse mood: Music group < control group

Disponível em: https://www.researchgate.net/publication/350615835_Does_Music_Listening_Affect_Attention_A_Literature_Review Acesso em 06/07/2022

Table 3. Descriptive characteristics of included studies that used the same test to measure the selective Attention.

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
1	Shih	2009	China	Randomized Controlled Trial (RCT)	To determine whether background music played during or preceding a task requiring attention/concentration influences performance.	Group 1 (n=11): listened classical compositions of Canon while completed the test Group 2 (n=11): completed the test in silence Group 3 (n=10): listened to Canon music for 10 minutes prior to the experiment, and took the test in silence.	N= 32 Female=14 Male= 18 Age: 20– 27	Chu Attention Test	Total score of attention: Group 3 (music prior to test) > Group 2 (no music) > Group 1 (music during test). Variation in performance: group 2 > group 1 > group 3 Standard of error: Group 3: the highest Total number of questions answered: Group 3 > Group 2 > Group 1
2	Huang	2011	China	Randomized Controlled Trial (RCT)	To understand how background music and listener fondness for types of music affects worker concentration	Listen to music or not while perfoming test. Group 1 (n=23): quiet environment Group 2 (n=22): popular music Group 3 (n=20): classical light music Group 4 (n=24): traditional Chinese music	N=89 Female=52 Male= 37 Age: 19-28	Chu Attention Test	Test takers exposed to background music < without music. But this difference was not significant. Liking for the background music: Group 1 (no music) x Group (background music): strongly liked or strongly disliked = lower attention test scores.
3	Shih	2012	China	Randomized Controlled Trial (RCT)	To compare how music with and without lyrics affects attention of workers	Baseline: Group 1 (n=49) and Group 2 (n=53) performed the test in a quiet environment Experiment (3 weeks later): listened music while performing the test Group 1 (music with lyrics) Group 2 (music without lyrics)	N= 102 Female=46 Male= 56 Age: 20–24	Chu Attention Test	Group 1 baseline x Group 2 baseline: no difference Group 1 baseline > Group 1 (music with lyrics) Group 2 baseline > Group 2 (without lyrics): not significant Group 1 (with lyrics) < Group 2 (without lyrics): not significant

Table 3. (Continued)

	First author	Year	Country	Study design	Objectives	Music Listening Procedures	Study subject	Measurement of attention	Main findings
4	Shih	2015	China	Randomized Controlled Trial (RCT)	To examine the influence of music on work attention in persons with schizophrenia	Pre-test: quiet environment Post-test (after 2 months): listen to music or not Group1 (control): quiet Group 2: classical light music Group3: popular music	N=49 Female=20 Male= 29 Age: 29-63	Chu Attention Test	Group 2 pre-test < Group 2 (classical light music): some significant variance (sig =0.071) Group 3 baseline < Group 3 (popular music)
5	Shih	2016	China	Randomized Controlled Trial (RCT)	Investigate the relationship between work attention performance and emotions arising from listening to music	Listen to music or not Baseline: quiet environment Experiment (3 weeks later): music while performing the test Group 1 (n=33; with lyrics) Group 2 (n=32; without lyrics)	N= 65 Female=34 Male= 31 Age: 20–24	Chu Attention Test	To background music: “loved” = higher score "sadness" = lower score and more errors Group 1 (with lyrics) < Group 2 (without lyrics) Group 1 baseline > Group 1 (music with lyrics)
6	Wua	2019	China	Quasi experimental study	Explore the difference in attention performance between musicians and non-musicians, and of the possible effect of background music on their attention performance	Pre-test: test in a quiet environment. Post test: while listen music or not Group 1 (n=23 non-musicians) Group 3 (n=28 musicians): quiet environment Group 2 (n=24 non musicians) Group 4 (n=28 musicians): soft music (songs popular in the Asian area)	N=103 Non-musicians N=47 Female=36 Male= 11 Age: 21–25 Musicians= N= 56 Female=43 Male= 13 Age: 21–25	Chu Attention Test	Attention performance: Musician > no musician Group 1 (no musician/no music) and Group 3 (musician/no music): post test > pre-test (not significant) Group 2 (non-musician/soft music) and Group 4 (musician/soft music): post test > pre-test

Study design

All included studies were experimental, with nine randomized controlled trials (RCTs) (N=9), eight quasi-experimental (N=8), and two Cross-Sectional studies (N=2). The majority of included RCTs (N=5) were performed in China, two in Canada, and one in India, Finland, and Switzerland. Three quasi-experimental studies were performed in China, three in EUA, and one in Canada and in UK. The cross-sectional study was performed in Bangladesh. Thus, studies were conducted mostly in Asia, followed by Europe and North America. The studies were published the year 2006 to 2019 (see Table 2).

Risk of bias

'Risk of bias' summaries was reported in Figure 2 and Figure 3, with details about each 'Risk of bias' item for each included study. Most studies reported insufficient detail to allow accurate assessment of domains of blinding and allocation concealment. With music listening, it is difficult to conceal the intervention from the participant. Thus, participant blinding was not used in any of the studies included, only to the researcher or caregiver, when appropriate.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

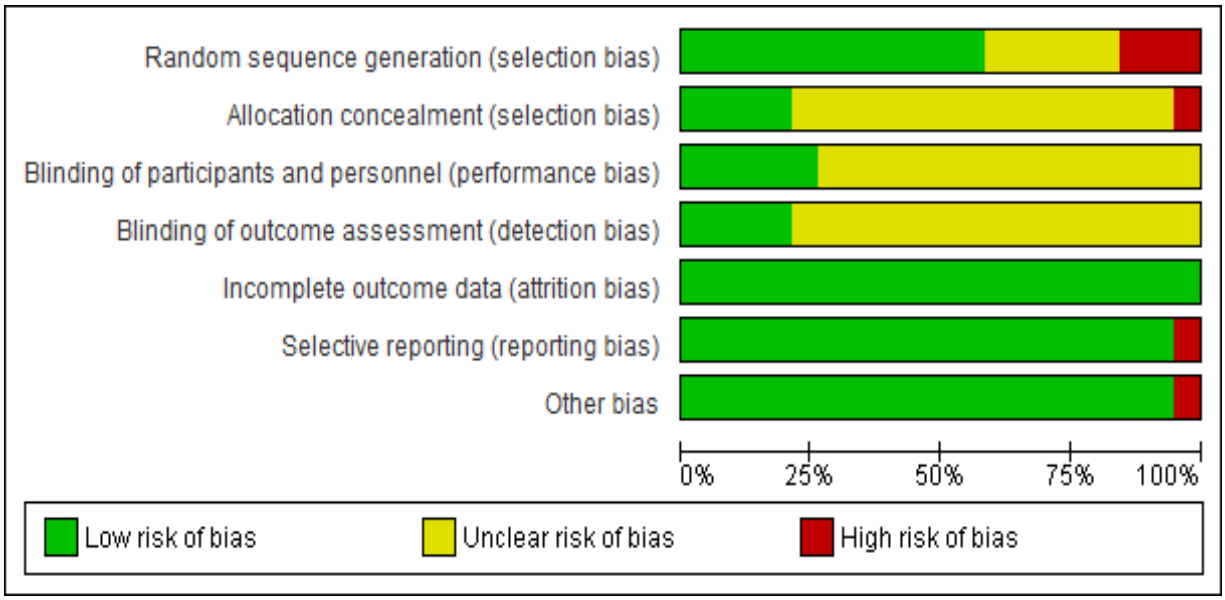
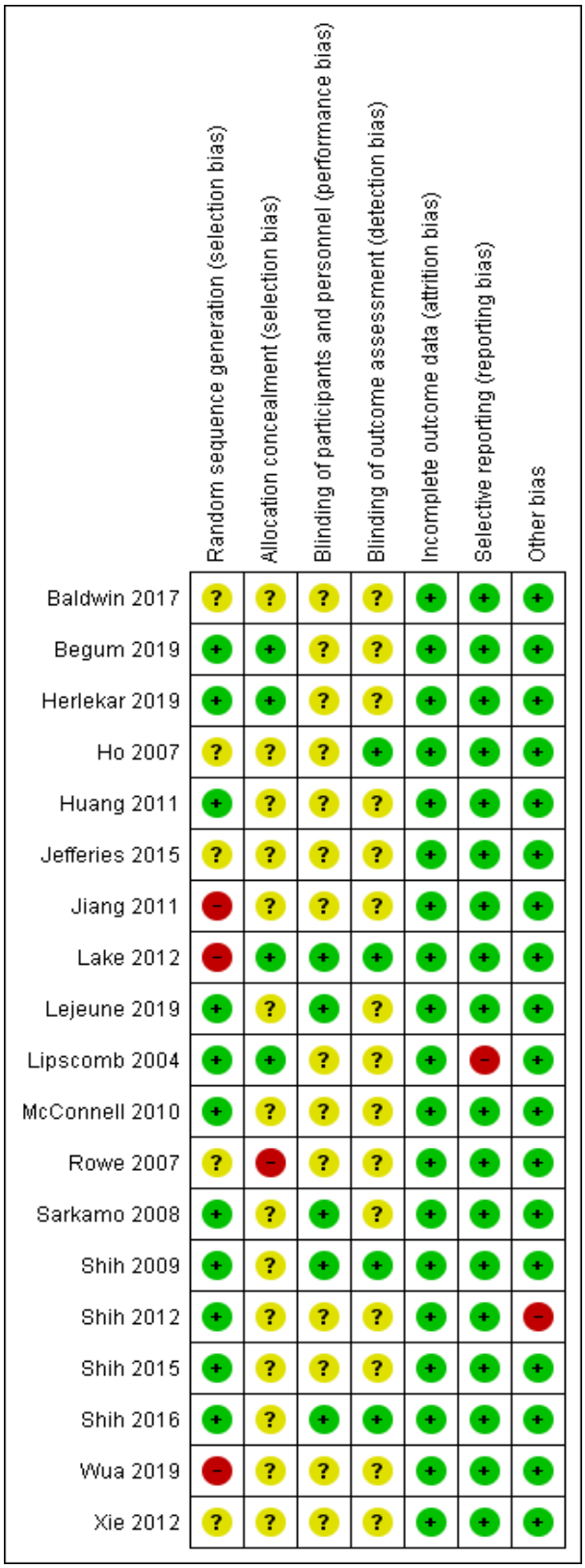


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Participant characteristics

Most studies (N=16) enrolled healthy adults, workers, students (18-28-years-old), and typically-developing children (12-24-months-old). One study enrolled patients who suffered a stroke (56-61-years-old), with chronic schizophrenia (29-63-years-old) and, diagnosed with amnestic mild cognitive impairment (mean of 74.3). Considering the samples, the number of subjects was more than 1,000 healthy people (mean of 80 participants per study; women and men), followed by 54 patients after stroke, 49 patients with chronic schizophrenia and, 12 individuals with mild cognitive amnesic impairment.

Music Listening Procedure

Different types of music listening procedures were identified: listening to music prior to or followed by attention performance for a short time (Shih et al.,2009; Baldwin & Lewis, 2017; Lake, & Goldstein, 2011), as background (listening to music while performing the task) (Huang & Shih, 2011; Shih et al., 2012; Shih et al., 2015; Shih et al., 2016; Wua & Shih, 2019; Ho et al., 2007; Xie et al., 2012; Herlekar et al., 2019; Begum, et al., 2019; Lipscomb & Society for Music Perception and Cognition., 2004) or as an induction procedure (i.e music with positive or negative valence to promote a particular mood) (Rowe et al., 2006; Jiang et al., 2011; Jefferies et al., 2008; McConnell & Shore, 2011). The mood induction studies used listener self-assessments as a measurement. Also, two studies evaluated the music as a long-term intervention and before the test: patients listened to music by themselves daily (minimum 1h per day) for two months while still in the hospital or at home (Särkämö et al., 2008); and the preterm-music group listened to music for eight minutes for five weeks and once in a full-term group at the first days of life (Lejeune et al., 2019).

Most of the studies had music selected by the researchers, and the most used genre was classical music (i.e., classical compositions of Bach and Mozart). Two studies did

not describe the criteria for choosing music (Shih et al., 2012; Shih et al., 2016), and three others chose music based on the participants' preferences (Lipscomb & Society for Music Perception and Cognition., 2004; Särkämö et al., 2008; Begum et al., 2019). The methodology to evaluate the effects of attention yet varied.

Effects of music on selective attention

Three studies used the same task to measure attention. They examined the effect of music on Attentional Blink Task (Ho et al., 2007; Xie et al., 2012; Jefferies et al., 2008). Two studies compared participants' attention performance under conditions with background music (Mozart Sonata K.448) and in silence (Ho et al., 2007; Xie et al., 2012). The results showed a significant improvement in the accuracy of T2 identification in the AB task while the participants who listened to Mozart typically played (i.e., forward) versus Mozart played in reverse (i.e., backward) or the silence condition (Ho et al., 2007). In contrast, the performances of detecting the second target T2 were slightly reduced under Mozart major and Mozart Minor when compare to the silence condition, though not significantly (Xie et al., 2012).

To investigate the effects on attention by changes in both mood valence (negative vs. positive) and arousal (low vs. high), Jefferies and colleagues (2008) created induction mood groups according to their ratings. These ratings included: sad (negative affect, low arousal), calm (positive affect, low arousal), anxious (negative affect, high arousal), happy (positive affect, high arousal), happy (positive affect, low arousal), anxious (negative affect, high arousal), happy (positive affect, high arousal), or neutral (no induction procedure). The mood-induction procedure consisted of listening to music and to generate thoughts consistent with induced mood, except in the neutral condition. This study observed sadness (low arousal with negative affect) produced the highest levels of

performance, anxiety (high arousal with negative affect) led to the lowest levels of performance, and calm and happy states (low and high arousal combined with positive affect) were associated with intermediate performance. These results were specific to one measure of attention, the accuracy of T2 identification.

Lipscomb and Society for Music Perception and Cognition (2004) examined the attention with and without previous musical training experience using the D^2 Test. The study reported the music majors (participants with previous musical training experience) achieved higher scores under the music condition than the no-music condition. Music majors processed more items on a test than non-music majors under all conditions, made fewer errors, processed more items correctly (number processed minus errors), and had better performance scores than non-music majors. When they heard the music first, the study also reported these participants completed significantly fewer total items in the following non-music condition, and those who listened to instrumental music completed more total items than those who listened to music with vocals (Lipscomb & Society for Music Perception and Cognition., 2004).

Rowe et al. (2006) and Jiang et al. (2011) used the same background music: a jazzed-up version of Concerto No.3 of Bach Brandenberg for happy mood induction, the Alexander Nevsky of Prokofiev (played at half speed) for sad mood, and a collection of basic facts about their own country (i.e., population size, gross national product) to read for neutral mood. Rowe et al. (2006) used a Flanker Task based on Eriksen and Eriksen's (Eriksen & Eriksen, 1974) to measure the attention and found positive moods resulted in greater flanker interference relative to both sad and neutral moods. Additionally, Jiang et al. (2011) revealed that the ANT test's alerting scores were significantly more harmful to mood conditions than positive and neutral moods. The same test was used by McConnell and Shore (2011) during the background music of Mozart Sonata K.448, which varied in

both tempo and mode (Fast-major x Slow major x Fast-minor x Slow minor) as induction procedure for valence and arousal state. Findings showed that when arousal levels were high, participants who experienced positive valence showed larger flanker effects relative to participants who experienced negative valence. However, when arousal levels were low, emotional valence did not influence flanker congruency effects.

Separately, studies of a Chinese group that used the Chu Attention test reported significant music effects on attention performance. In Shih et al. (2009) the total score of attention and number of questions answered were greater in workers who listened to music before the test than those who received the silence condition and then listened to music during the test. Additionally, the group that listened to music prior to the test had the highest standard of error ratio reflecting the actual quality of the work accomplished.

Other studies demonstrated that background music might impair performance attention when the music had lyrics, compared to baseline (without music) (Shih et al., 2012; Shih et al., 2016). None of them provided the effect size regarding differences between groups; therefore, the current study calculated Cohen's D from published data and found a moderate to large effect size in the comparison of the control group (no music) and lyric music group (d =0.41; d=0.56) (Shih et al., 2012; Shih et al., 2016). These results demonstrated a potential moderate to enormous harm in using background music with lyric in the tested scenarios. Attention performance was also lower when the background music had lyrics compared to when the music did not have lyrics, but the difference was not statistically significant (Shih et al., 2012). Besides, Shih et al. (2016) found an association between feelings self-assessed by listeners about the background music with lyrics. Listeners who self-reported feeling "loved" while music played showed higher scores on their attention test. Whereas, listeners who self-report feeling "sadness" while music played showed lower scores on attention.

Another study compared the attention performance of musicians and non-musicians and found higher scores under the music condition than the no-music condition for both groups. Finally, one study tested persons with schizophrenia and found that the background music increased the attention test scores under both types of music: popular and classical light music (Shih et al., 2015).

Effects of music on focused attention

The post-test scores of Indian and Malaysian's participants in attention performance in the Symbol Digit Modality Test (SDMT) were higher in the music group than the control group (no music). Malaysian participants in the music group were better on the attention test than the other groups (Herlekar & Siddangoudra, 2019).

Different types of preferred music (divided into soft, stimulating, and depressing songs) showed effects on two attention tests (Numeral Finding Test and Typo Revealing Test). The attention was more significant in the stimulating song group than the control group, followed by a soft song group. The lowest rate was reported for the depressing song group (Begum et al., 2019).

Lake and Goldstein (2011) examined the attention performance of Digit Span and Coding subtests under music and no music conditions. No difference was found.

Effects on sustained attention

Sustained Attention to Response Task (SART) was performed sometimes with music (positive fast songs, positive slow songs, negative fast songs, negative slow songs) between its blocks, sometimes without music and with a break and sometimes without a break according to the groups (Baldwin & Lewis, 2017). The valence (positive or negative) was used to perceived emotion and was classified by researchers. The results showed only listening to positive music mitigated misses, while negative music tended to

increase misses compared to the no-music condition, though not above the no break condition. Additionally, those who described liking the music less, tended to have increased "misses" independent of the group they were in. Those who moderately liked the music displayed the same amount of misses as their group did. Individuals after-stroke who listened to their favorite music for two months had a more remarkable improvement in focused attention and verbal memory than patients who listened to audiobooks or had no listening activity (Särkämö et al., 2008).

Discussion

Music listening improved attention performance in healthy people and groups of individuals with schizophrenia and stroke. Specifically, when the music listening occurs before or during the task, performance in an attention test was better than in silence (Shih et al., 2009; Shih et al., 2012; Shih et al., 2016; Wu & Shih, 2019). Still, the effect of music on attention performance was influenced by the mood and arousal state of participants (Rowe et al., 2006; Jiang et al., 2011; Jefferies et al., 2008; McConnell & Shore, 2011; Baldwin & Lewis, 2017) and by characteristics of music such as the presence of lyrics or not (Shih et al., 2012; Shih et al., 2016).

Most studies showed the positive effects of music on attention, but it is impossible to say what kind of music or the best time to listen to music (before the task or during the task).

A preview meta-analysis identified two moderate music factors to explain the heterogeneity on the effect of background music in performance tasks: tempo and loudness (Kämpfe, Sedlmeier, & Renkewitz, 2011). The authors concluded that the tempo with which music is played affects the behavior's tempo (i.e., speed to eat or to drive). For example, high-intensity music impaired performance during simple vigilance or simulated driving tasks (Dalton & Behm 2007). The first music effects on task

performance described in literature were with music listening before the task (Rauscher et al., 1993, 1994). These studies found participants performed better on spatial-temporal tasks after listening to a Mozart Sonata than those who did not listen to music (Rauscher et al., 1993, 1994). One explanation for this result is the listening of preferred or enjoyable music increases pleasant mood and arousal levels, benefitting cognitive tasks (Schellenberg & Hallam, 2005). However, background music listening also might be concurrent with task performance (Perham & Sykora, 2012). During the task, the music causes a narrowing of attention, allowing the performer to block out irrelevant cues (O'Malley & Poplawsky, 1971). Music might also promote an attentional conflict (i.e., when a task requires several attentional resources, making it difficult to divide the task's attention and distractor). Thus, music's effect on performance will depend on the music, the task, and the performer (Gonzalez & Aiello, 2019).

The presence of lyrics, the valence (i.e., negative and positive), mood state and degree of liking self-reported (i.e., if happy or sad, if like or dislike) or other categories based on the feelings of the listener (i.e., stimulant, depressing) are other factors that explain the differences found. Though still controversial, findings seem to indicate that feelings such as happiness or calmness seem to improve the performance of selective attention tasks more than elicited feelings of anxiety or sadness (Shih et al., 2012; Shih et al., 2016). Feelings of happiness and calmness contributed to poor performance on the attentional blink task (Jefferies et al., 2008). Rather than depressing songs, music without lyrics or stimulant or soft music may be more useful to improve work performance (Begum et al., 2019). Previous experiences with music also changed the effects found in attention. Since musicians and individuals with music training performed significantly better than nonmusicians, may be because of experiences with studying music and attending to details in the music. Therefore, they may be more adept at detail-oriented

tests and less distracted by background music. (Wu & Shih, 2019; Lipscomb & Society for Music Perception and Cognition., 2004).

This review's findings were consistent with previous studies about music's effect in people with schizophrenia or post-stroke (Na & Yang, 2009; Thaut et al., 1997; Soto et al., 2009). Based on previous studies, music may be beneficial for people who experienced a stroke to improve focused attention and for people with schizophrenia to improve selective attention. None of the studies in this review examined other clinical conditions, therefore, the applicability of these conclusions to other clinical conditions is minimal.

This is the first known systematic review that brought together studies investigating the effect of music on a single dependent variable, the attention. Six studies from the Chinese population applied to occupational activities and showed an improvement related to the effect of background music on work performance. There were nine randomized controlled trials evaluating music used to improve attention, with moderate to large effect size, but they are not comparable because they use different attention tasks and stimuli, showing a need for more standardized research on the field. Given these findings, it seems that music can improve attention, especially listener preferred music or music without lyrics. Music listening also seems useful as a background (during the performance of a task. However, more comparative studies are needed for generalization to other contexts and populations.

Limitations

The first limitation is regarding the heterogeneity of methods for evaluating attention and for music listening procedures implemented in the studies. These differences made it difficult to compare results and draw broad conclusions. Secondly,

the variety of culture backgrounds also made it challenging to generalize to other cultural backgrounds different than those examined (Lee & Hu, 2014). While there is strong evidence to support the effect of music on attention, it is unknown as to what extent these results can be generalized to other populations and cultural contexts without further testing.

Lastly, most of the studies were conducted in a laboratory setting. Therefore, it was difficult to infer the success of music listening in ecological contexts such as home, school, or workplace.

Conclusion

Attention is a cognitive function essential to the performance of activities in daily life. This systematic review contributes to synthesizing the current literature related to music listening in changing attention. Does music listening affect attention? Yes, it does. Music, especially music without lyrics, tends to help people pay more attention to tasks that require concentration. It is a non-invasive intervention mostly studied in healthy individuals. More data is needed to determine music's potential applications to other clinical conditions that affect attention. If music does not have side effects, it could at times be distracting, such as when the music has lyrics.

Declaration of interest statement

The authors report no conflict of interest.

References

Abikoff, H., Courtney, M.E, Szeibel, P.J, & Koplewicz H.S. (1996). The effects of auditory stimulation on the arithmetic performance of children with ADHD and nondisabled children. *Journal of Learning Disabilities, 29,* 238–246.

Baldwin, C., & Lewis, B. (2017). Positive valence music restores executive control over sustained attention. *PLoS ONE, 12(11).*

Begum, M., Uddin, M., Rithy, J., Kabir, J., Tewari, D., Islam, A., & Ashraf, G. (2019). Analyzing the impact of soft, stimulating and depressing songs on attention among undergraduate students: A cross-sectional pilot study in Bangladesh. *Frontiers in Psychology*, *10*.

Burton, R.L. (2015). *The Elements of Music: What Are They, and Who Cares? In Music: Educating for Life:* ASME XXth National Conference Proceedings, edited by Jennifer Rosevear and Susan Harding, 22–28. Parkville, Victoria: The Australian Society for Music Education Inc.

Cohen, R. A. (2014). *The Neuropsychology of Attention.* EUA: Springer.

Dalton, B., & Behm, D. (2007). Effects of noise and music on human and task performance: A systematic review. *Occupational Ergonomics*, *7,* 143–152.

Eriksen, B.A., & Eriksen, C.W. (1974). *Percept Psychophys, 16,*143–149.

Etaugh,C., and Michaels, D. (1975). Effects of reading comprehension of preferred music and frequency of studying to music. *Perceptual and Motor Skills, 41,* 533-554.

Goldman, R.F. (1961). *Varèse: Ionisation; Density 21.5; Intégrales; Octandre; Hyperprism*; Poème Electronique. Instrumentalists, cond. Robert Craft. Columbia MS 6146 (stereo)" (in Reviews of Records). *Musical Quarterly 47 (1),* 133–134.

Greenop, K., & Kann, L. (2007). Extra-Task Stimulation on Mathematics Performance in Children with and without ADHD. *South African Journal of Psychology, 37(2),* 330-344.

Gunter, P. L., & Fox, J. J. (1993). A case study of the reduction of aberrant, repetitive responses of an adolescent with autism. *Education & Treatment of Children, 16,* 187–197.

Hallam, S., Price, J., & Katsarou, G. (2002). The effects of background music on primary school pupils' task performance. *Educational Studies, 28(2),* 111-122.

Hampton, A. (2007). A cognitive crescendo: How music affects the brain. *American Choral Directors Association, 2,* 1–3. Retrieved from http://acda.org/files/ChorTeach-Vol2%20no1_Hampton,%20A. pdf

Herlekar, S., Siddangoudra, S., & Professor, A. (2019). Original Article Effect of Classical Instrumental Music on Successive Divided Attention Tests in Indian and Malaysian First Year Medical Students-A Randomized Control Trial. *Indian journal of physiology and pharmacology*, *63(1),* 2-7.

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., . . . Cochrane Statistical Methods Group (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ (Clinical research ed.), 343,* d5928. https://doi.org/10.1136/bmj.d5928.

Ho, C., Mason, O., & Spence, C. (2007). An investigation into the temporal dimension of the Mozart effect: Evidence from the attentional blink task. *Acta Psychologica, 125(1),* 117-128.

Huang, R., & Shih, Y. (2011). Effects of background music on concentration of workers. *Work, 38(4),* 383-387.

Husain, G., Thompson, W.F. and Schellenberg, E.G. (2002). Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial abilities. *Music Perception, 20(2),* 151–171.

Jefferies, L., Smilek, D., Eich, E., & Enns, J. (2008). Emotional Valence and Arousal Interact in Attentional Control. *Psychological Science, 19(3),* 290-295.

Jiang, J., Scolaro, A., Bailey, K., & Chen, A. (2011). The effect of music-induced mood on attentional networks. *International Journal of Psychology, 46(3),* 214-222.

Kämpfe, J., Sedlmeier, P., & Renkewitz, F. (2011). The impact of background music on adult listeners: A meta-analysis. *Psychology of Music, 39(4),* 424-448.

Lake, J. I., & Goldstein, F. C. (2011). An examination of an enhancing effect of music on attentional abilities in older persons with mild cognitive impairment. *Perceptual and motor skills*, *112(1),* 267–278.

Lanovaz, M. J., Sladeczek, I.E., & Rapp, J.T. (2011). Effects of music on vocal stereotypy in children with autism. *Journal of Applied Behavior Analysis, 44(3),* 647-651.

Lee, J. H., & Hu, X. (2014). Cross-cultural Similarities and Differences in Music Mood Perception. *In iConference 2014 Proceedings*, 259–269.

Lejeune, F., Lordier, L., Pittet, M., Schoenhals, L., Grandjean, D., Hüppi, P., . . . Tolsa, C. (2019). Effects of an early postnatal music intervention on cognitive and emotional development in preterm children at 12 and 24 months: Preliminary findings. *Frontiers in Psychology, 10.*

Lipscomb, S., & Society for Music Perception and Cognition. (2004). Proceedings of ICMPC8. Society for Music Perception & Cognition. August 3-7.

McConnell, M., & Shore, D. (2011). Upbeat and happy: Arousal as an important factor in studying attention. *Cognition and Emotion, 25(7),* 1184-1195.

Na, H.J., & Yang, S. (2009). Effects of listening to music on auditory hallucination and psychiatric symptoms in people with schizophrenia. *Journal of Korean Academy of Nursing, 39,*62-71.

O'Malley, J. J., & Poplawsky, A. (1971). Noise-induced arousal and breadth of attention. *Perceptual and Motor Skills, 33,* 887– 890.

Perham, N., & Sykora, M. (2012). Disliked music can be better for performance than liked music. *Applied Cognitive Psychology, 26,* 550 –555.

Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature, 365,* 611.

Rauscher, F. H., Shaw, G. L., Levine, L. J., Ky, K. N., & Wright, E. L. (1994). Music and spatial task performance: A causal relationship. *Paper presented at the 102nd Annual Convention of the American Psychological Association*, Los Angeles, CA.

Rowe, G., Hirsh, J., & Anderson, A. (2006). Positive affect increases the breadth of attentional selection. *Proceedings of the National Academy of Sciences of the United States of America PNAS, 104 (1)* 383-388.

Särkämö, T., Tervaniemi, M., Laitinen, S., Forsblom, A., Soinila, S., Mikkonen, M., ... Hietanen, M. (2008). Music listening enhances cognitive recovery and mood after middle cerebral artery stroke. *Brain, 131(3),* 866-876.

Schwartz, R., Ayres, K., & Douglas, K. (2017). Effects of music on task performance, engagement, and behavior: A literature review. *Psychology of Music, 45(5),* 611-627.

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., . . . Whitlock, E. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA) 2015: Elaboration and explanation. *BMJ (Online), 349.*

Shih, Y., Chen, C., Chiang, H., & Liu, C. (2015). Influence of background music on work attention in clients with chronic schizophrenia. *Work, 51(1),* 153-158.

Shih, Y., Chien, W., & Chiang, H. (2016). Elucidating the relationship between work attention performance and emotions arising from listening to music. *Work, 55(2),* 489-494.

Shih, Y., Huang, R., & Chiang, H. (2009). Correlation between work concentration level and background music: A pilot study. *Work, 33(3),* 329-333.

Shih, Y., Huang, R., & Chiang, H. (2012). Background music: Effects on attention performance. *Work, 42(4),* 573-578.

Shih, Y.N., Hwang, M.T., Chiang, H.S. (2003). A Comparison of the reducing Effects of different background music upon the inappropriate behavior of the patients receiving psychological occupational therapy. *New Taipei journal of medicine, 5(1),* 39–47.

Soto, D., Funes, M. J., Guzmán-García, A., Warbrick, T., Rotshtein, P., & Humphreys, G. W. (2009). Pleasant music overcomes the loss of awareness in patients with visual neglect. *Proceedings of the National Academy of Sciences of the United States of America, 106(14),* 6011–6016. https://doi.org/10.1073/pnas.0811681106.

Thaut M.H. (1997). Rhythmic facilitation of gait training in hemiparetic stroke rehabilitation. *Journal of Neurological Sciences, 151(2),* 207-212.

Treisman, A. (2006). How the deployment of attention determines what we see. *Visual Cognition, 14,* 411–443

Wu, C., & Shih, Y. (2019). The effects of background music on the work attention performance between musicians and non-musicians. *International Journal of Occupational Safety and Ergonomics, 13,* 1-5

Xie, C., Miao, D., Zhang, J., & Tang, Z. (2012). A study of Mozart effect in Attentional blink. *International journal on information, 15(2),* 779-791.

Zillmer, E.A., Spiers, M.V., & Culbertson, W. *Principles of Neuropsychology*. EUA: Wadsworth Publishing.

3. OBJETIVOS

3.1 Objetivo geral

O objetivo deste estudo foi verificar o efeito da escuta de estímulo musical (músicas familiares) no desempenho de crianças e adolescentes com e sem TDAH durante uma tarefa de atenção.

3.2 Objetivos específicos

- Avaliar o desempenho atencional (tempo médio de reação nas redes atencionais e taxa de erro geral) de crianças dos dois grupos, com TDAH e com desenvolvimento típico (DT), em uma tarefa de atenção (Attention Network Test – ANT child) nas condições experimentais: com música (MU) e sem música (SMU);

- Comparar o desempenho atencional **intragrupo** de crianças com TDAH e sem TDAH no ANT nas condições experimentais: com música (MU) e sem música (SMU);

- Comparar o desempenho atencional **intergrupos** com TDAH e sem TDAH no ANT nas condições experimentais: com música (MU) e sem música (SMU);

- Avaliar se as diferenças encontradas entre os grupos e/ou condições dependem do nível atencional basal das crianças avaliado pelo CCPT.

4. METODOLOGIA

Trata-se de um estudo de desenho experimental com crianças e adolescentes com e sem TDAH. Todos os participantes foram submetidos às mesmas condições experimentais (com música e sem música) durante a realização de uma tarefa de atenção computadorizada: o Attention Network Test, versão para crianças e foram equivalentes quanto às variáveis: sexo, idade, e nível socioeconômico.

4.1 Participantes

Participaram 76 crianças e adolescentes, sendo 34 com TDAH e 42 com desenvolvimento típico (DT), do sexo masculino e na idade de 10 a 12 anos. Sabemos que o TDAH é diagnosticado e tratado mais frequentemente em meninos do que em meninas (Biederman et al., 2002), por isso optamos por fazer o estudo apenas com meninos.

Para a definição da idade dos participantes, era necessário pensar em uma faixa etária, cujo gosto musical já estivesse um pouco mais definido e não tão associado ao que os membros da família ouvem, assim como sua capacidade de julgamento sobre os seus interesses. Isso, porque o estímulo musical utilizado durante a pesquisa seria composto por músicas conhecidas e de interesse dos grupos. Existem evidências de que antes dos 10 anos de idade, as crianças ainda estão desenvolvendo sua identidade quanto às preferências musicais sendo, portanto, mais influenciadas pelo que seus pais ouvem em casa e mais abertas a ouvir músicas desconhecidas (Egermann & Hauke, 2013). Nesse sentido, é mais provável que após essa idade a escolha e gosto musical possuem mais influência dos amigos com quem passam mais tempo que com os membros da família (Finnas, 1989). Por isso, escolhemos a faixa de 10 a 12 anos.

Todas as crianças do grupo com TDAH foram recrutadas no Ambulatório Borges da Costa, em Belo Horizonte, onde se encontravam em tratamento pelo Núcleo de Investigações sobre a Impulsividade e Atenção (NITIDA). Dados de registro de protocolos dos pacientes foram utilizados para verificação dos critérios de inclusão do grupo TDAH. As crianças com desenvolvimento típico foram recrutadas por conveniência em Belo Horizonte e região metropolitana.

4.2 Critérios de inclusão

Foram incluídas no grupo com TDAH crianças com o diagnóstico confirmado pelos critérios estabelecidos pelo DSM-5 (American Psychiatric Association, 2013) e por entrevista semi-estruturada através do K-SADS (*Schedule for Affective Disorders and Schizophrenia for School- Age Children/ Present and Life time Version (KSADS-PL)*(Kaufman et al., 1997), parte do protocolo utilizado pela equipe do ambulatório NITIDA. Para evitar fatores confundidores, foram incluídos apenas os pacientes que apresentaram desempenho dentro da normalidade no teste de inteligência de Raven (Pasquali et al., 2002), teste que também faz parte do protocolo utilizado pela equipe. Os pacientes que fizessem uso de medicação para TDAH, eram orientados a suspendê-lo para o dia da testagem atencional, como realizado em estudos anteriores semelhantes (Adólfsdóttir et al., 2008; Johnson et al., 2008).

Para a inclusão no grupo das crianças com desenvolvimento típico, elas não poderiam ter o diagnóstico de TDAH, ou mais de cinco sintomas de desatenção e hiperatividade identificados pelo *Swanson Noland Pelham-IV (SNAP IV)* (Costa et al., 2019) (ANEXO I) ou pontuação T acima de 70 na escala de comportamento infantil de TDAH no Child Behavior Checklist for Ages 6-18 (CBCL/6-18) (Achenbach & Ruffle, 2000).

4.3 Critérios de exclusão

Os critérios de exclusão foram: crianças com história ou evidência atual de psicose, autismo, distúrbios neurológicos, ou qualquer doença genética relacionada a comportamentos exteriorizados que pudessem mimetizar ou influenciar no TDAH, e em descontinuidade do tratamento medicamentoso por pelo menos 3 meses (para o caso de crianças com TDAH).

4.4 Aspectos éticos

Este estudo foi aprovado pelo Comitê de Ética da Universidade Federal de Minas Gerais (CAE: 02899412.9.0000.5149) (ANEXO II) e o protocolo registrado pelo Registro Brasileiro de Ensaios Clínicos (REBEC - U1111-12589039) (https://ensaiosclinicos.gov.br/rg/RBR-8s22sh8). Todos os pais / responsáveis das crianças que participaram do estudo foram previamente informados sobre os procedimentos da pesquisa e assinaram um Termo de Consentimento Livre e Esclarecido – TCLE (APÊNDICE A) e o Termo de Assentimento Livre e Esclarecido – TALE (APÊNDICE B).

4.5 Medidas

4.5.1 Tarefa de atenção

O Attention Network Test - ANT é uma medida desenvolvida pelo Modelo de Posner (Posner & Petersen, 1990), que avalia três diferentes funções da atenção: alerta, orientação e controle executivo (conflito). Para este estudo, foi utilizada uma versão adaptada desse teste para crianças (Rueda et al., 2004), reproduzido através do Software E-Prime (version 2.0 professional: Psychological Software Tools®, Sharpsburg PA, USA), e utilizou-se um controle de vídeo game da marca Knup e um Notebook Samsung de 15,6 polegadas. Para o estímulo musical, foi utilizado um fone de ouvido Shure® 440Hz. Todos os equipamentos mencionados encontram-se na Figura 1.

Figura 1. Equipamentos utilizados durante a tarefa de atenção.

A tarefa consiste em alimentar um peixe colorido que aparece no centro da tela, indicando a sua direção através do botão de controle correspondente (L= o peixe está nadando em direção ao lado esquerdo; R= o peixe está nadando em direção ao lado direito). O peixe pode aparecer sozinho (condição neutra) ou acompanhado por outros peixes convergindo na mesma direção (condição congruente) ou na direção oposta a ele (condição incongruente). Além disso, o alvo (peixe) pode aparecer seguido ou não de pistas (asteriscos) na tela (sem pista = o peixe não é precedido por um asterisco; pista central = o peixe é precedido por um asterisco no centro da tela; pista dupla = o alvo é precedido por dois asteriscos, um acima e outro abaixo do centro da tela; pista espacial = o peixe é precedido por um asterisco acima ou abaixo do centro da tela) (Rueda et al. 2004) (Figura 2). Acertos e erros são seguidos de feedbacks auditivos e visuais durante uma rodada de treino de 4 minutos (1 bloco de 24 apresentações), e somente visuais para as rodadas de teste sob as condições experimentais (3 blocos de 24 apresentações). Para respostas corretas, o peixe alvo sopra bolhas e exclama “Woohoo!”; para respostas incorretas, um único tom é emitido e nenhuma animação aparece no peixe. A duração da rodada de treino e as duas rodadas (15 minutos cada, com intervalos de 1 a 2 minutos de descanso)

sob as condições experimentais (com música e sem música) duram aproximadamente 45 minutos.

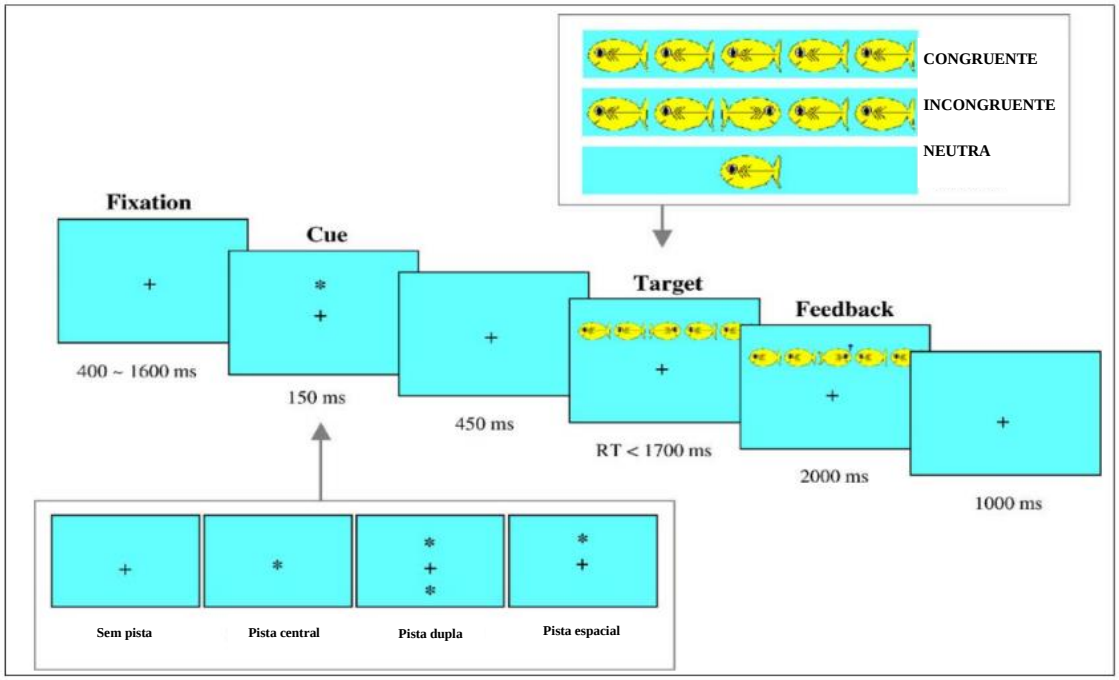


Figura 2. Attention Network Test adaptado de Rueda (2004)

4.5.2 Estímulo musical

O estímulo musical foi composto por um compilado de músicas que foram selecionadas através de entrevistas com crianças de 10 a 12 anos, visando identificar seus gêneros, artistas ou mesmo nome de canções favoritas.

A familiaridade com a música pode ter um papel importante no engajamento dos seus ouvintes com essa música, e tende a ser melhor para o desempenho de tarefas cognitivas (Salimpoor et al., 2009; Pereira et al., 2011; Wan & Taatgen, 2018). Também, áreas do circuito de recompensa parecem estar mais ativas quando ouvimos músicas conhecidas do que quando ouvimos músicas desconhecidas (Salimpoor et al., 2009; Salimpoor et al., 2011), sugerindo ser uma boa estratégia para melhorar a motivação e engajamento em

uma tarefa que esteja chata ou que não tenhamos tanto interesse. Como a nossa hipótese é de que o estímulo musical pode melhorar o desempenho na tarefa de atenção, optamos por um estímulo musical composto por músicas conhecidas.

Como a duração da testagem no ANT média seria de até 15 minutos, cinco músicas foram selecionadas (Tabela 1). Aquelas que originalmente não eram instrumentais passaram por uma edição através do Programa Audacity Versão 2.3.2 (www.audacityteam.org) para remoção das vozes, uma vez que previamente vimos que músicas com letra podem prejudicar o desempenho atencional (Mendes et al., 2021). Na condição sem música, a criança se mantinha com o fone de ouvido, porém sem ouvir qualquer música ou estímulo auditivo.

Tabela 1. Músicas selecionadas para a condição experimental com música (MU). Adaptada do Artigo 2 (submetido em maio de 2022 na *Psychology of Music*)

Ordem	**Título**	**Duração**
1	Fortnite OST - Battle Royale Menu Music (Rock Version)[a] https://www.youtube.com/watch?v=2q-k7ScMs0k	3:50
2	Alone (Mashmallo) – Modified[b] https://www.youtube.com/watch?v=ALZHF5UqnU4	3:19
3	Free Fire New EPIC Theme Song[c] https://www.youtube.com/watch?v=oCBMY0MSiWA	3:56
4	Herobrine's Life (Instrumental)[d] https://www.youtube.com/watch?v=Qk1FDPOP8ys	4:00
5	Olha a explosão (Mc Kevinho) – Modified[b] https://www.youtube.com/watch?v=3yd_eoMOvqk	3:07

[a] Esta música é tocada quando você está entrando no menu do jogo Fortnite e quando você vence a batalha. A música é composta por Rom Di Prisco e todo o conteúdo pertence à Epic Games.

[b] A música original foi modificada pelo Programa Audacity Versão 2.3.2 (editor de áudio) para remover as vozes

[c] Essa foi a música tema do Free Fire em 2019.

[d] Esta música é uma paródia Minecraft da música “Something Just Like This” de The Chainsmokers e Coldplay

Para validar a listagem das músicas utilizadas, com relação à familiaridade, preferência e emoções despertadas para cada criança/adolescente, um trecho de 20-30 segundos das canções eram apresentadas e um questionário semi-estruturado era preenchido (APÊNDICE C). Esse questionário utilizou figuras com base na Escala de Manequim de Autoavaliação Adaptada (Bradley & Lang, 1994) para facilitar a identificação das emoções despertadas pela música. Isso acontecia necessariamente antes da realização do ANT, para evitar que as respostas fossem induzidas pelo desempenho no teste.

4.5.3 Caracterização da amostra

O *Swanson Nolandand Pelham-IV* (SNAP IV) (Costa et al., 2019) foi utilizado para caracterização da amostra com relação ao número de sintomas de desatenção e hiperatividade/impulsividade. Trata-se de uma escala de triagem para TDAH e Transtorno Opositivo Desafiador (TDO) que se baseia nos critérios estabelecidos pelo DSM IV (Costa et al., 2019). A escala é composta por 26 itens, divididos em três sub-escalas: desatenção (itens de 1 a 9), hiperatividade /impulsividade (itens de 10 a 18) e comportamento de oposição (últimos 8 itens). Para cada item, os pais/responsáveis devem indicar a frequência dos comportamentos por meio de uma escala de 4 pontos (0=nem um pouco, 1=só um pouco, 2=bastante e 3=demais). A cada item pontuado com escores equivalentes a 2 (bastante) e (demais), considera-se a presença de um sintoma referente à sua subscala, sendo o escore máximo de 9 para desatenção e hiperatividade/impulsidade, e 8 para TDO (Costa et al., 2019).

O *Child Behavior Checklist for Ages 6-18 (CBCL/6-18)* é um questionário destinado aos pais/responsáveis em relação aos aspectos sociais e comportamentais de suas crianças/adolescentes, na idade de 6 a 18 anos (Achenbach & Ruffle, 2000). A escala é composta por 138 sentenças, nas quais 118 referem-se a problemas de comportamento

divididos em 8 escalas (ansiedade e depressão, isolamento e depressão, queixas e somáticas, comportamento de quebrar regras, comportamento agressivo, problemas sociais, problemas de pensamento e problemas de atenção) que fazem parte de duas escalas maiores (problemas de comportamento internalizantes e externalizantes). As demais sentenças referem-se à competência social. Para este estudo, foram utilizadas as respostas da escala de TDAH para triagem do grupo com desenvolvimento típico, e as demais para exclusão de outras patologias que pudessem mimetizar ou influenciar o TDAH.

Para cada sentença, os pais/responsáveis devem avaliar a afirmação como "não verdadeira", "pouco verdadeira ou algumas vezes verdadeira" ou "frequentemente verdadeira", que correspondem a 0, 1 e 2 pontos, respectivamente. A somatória desses pontos em cada escala produz um escore bruto que é convertido em escore T, conforme gênero e idade (Bordin et al., 2013). Os pontos de corte do escore T para as escalas de problemas de atenção e TDAH, determinam o grau de desvio da normalidade, categorizando as crianças em clínicas, limítrofes ou não clínicas.

O *Critério de Classificação Econômico Brasil (CCEB*) (Associação Brasileira de Empresas de Pesquisa (ABEP). [2019]) foi utilizado para identificar o nível socioeconômico das famílias. Esse questionário que inclui informações sobre a presença e quantidade de bens duráveis no domicílio (ex. computadores, microondas, máquina de lavar, geladeira), a quantidade de banheiros, a existência de empregada mensalista no domicílio, serviços públicos utilizados (ex. água encanada) e o grau de instrução do chefe de família. O critério atribui pontos para cada item do questionário, que são somados resultando em um escore final que caracteriza a famílias nos níveis de A a E (ANEXO III). O critério de avaliação econômica é um importante instrumento para compreender

os efeitos sociais relacionados a alguns comportamentos e condições. Sabe-se, por exemplo, que crianças mais vulneráveis economicamente podem apresentar mais sintomas de TDAH (Markham & Spencer, 2022).

O *Conner's Continuous Performance Test (CCPT)* é um instrumento muito utilizado no diagnóstico de TDAH que avalia problemas de atenção sustentada e o controle inibitório (B. C. K. Conners, 2014). Trata-se de uma tarefa computadorizada, em que o sujeito é instruído a apertar a tecla "espaço" para qualquer letra que apareça na tela, exceto para a letra "X". Sua estrutura consiste em seis blocos e três sublocos, cada um contendo 20 trilhas (apresentação das letras) que variam entre os blocos. (Ao final, um relatório é gerado com os escores de omissões, comissões, tempo de reação de respostas corretas, erro padrão do tempo de reação das respostas corretas, variabilidade e defectibilidade) (B. C. K. Conners, 2014). O teste foi aplicado em todas as crianças antes da aplicação do ANT.

Além dos instrumentos acima, dois questionários semi-estruturados foram aplicados, um deles para colher informações sobre a experiência prévia musical da criança, preferências musicais e rotina de escuta musical em casa (ex. "Já fez aula de música alguma vez?" "Com que frequência você ouve música em casa?") (APÊNDICE D), e o outro para a validação da listagem das músicas utilizadas, já mencionado anteriormente. Também, ao final do experimento, as crianças eram questionadas se haviam percebido alguma diferença em fazer o teste com música e sem música.

4.6 Procedimentos

O estudo foi realizado em um único dia com a criança/adolescente, com o consentimento dos pais/responsáveis, podendo haver agendamento prévio ou não. O local de realização

do teste foi definido conforme disponibilidade dos participantes, visando também facilitar a adesão ao estudo. Por exemplo, a maior parte do grupo TDAH realizou a pesquisa no dia da consulta periódica, no Ambulatório Borges da Costa, mesmo local onde eram recrutadas. Enquanto a criança realizava os testes com a pesquisadora em uma sala silenciosa, o pai/responsável preenchia os questionários SNAP-IV, CBCL e CCEB. No caso das crianças com desenvolvimento típico, boa parte das crianças participaram do estudo em suas próprias casas, uma vez que toda a coleta desse grupo se deu durante a pandemia da COVID-19. Assim, as famílias que não se sentissem seguras para deslocar até o local da pesquisa, optaram por receber a pesquisadora em suas casas. Nesse caso, a verificação dos critérios de inclusão, através dos questionários de triagem, era feita previamente pelos familiares (via internet) e caso houvesse elegibilidade, o encontro era agendado.

Todos os procedimentos foram realizados por uma única pesquisadora, e duraram em média 1h a 1h30min (Figura 3). As condições experimentais foram aleatorizadas através de um sorteio, para definir em que ordem aconteceriam, mas todas as crianças realizariam o teste sob as duas condições (MU e SMU). Durante todo o protocolo de estudo, a criança/adolescente se mantinha sentada em uma cadeira e mesa confortáveis, de frente para o computador que reproduzia os testes de atenção (CCPT e ANT). Quando realizados no Ambulatório Borges da Costa, os testes ocorreram em uma sala reservada, com poucas distrações e barulho; quando na casa do participante, era orientado aos pais/responsáveis que indicassem o lugar mais silencioso da casa (Figura 4).

4.7 Tamanho amostral

O tamanho amostral de 46 foi estimado a priori pelo software G-power 3.010 com os seguintes parâmetros: $\alpha = 0,05$; tamanho de efeito médio = 0,25 e poder de 90%. As

medidas de rede de atenção e taxa de erro foram calculadas usando uma Planilha do Excel baixada da página do Jin Fan (Fan, 2019).

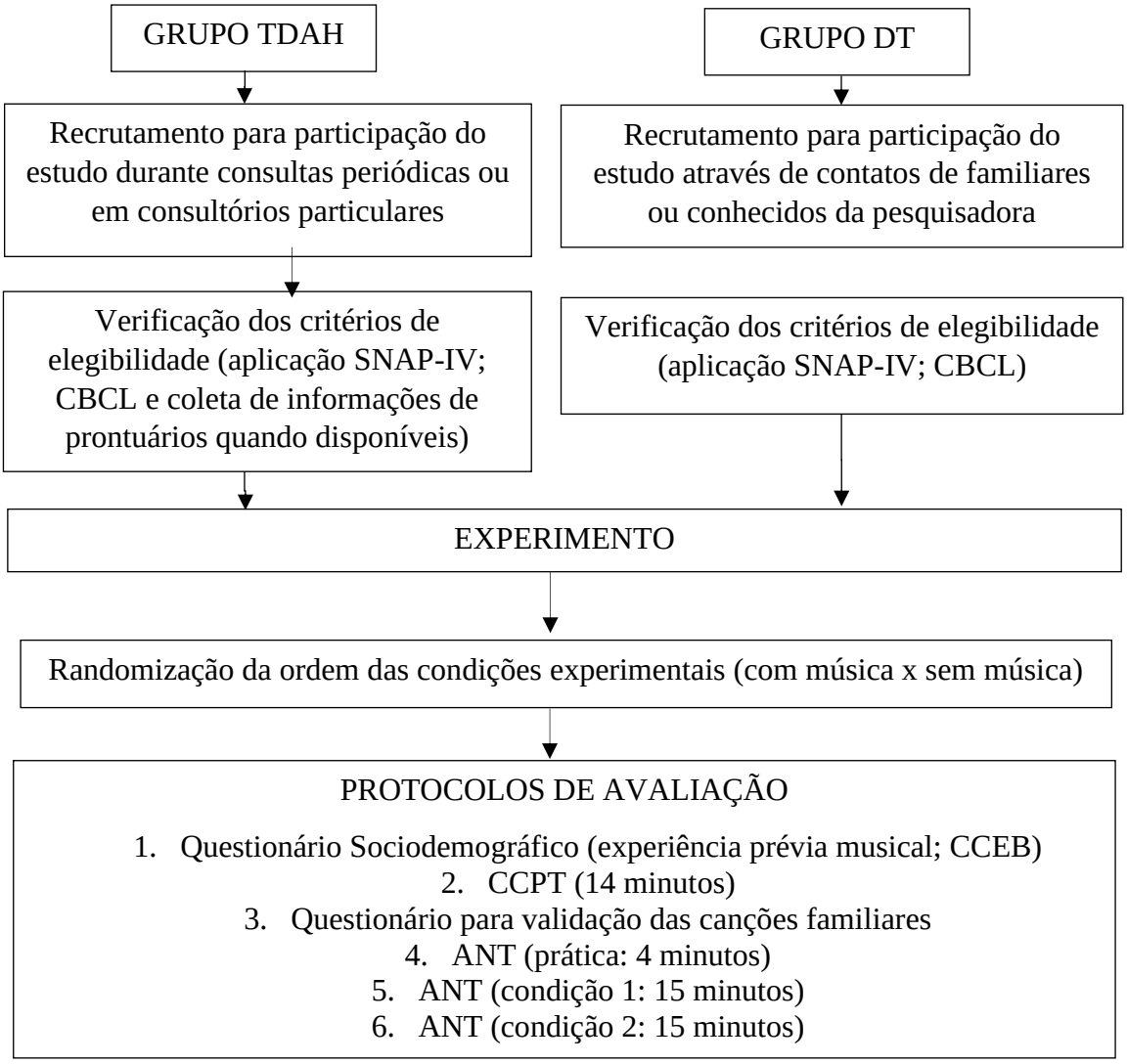


Figure 3. Fluxograma do estudo

SNAP-IV= Swanson Nolandand Pelham-IV; CBCL= Child Behaviour Checklist; CCEB= Brazilian Economic Classification Criterion; CCPT= Conner's Continuous Performance Test.

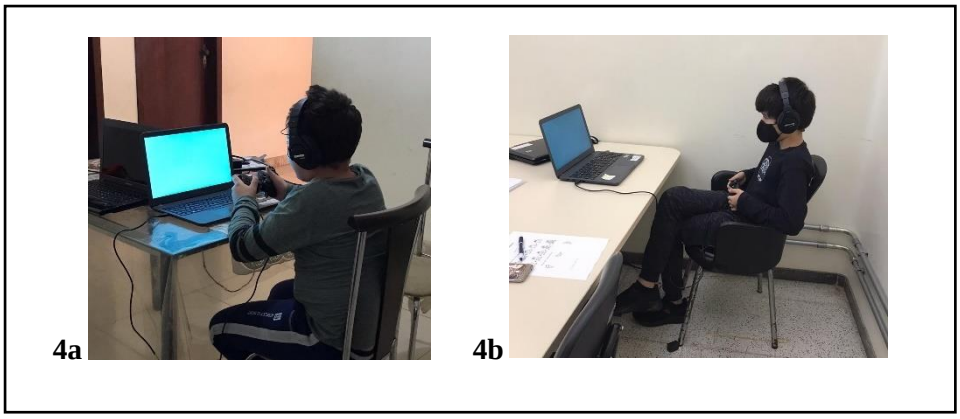


Figura 4. Local de realização dos testes. A figura 4a mostra uma criança realizando a teste ANT no ambiente domiciliar. A figura 4b mostra uma criança realizando o teste ANT em uma sala do Ambulatório Borges da Costa.

4.8 Análise de dados

As análises estatísticas foram realizadas através do Statistical Package for Social Sciences for Personal Computer (SPSS 22.0). A significância estatística foi de 0,05.

4.8.1 Análise descritiva

As médias do tempo de reação (TR) para cada rede atencional foram calculadas utilizando uma planilha macro do Excel baixada da página de Jin Fan (Fan, 2019). Para descobrir as médias de TR de alerta e orientação por sujeito, foi calculado o tempo médio por condição de pistas (alerta = TR para pista dupla – TR para a condição sem pista; orientação = TR para pista espacial – TR para pista central). Para obter a pontuação de conflito, calculamos o TR médio de todas as condições de pista e alvos (TR para incongruente – TR para congruente). A taxa de erros geral foi obtida pela média de erros para todas as condições de pistas e de alvo.

Número de sintomas de TDAH e escore T para as escalas de problemas de atenção e TDAH, foram calculadas através da aplicação do SNAP-IV e CBCL respectivamente. Além disso, outras informações descritivas da amostra foram apresentadas como: idade da criança, nível socioeconômico da família e informações colhidas no questionário semi-

estruturado, a respeito da experiência prévia musical da criança e frequência de escuta de músicas em casa.

4.8.2 Análises de comparação

A análise de variância (ANOVA) de medidas repetidas foi utilizada para investigar o efeito da música no desempenho da tarefa de atenção. A condição (música e sem música) foi colocada como variável intra-sujeitos e o grupo (TDAH e sem TDAH) como variável dentre sujeitos. As médias do tempo de reação das redes atencionais (alerta, orientação e conflito) e a taxa de erro geral foram examinadas separadamente. Também foram incluídas como covariantes, os valores de omissões (erros cometidos com relação aos alvos) e comissões (erros cometidos com relação ao que não seria o alvo, no caso a letra X) gerados através do CCPT. Como o comportamento dos participantes no ANT poderia ser influenciado pela atenção basal obtida pelo CCPT, o controle dessas co-variáveis poderia reduzir erros e aumentar a precisão dos resultados.

REFERÊNCIAS BIBLIOGRÁFICAS

Abikoff, H., Courtney, M. E., Szeibel, P. J., & Koplewicz, H. S. (1996). Abikoff 1996. *Journal of Learning Disabilities, 29*(3), 238–246.

Achenbach, T. M., & Ruffle, T. M. (2000). The child behavior checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review, 21*(8), 265–271. https://doi.org/10.1542/pir.21-8-265

Adólfsdóttir, S., Sørensen, L., & Lundervold, A. J. (2008). The attention network test: A characteristic pattern of deficits in children with ADHD. *Behavioral and Brain Functions, 4*, 1–9. https://doi.org/10.1186/1744-9081-4-9

Amaravathi, T., Murugan, M., Subramanian, A., & Geetha, A. P. S. (2019). Attention deficit hyperactivity disorder. *Trends in Biosciences*, 214–221. https://doi.org/10.4324/9780203754818-11

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)* (5th ed).

Antshel, K. M., & Barkley, R. (2020). Attention deficit hyperactivity disorder. In *Handbook of Clinical Neurology* (1º ed, Vol. 174). Elsevier B.V.

https://doi.org/10.1016/B978-0-444-64148-9.00003-X

Associação Brasileira de Empresas de Pesquisa (ABEP). ([s.d.]). *Dados com Base no Levantamento Sócio Econômico – IBOPE*. 2015. http://www.abep.org/new/criterioBrasil.aspx

Barkley, R. A. (1997). Behavioral Inhibition, Sustained Attention, and Executive Functions: Constructing a Unifying Theory of ADHD. In *Psychological Bulletin* (Vol. 121, Número 1). Routledge. https://doi.org/10.1037/0033-2909.121.1.65

Berger, A., & Posner, M. I. (2000). Pathologies of brain attentional networks. *Neuroscience and Biobehavioral Reviews*, *24*(1), 3–5. https://doi.org/10.1016/S0149-7634(99)00046-9

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., Wilens, T. E., Frazier, E., & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of Psychiatry*, *159*(1), 36–42. https://doi.org/10.1176/appi.ajp.159.1.36

Bordin IAS, Rocha MM, Paula CS, Teixeira MCTV, Achenbach TM, Rescola LA, S. E., Bordin, I. A., Rocha, M. M., Paula, C. S., Teixeira, M. C. T. V., Achenbach, T. M., Rescorla, L. A., & Silvares, E. F. M. (2013). Child Behavior Checklist (CBCL), Youth Self- Report (YSR) and Teacher's Report Form (TRF): an overview of the development of the original and Brazilian versions. *Cadernos de Saúde Pública*, *29*(1), 13–28. http://www.ncbi.nlm.nih.gov/pubmed/23370021%0Ahttp://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2013000500004&lng=pt&nrm=iso&tlng=en

Bradley, M., & Lang, P. J. (1994). Self-Assessment Manikin (SAM). *J.Behav.Ther. & Exp. Psychiat.*, *25*(1), 49–59.

Brown, T. E. (2008). ADD/ADHD and impaired executive function in clinical practice. *Current Psychiatry Reports*, *10*(5), 407–411. https://doi.org/10.1007/s11920-008-0065-7

Christiansen, H., Hirsch, O., Albrecht, B., & Chavanon, M. L. (2019). Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span. *Current Psychiatry Reports*, *21*(3), 16–18. https://doi.org/10.1007/s11920-019-1003-6

Conners, B. C. K. (2014). Conners ' Continuous Performance Test II (CPT II V . 5) Profile Report Client Name : Iago Oliveira. *Musician*, 1–15. https://www.pearsonclinical.co.uk/Psychology/ChildMentalHealth/ChildADDADHDBehaviour/ConnersContinuousPerformanceTestIIVersion5forWindows(CPTII V5)/PDFReports/Profile.pdf

Conners, C. K. (2002). *Conners' continuous performance test for Windows*.

Costa, D. S., de Paula, J. J., Malloy-Diniz, L. F., Romano-Silva, M. A., & Miranda, D. M. (2019). Parent SNAP-IV rating of attention-deficit/hyperactivity disorder: accuracy in a clinical sample of ADHD, validity, and reliability in a Brazilian sample. *Jornal de Pediatria*, *95*(6), 736–743. https://doi.org/10.1016/j.jped.2018.06.014

Dalton, B. H., & Behm, D. G. (2007). Effects of noise and music on human and task performance: A systematic review. In *Occupational Ergonomics* (Vol. 7). IOS Press.

de Souza Almeida, R., Faria-Jr, A., & Klein, R. M. (2021). On the origins and evolution of the Attention Network Tests. *Neuroscience and Biobehavioral Reviews*, *126*(September 2020), 560–572. https://doi.org/10.1016/j.neubiorev.2021.02.028

Egermann, & Hauke. (2013). *Can parents influence children ' s music preferences and positively shape their development ? Dr Hauke Egermann*.

Fabio, R. A., & Urso, M. (2014). The analysis of Attention Network in ADHD, attention problems and typically developing subjects. *Life Span and Disability*, *17*(2), 199–221.

Fan, J., McCandliss, B. D., Sommer, T., & Raz, A., Posner, M. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. http://www.sacklerinstitute.org/users/jin.fan/publications/ANT.pdf

Greenop, K., & Kann, L. (2007). Extra-task stimulation on mathematics performance in children with and |PsyssA without ADHD. *South African Journal of Psychology*, *37*(2), 330–344.

Hall, C. L., Guo, B., Valentine, A. Z., Groom, M. J., Daley, D., Sayal, K., & Hollis, C. (2020). The Validity of the SNAP-IV in Children Displaying ADHD Symptoms. *Assessment*, *27*(6), 1258–1271. https://doi.org/10.1177/1073191119842255

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. *Music Perception*, *20*(2), 151–171. https://doi.org/10.1525/mp.2002.20.2.151

Ilieva, I. P., & Farah, M. J. (2019). Attention, Motivation, and Study Habits in Users of Unprescribed ADHD Medication. *Journal of Attention Disorders*, *23*(2), 149–162. https://doi.org/10.1177/1087054715591849

Posner, J., Polanczyk, E. S.-B. (2020). Attention-deficit hyperactivity disorder. *Lancet*, *8*(6), 450–462. https://doi.org/10.1097/00004703-200312000-00013

Johnson, K. A., Robertson, I. H., Barry, E., Mulligan, A., Dáibhis, A., Daly, M., Watchorn, A., Gill, M., & Bellgrove, M. A. (2008). Impaired conflict resolution and alerting in children with ADHD: evidence from the Attention Network Task (ANT). *Journal of child psychology and psychiatry, and allied disciplines*, *49*(12), 1339–1347. https://doi.org/10.1111/j.1469-7610.2008.01936.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Markham, W. A., & Spencer, N. (2022). Factors that mediate the relationships between household socio-economic status and childhood Attention Deficit Hyperactivity Disorder (ADHD) in children and adolescents: A systematic review. *PLoS ONE*, *17*(3 March), 1–22. https://doi.org/10.1371/journal.pone.0262988

Martella, D., Aldunate, N., Fuentes, L. J., & Sánchez-Pérez, N. (2020). Arousal and Executive Alterations in Attention Deficit Hyperactivity Disorder (ADHD). *Frontiers in Psychology*, *11*(August), 1–7. https://doi.org/10.3389/fpsyg.2020.01991

Mattos, P., Serra-Pinheiro, M. A., Rohde, L. A., & Pinto, D. (2006). MTA-SNAP-IV em português para uso no Brasil. *Revista de Psiquiatria do Rio grande do Sul*, *28*(3), 290–297.

Mendes, C. G., Diniz, L. A., & Marques Miranda, D. (2021). Does Music Listening Affect Attention? A Literature Review. *Developmental Neuropsychology*, *46*(3), 192–212. https://doi.org/10.1080/87565641.2021.1905816

Morsink, S., Sonuga-Barke, E., Van der Oord, S., Van Dessel, J., Lemiere, J., & Danckaerts, M. (2021). Task-related motivation and academic achievement in children and adolescents with ADHD. *European Child and Adolescent Psychiatry*, *30*(1), 131–141. https://doi.org/10.1007/s00787-020-01494-8

Nigg, J. T. (2005). Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: The state of the field and salient challenges for the coming decade. *Biological Psychiatry*, *57*(11), 1424–1435. https://doi.org/10.1016/j.biopsych.2004.11.011

Pasquali, L., Wechsler, S., & Bensusan, E. (2002). Matrizes progressivas do Raven Infantil: um estudo de validação para o Brasil. *Aval. psicol*, 94–110.

Pelham, W. E., Waschbusch, D. A., Hoza, B., Gnagy, E. M., Greiner, A. R., Sams, S. E., Vallano, G., Majumdar, A., & Carter, R. L. (2011). Music and video as distractors for boys with ADHD in the classroom: Comparison with controls, individual differences, and medication effects. *Journal of Abnormal Child Psychology*, *39*(8), 1085–1098. https://doi.org/10.1007/s10802-011-9529-z

Pereira, C. S., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., & Brattico, E. (2011). Music and Emotions in the Brain: Familiarity Matters. *PLoS ONE*, *6*(11). https://doi.org/10.1371/journal.pone.0027241

Pizzo, R., Urben, S., Van Der Linden, M., Borradori-Tolsa, C., Freschi, M., Forcada-Guex, M., Hüppi, P., & Barisnikov, K. (2010). Attentional networks efficiency in preterm children. *Journal of the International Neuropsychological Society*, *16*(1), 130–137. https://doi.org/10.1017/S1355617709991032

Polanczyk, G. (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry*, *164*(6), 942. https://doi.org/10.1176/appi.ajp.164.6.942

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *International Journal of Epidemiology*, *43*(2), 434–442. https://doi.org/10.1093/ije/dyt261

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(February), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P.,

& Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040. https://doi.org/10.1016/j.neuropsychologia.2003.12.012

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*(2), 257–264. https://doi.org/10.1038/nn.2726

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE*, *4*(10). https://doi.org/10.1371/journal.pone.0007487

Schellenberg, E. G., & Hallam, S. (2005). Music listening and cognitive abilities in 10- and 11-year-olds: the blur effect. *Annals of the New York Academy of Sciences*, *1060*, 202–209. https://doi.org/10.1196/annals.1360.013

Sergeant, J. (2004). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive?energetic model. *Biological Psychiatry*. https://doi.org/10.1016/j.bps.2004.09.010

Sergeant, Joseph. (2000). Sergeant.00 Modelo cognitivo energético.pdf. *Neuroscience and Biobehavioral Reviews*, *24*, 7–12.

Siti Norazah, S., Abdullah, N., Salleh, N., Renuka, J., Azlina, M., Abd Rahman, H., & Nor Azila, N. (2017). The Effects of Music on Cognitive Performance in Attention Deficit Hyperactive Disorder (ADHD) Children: A Systematic Review. *Asian Journal of Multidisciplinary Studies*, *5*(9), 11–17. http://www.adhd-federation.org/fileadmin/user_upload/Abstract_Review/2017/10_Oktober/Treatment/The_Effects_of_Music_on_Cognitive_Performance_in_ADHD_Children_-_A_Systematic_Review.pdf

Skalski, S., Pochwatko, G., & Balas, R. (2020). Impact of Motivation on Selected Aspects of Attention in Children with ADHD. *Child Psychiatry and Human Development*, *52*(4), 586–595. https://doi.org/10.1007/s10578-020-01042-0

Smith, Z. R., & Langberg, J. M. (2018). Review of the Evidence for Motivation Deficits in Youth with ADHD and Their Association with Functional Outcomes. *Clinical Child and Family Psychology Review*, *21*(4), 500–526. https://doi.org/10.1007/s10567-018-0268-3

Smith, Z. R., Langberg, J. M., Cusick, C. N., Green, C. D., & Becker, S. P. (2020). Academic Motivation Deficits in Adolescents with ADHD and Associations with Academic Functioning. *Journal of Abnormal Child Psychology*, *48*(2), 237–249. https://doi.org/10.1007/s10802-019-00601-x

Söderlund, G., Sikström, S., & Smart, A. (2007). Listen to the noise: Noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(8), 840–847. https://doi.org/10.1111/j.1469-7610.2007.01749.x

Wan, J., & Taatgen, N. (2018). The Influence of Music and Music Familiarity on Time Perception. *CogSci 2018*, 2657–2662.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005).

Validity of the executive function theory of attention-deficit/ hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Zajenkowski, M., Goryńska, E., & Winiewski, M. (2012). Variability of the relationship between personality and mood. *Personality and Individual Differences*, *52*(7), 858–861. https://doi.org/10.1016/j.paid.2012.01.007

5 RESULTADOS

Foram avaliadas 76 (34 do grupo TDAH e 42 do grupo sem TDAH) entre julho de 2019 a março de 2022. Ambos os grupos realizaram a tarefa de atenção em duas condições experimentais (com música e sem música) e foram comparados entre si (Grupo TDAH versus Grupo sem TDAH).

O Artigo 2, intitulado **"**Music may impact attention performance in ADHD children: Protocol for a Clinical trial" apresentou o protocolo com todos os procedimentos a serem realizados e está submetido desde maio de 2022 na *Psychology of Music*. O mesmo protocolo, foi também registrado pelo Registro Brasileiro de Ensaios Clínicos (REBEC - U1111-12589039) em 05/04/2021.

O Artigo 3, intitulado *"Effects of background music on attentional networks of children with and without ADHD"* descreve os resultados da pesquisa original. Esse artigo será submetido no *Journal of Experimental Psychology*.

5.1 Artigo 2

Title: Music may impact attention performance in ADHD children: Protocol for a Clinical trial

Short title: Music may impact attention in ADHD

Authors: Camila Guimarães Mendes[a, *], António Alvim-Soares[b], Débora Marques Miranda[c]

Institutional affiliation:

[a] Graduate Program in Children and Adolescent Health, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil.

[b] Department of Mental Health, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil.
[c] Department of Pediatrics, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil.

***Corresponding Author:**
Camila Guimarães Mendes, Universidade Federal de Minas Gerais, Avenida Prof. Alfredo Balena, 190 Santa Efigênia, 30130-100, Belo Horizonte, MG, Brazil. Email: camilagmbh@gmail.com.

Abstract

Music might help children with learning difficulties to improve performance on attentional tasks. The aim of the present study is to investigate the effect of music on attention in children with and without Attention Deficit/ Hyperactivity Disorder, assessed with the experimental music intervention carried out during the Attention Network Test for Child (Child ANT). Inclusion criteria include children with ADHD and comparison group. Estimated thirty-four boys from 10-12 years old are expected to be included in the experiment. The primary outcome measure of attention is the flanker task performance under two conditions: listening to music during the task and in silence for all participants. Secondary outcomes were selected and included measures to assess the clinical symptoms of ADHD and to screen the control group, sociodemographic questionnaires, and a computerized test to measure baseline attention before the ANT. Appropriate statistical analyzes will evaluate relevant differences among the groups with respect to conditions (music versus no-music). Clear knowledge about the effectiveness of non-pharmacologic treatments for children with ADHD, such use of music, can support the use of complementary therapies to improve well-being of children and their families and caregivers.

Keywords: child development, attention, background music, mental health, listening

Attention Deficit/ Hyperactivity Disorder (ADHD) is one of the most common neurobehavioral disorders in childhood, affecting about 6% of the child population worldwide (Polanczyk et al., 2014). It is characterized by harmful levels of inattention, impulsivity, and hyperactivity, which can persist into adulthood (American Psychiatric Association, 2013). Individually variable deficits in executive functions may also be

present in ADHD, especially in cognitive processes: working memory, planning, and organization, cognitive flexibility, cognitive attention, and impulsivity, among others (Brown, 2008; Willcutt et al., 2005; Amaravathi et al., 2019), which are essential functions for performing tasks that require effort and concentration to complete everyday tasks and related to learning.

Some losses found in ADHD could be explained by a deficit in the inhibition capacity, which is an individual's difficulty in breaking an impulsive response, faced with a task that requires a response that requires greater cognitive effort (Barkley, 1997; Antshel & Barkley, 2020). On the other hand, many of the characteristics of ADHD could also be associated with cognitive energetic factors such as difficulties in self-regulation in response to changing environmental circumstances and according to the demand of task (Sergeant, 2004; Christiansen et al., 2019; (Posner et al., 2020). In response ADHD symptoms can be exacerbated leading to an overactivation of the alert system, culminating in difficulties in adding necessary effort to properly adjust performance to the requirements of the task (Sergeant, 2004;Martella et al., 2020). As the processing of stimuli depends on their alertness state, some evidence indicates that children with ADHD could benefit from stimuli promoting increased alertness and consequently improve the performance of the task (Abikoff et al., 1996; Pelham et al., 2011; Söderlund et al., 2007).

Listening to music without lyrics and chosen by the listener seems to improve the performance of tasks that require attention (Mendes et al., 2021). In ADHD children, music listening may be beneficial for performance on math problems, increasing the number of items correctly answered (Abikoff et al., 1996; Greenop & Kann, 2007) or not impair performance (Pelham et al., 2011). In addition, listening to preferred or enjoyable music increases pleasant mood and arousal levels, improving performance on cognitive tasks (Schellenberg & Hallam, 2005). Music can evoke emotions, and these are

influenced by individual factors such as familiarity with the music, personality (i.e., introvert versus extrovert), current mood, and liking (Pereira et al., 2011; Salimpoor et al., 2009).

For Posner and Petersen (Posner & Petersen, 1990), attention involves three networks that have different functions: alert (alert phase) and surveillance (general state of activation of the cognitive system); orientation (allocation of the focus of visual attention to a relevant area); and executive control (ability to control our behavior to achieve certain goals or resolve conflicts in the face of alternative responses). Based on this taxonomy, the Attention Network Test (ANT) was designed to evaluate the efficacy of these networks which can be isolated for study (Posner et al., 2002; de Souza Almeida et al., 2021).

The existing evidence still does not allow us to have clear conclusions about how music affects attention or task performance. The purpose of the present study is to determine music effects on attention components of children with and without ADHD. We hypothesize that the music may improve the attention performance of children with ADHD differently from the typical children.

Materials and methods

Study design

This study is designed as an experimental design with children and adolescents with and typically developing (TD) children during performance of attentional tasks under musical stimuli in a university hospital. A figure for the schedule of enrolment, interventions and assessments is also presented (see figure 1). Participants will be compared to their respective performance with and without music. The order of conditions will be randomized through a lottery of sealed papers (if the chosen paper

includes the number 1: it means the task should be performed first without music; if the chosen paper includes the number 2: it means the task should be performed first with music). This protocol is reported based on the SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) statement.

	STUDY PERIOD	
	Enrolment	**Allocation**
TIMEPOINT	***First time point***	***Second time point***
ENROLMENT:		
Eligibility screen	X	X
Informed consent	X	
Allocation		X
INTERVENTION:		
[ANT testing under music condition]		X
[ANT testing under no music condition]		X
ASSESSMENTS:		
[Interview]	X	X
[SNAP-IV]	X	X
[CBCL]	X	X
[CCEB]	X	X
[CCPT]		X

Figure 1. Schedule of enrolment, interventions, and assessments.

Participants

This study will include children and adolescents aged 10-12 years old. Participants will be recruited from university hospital and divided in two groups: ADHD and non-ADHD (see figure 2). The researcher and one expert (from pediatric and psychiatric care will decide the eligibility unanimously following the inclusion and exclusion criteria. All eligible recruiters who agree to participate will sign a written informed consent and will be enrolled. Ethical approval was obtained from the appropriate Ethics Committee.

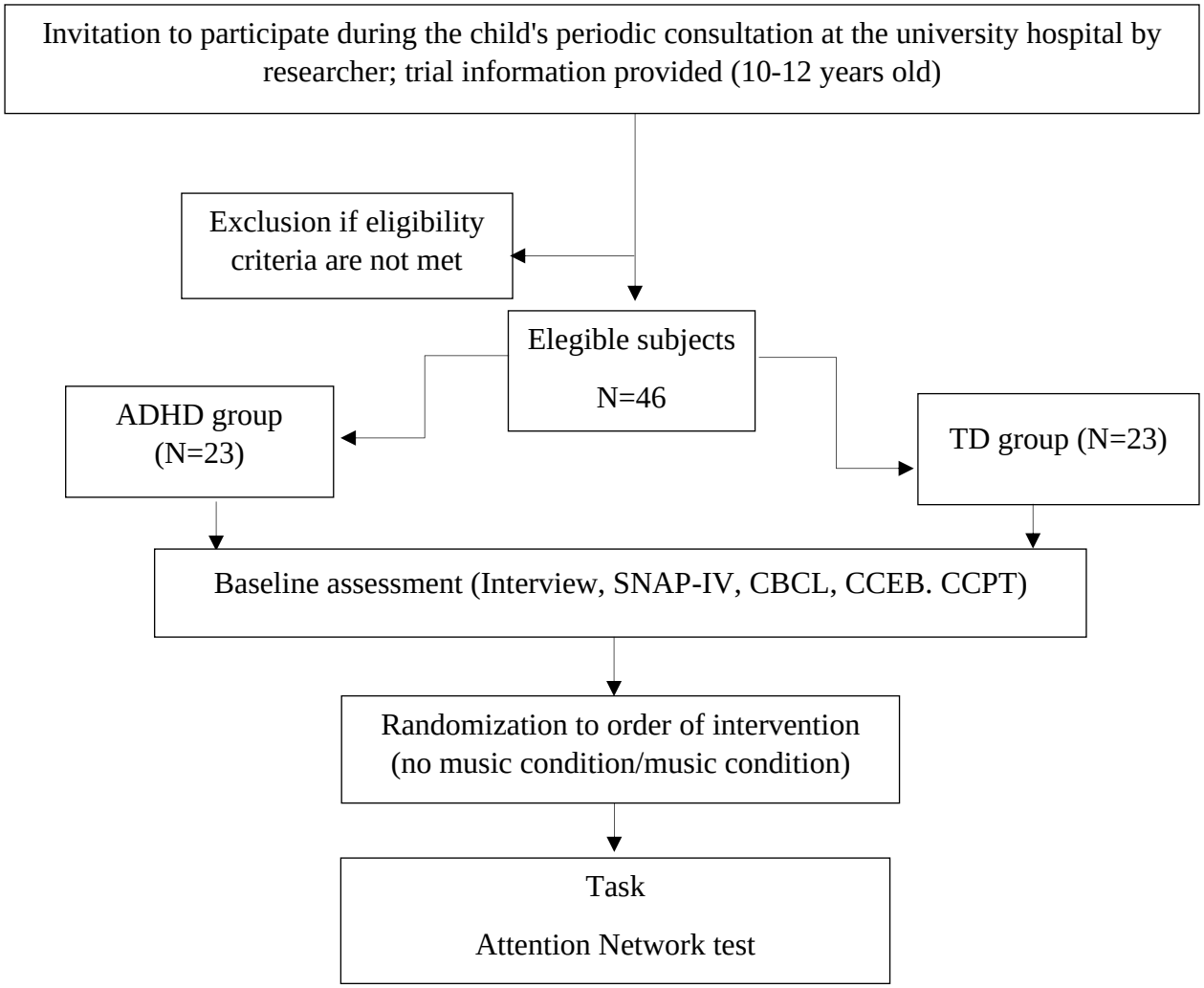


Figure 2. Flow chart of the study

For the ADHD group, children should have a confirmed diagnosis of ADHD according to the DSM-5 criteria (American Psychiatric Association, 2013) and the semi-structured K-SADS diagnostic protocol administered by the team responsible for psychiatric care at the hospital where the child will already be in treatment for ADHD. Also, they shouldn't be present a percentile equal to or small than 10 in the Brazilian version of Raven's CPM intelligence test, administrated by the same team (Pasquali et al., 2002).

For the non-ADHD group, children should not have a diagnosis of ADHD or any suspects of diagnosis identify by screening questionnaires as follows: more than five inattention and hyperactivity symptoms in Swanson Nolan and Pelham-IV (SNAP-IV) (Mattos et al., 2006); and T-score above 70 on ADHD scale of Child Behavior Checklist for Ages 6-18 (CBCL/6-18) (Achenbach & Ruffle, 2000). The questionaries SNAP-IV and CBCL have been widely used by the hospital's team of neuropsychologists for diagnostic assessment of ADHD and because of this they were chosen to test the eligibility of the normal group for the study. Children should also not have a history of school failure.

All children with a history or current evidence of psychosis, severe autism, brain disease, or any genetic or medical disease related to behaviors that may mimic or influence ADHD, and discontinuity of the treatment for at least three months will be excluded.

Intervention

For each participant included, we aim to perform all clinical measurement of primary and secondary outcomes on the same day. The music condition will consist in recordings of familiar music will last up to 15 minutes, according to duration of attention task. Shure® 440Hz headphones will be used and songs will be played by the same phone and the volume will be constant for all participants.

The choice of songs was done through formal interviews with children aged 10 to 12 years. The most cited songs were selected and those that were not instrumental were edited by Audacity Program (https://www.audacityteam.org/), audio editing software running on a Windows 11 operating system to remove the voices. All participants will hear the same songs during the performance of test. Before the test, they will listen pieces

of these songs (40s-60s) and will rate the subjective dimension of their familiarity (yes or maybe or no, for the question: Do you know this song?), liking (like or neutral or dislike, for the question: Do you like this song?), arousal and valence (based on the adapted Self-Assessment Manikin Scale)(Bradley & Lang, 1994). Children will point to one of five figures on a Manikin' scale (see figure 3) regarding the arousal and valence, which results in a 5-point rating scale. This questionnaire to validate the relationship of children with selected songs will be applied before the ANT test so that the results are not influenced by child's performance.

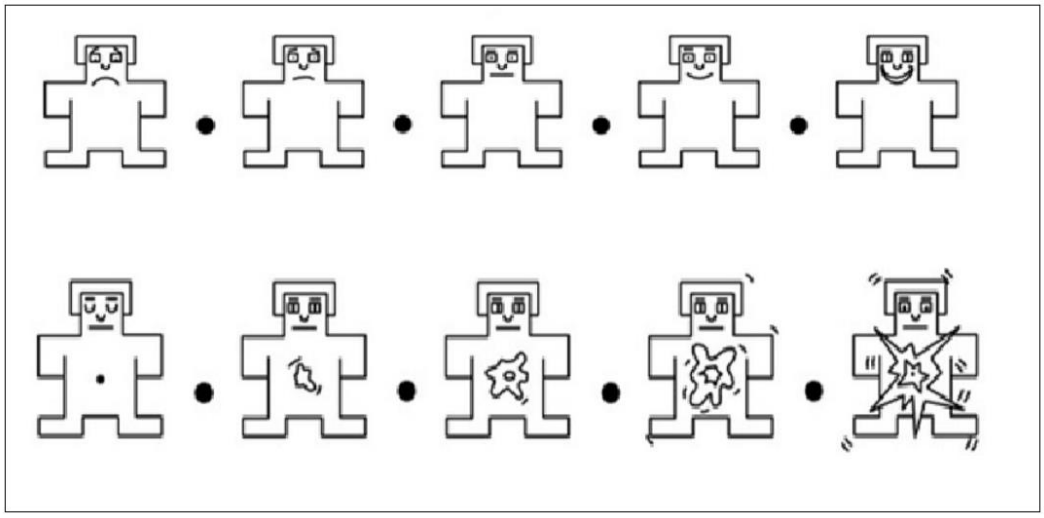


Figure 3. Manikin' scale adapted from the Self-Assessment Manikin Scale

To improve adherence to intervention, ADHD group will be invited to the study during the child's periodic consultation on the hospital. Thus, if the family agreed and the child was eligible, intervention would be performed there. Interventions may also be scheduled in advance, according to the date of the psychiatric consultation. Since most of the children could be using methylphenidate or other medication for attention problems, only those who are not using medication that day for at least 24 hours will be able to participate. For control group, the same will be performed, but during regular pediatric consultations or in the family's preferred location.

Sample Size

We calculated the estimated sample size a priori using G*Power (version 3.1). Since we expect to find some relevant effect, we used a medium effect size of 0.25 to reach the power of 0.90. With these parameters a total sample size of N=46. However, this calculation is limited because there is no previous evidence in the literature to estimate the expected effect size.

Procedures

Outcomes data will be collected at the same day of experiment. For control group, data collection may be interrupted if the child does not meet all the eligibility criteria, such as those referring to the cutoff points. The entire experiment will last about 1 hour with a break between each condition if necessary.

Primary Outcome Measure

Alert, orientation, and executive control skills will be evaluated through version for the child of an experimental task called the Attention Network Test (ANT), which combines a cue-target and a flanker to obtain their measures of efficiency and accuracy. The ANT is a single task structure consistent with Posner's Model (Posner & Petersen, 1990) and is not evidence of error and variability measures in studies of children with ADHD. ANT, child version, will be generated by the software, E-Prime (version 2.0 professional: Psychological Software Tools®, Sharpsburg PA, USA). A 15.6-inch Notebook Samsung will execute the task and response collection. Responses will be made using joystick buttons depending on the direction of the target if was left or right.

The task consists of presentation of a visual target stimulus (a yellow fish) placed in the center of the visual blue background that is oriented toward the left or right side (see figure 4) (Rueda et al., 2004). The fish will appear either alone (neutral condition) or with five yellow fishes who will be oriented in the same direction (congruent condition) or in the opposite direction (incongruent condition) from central fish. Also, this target will be present with different types of cues (center, double, spatial, and no cue) and below or above of the fixation cross. Children should identify the direction of the central fish by pressing the button of a joystick whatever their direction. The target (central fish) and flankers (cues) will appear simultaneously, and they will be presented until the child responds (de Souza Almeida et al., 2021).

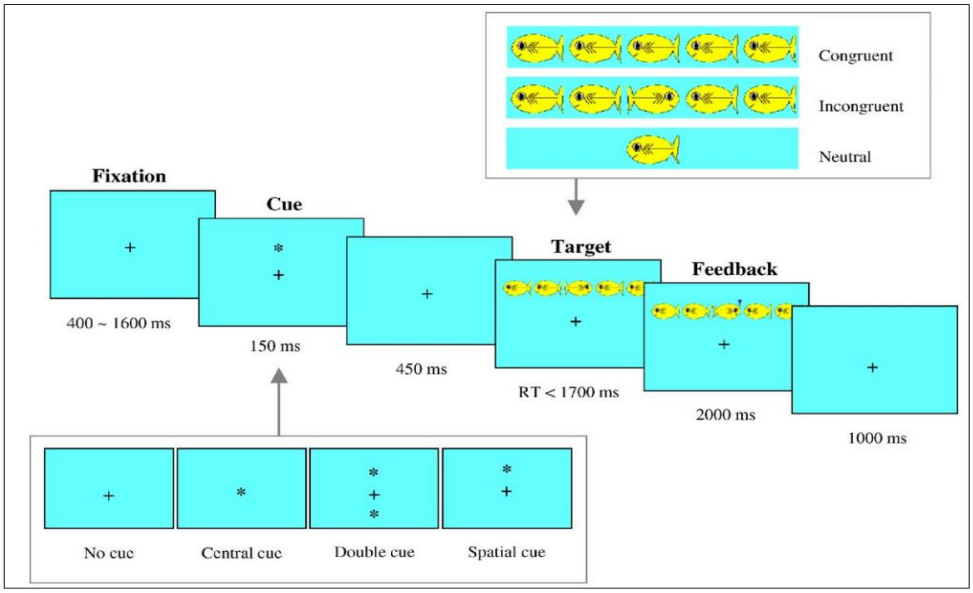


Figure 4. Schematic of the Attention Network Test for Child (Child ANT) adapted from Rueda et al. (Rueda et al., 2004)

To test the effect of background music on attention performance, children will be asked to complete the experimental task in two random conditions: listening to music during performance and in silence. The option for silence as a comparison stimulus was based on the fact many sounds have some potential attentional effects (Söderlund et al.,

2007). Before the first condition, a practice trial will be executed in silence condition, with auditory feedback on their success or not, to verify if children are understanding the task. The session of ANT will consist of a total of 24 practice trials once and three blocks of 48 trials in each condition (with a 1-2min break between each block): 4 cues conditions × 2 target locations (up, down) × 2 target directions (left, right) × 3 flanker conditions (neutral, congruent, incongruent). All trials will be randomized and the order of experimental condition too. In practice trials the participant will receive auditory and visual feedback from the computer, after responding (for correct responses, the target fish will blow bubbles and exclaim "Woohoo!"; for incorrect responses, a single tone will sound, and no animation will appear on the fish.

Secondary outcomes measures

The Brazilian version of Swanson Nolan and Pelham-IV (SNAP IV) (Mattos et al., 2006) is a self-report screening scale for parents based on the criteria established by DSM IV, regarding symptoms of ADHD and Oppositional Defiant Disorder. Through this instrument, it will be possible to characterize the sample of children with ADHD and apply the eligibility criteria for children in the control group. A recent study showed evidence of good psychometrics proprieties of SNAP-IV scale in a Brazilian sample (Costa et al., 2019). Since it is one of the most used instruments for measuring ADHD symptom severity (Hall et al., 2020).

Child Behaviour Checklist (CBCL) (Achenbach & Ruffle, 2000) assess behavioral problems in children (6-18 years old) by parent's ratings and includes 118 for eight narrow-band scales (Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, and Aggressive Behavior), and three broad-band scales (Internalizing Behavior

Problems, Externalizing Behavior Problems, and Total Behavior Problems. The data from this questionnaire will allow a characterization of symptoms and broader behaviors in our sample and to the eligibility criteria for the control group.

Conner's Continuous Performance Test (CCPT) (B. C. K. Conners, 2014) is a widely used instrument for the diagnosis of ADHD that assesses problems of sustained attention and inhibitory control. It is a computerized task, in which the subject is instructed to press the computer key for any stimulus that appears on the screen, except the one that is the target (e.g., letter, an image). This test will be applied before the experiment, to acquire a basic assessment of the child's sustained attention before ANT is performed.

Brazilian Economic Classification Criterion (CCEB, Brazilian Association of Research Companies) characterizes the socioeconomic level of the families through questions about family properties and household appliances, educational attainment of the head of the family and if there is street paving and treated water in their house. This is necessary for both groups to be paired, avoiding future bias.

In addition, we will conduct a semi-structured interview to investigate some variables that in the future can be correlated with the study's results, such as previous musical experiences of participants and their current routine with music (i.e., How often do you listen to music? How often do you listen to music while studying? Have you ever studied music in your life?)

Statistical analysis

We will first compare the RT for different cue and flanker conditions, and the network measures of the children under music condition and no music condition in both

groups. Also, we will compare the overall RT of ADHD children versus control group for each attention components. We will use variables of CPT test such as omission (the average range of failure to response to target letters, non-Xs) and commission (the average range of responses to non-targets, Xs) as covariates in all statistical analysis. To determine the most appropriate statistical test, we will verify the required assumptions about data distributions (normality of attentional scores, homoscedasticity, and sphericity). Statistical significance will be set to 0.05.

Ethics and dissemination

The results of research will be disseminated through publication in scientific journals, presentations in conference proceedings or other events relevant and directly to the families who participated in the study. The dissemination would help families of children with ADHD to understand alternatives to complement their ongoing therapy by improving the ability of the child to pay attention at school and at homework decreasing harmful environmental factors for both the child and their parents' relationship.

Discussion

Consequences of attention deficits in children with ADHD are a recurrent concern for families. The presence of external stimuli might be considered by parents and teachers as distractors for children predisposed to worse performance. The aim of this study is to examine the effects of background music on a specific attention task in children with ADHD. The use of stimulants has increased in the last decades due to an increase in the number of people diagnosed with attention deficits, and the prolonged use of this medication (Meijer et al., 2009). There is a perspective of overdiagnosis and excessive treatment of ADHD that has also raised global concerns and led to public and political debates (Meijer et al., 2009). So, this study will produce relevant information to contribute

to the risk-benefit understanding of non-pharmacological intervention that might improve attentional engagement without adverse effects.

Understanding how attention is impaired in ADHD under the effect of external stimuli may have important implications for interventions with this population and for music education, being of relevance for classroom teachers and parents who deal with these children. This knowledge might help to design better strategies to intervene beyond pharmacology to improve learning and modulate the motivation to learn evolving pleasant strategies.

Lastly, the use of standardized tests, such as ANT (Fan et al., 2002), can make it easier to carry out future studies maintaining the comparability of results between studies that investigate effects of music on attentional networks. This study protocol may elicit more attention and awareness for research involving music and non-pharmacological treatments without side effects by giving insight into what methods are applied to plan future investigations into music interventions on ADHD.

Trial status

The recruitment period started on Jul 2019, however, due to COVID-19 it has been suspended in 2020. In May 2021 data collection is ongoing, and we expect to be finalized by early 2022. Data analysis will start after all data will have been collected.

References

Abikoff, H., Courtney, M. E., Szeibel, P. J., & Koplewicz, H. S. (1996). Abikoff 1996. *Journal of Learning Disabilities*, *29*(3), 238–246.

Achenbach, T. M., & Ruffle, T. M. (2000). The child behavior checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review*, *21*(8), 265–271. https://doi.org/10.1542/pir.21-8-265

Adólfsdóttir, S., Sørensen, L., & Lundervold, A. J. (2008). The attention network test: A

characteristic pattern of deficits in children with ADHD. *Behavioral and Brain Functions*, *4*, 1–9. https://doi.org/10.1186/1744-9081-4-9

Amaravathi, T., Murugan, M., Subramanian, A., & Geetha, A. P. S. (2019). Attention deficit hyperactivity disorder. *Trends in Biosciences*, 214–221. https://doi.org/10.4324/9780203754818-11

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)* (5th ed).

Antshel, K. M., & Barkley, R. (2020). Attention deficit hyperactivity disorder. In *Handbook of Clinical Neurology* (1º ed, Vol. 174). Elsevier B.V. https://doi.org/10.1016/B978-0-444-64148-9.00003-X

Associação Brasileira de Empresas de Pesquisa (ABEP). ([s.d.]). *Dados com Base no Levantamento Sócio Econômico – IBOPE.* 2015. http://www.abep.org/new/criterioBrasil.aspx

Barkley, R. A. (1997). Behavioral Inhibition, Sustained Attention, and Executive Functions: Constructing a Unifying Theory of ADHD. In *Psychological Bulletin* (Vol. 121, Número 1). Routledge. https://doi.org/10.1037/0033-2909.121.1.65

Berger, A., & Posner, M. I. (2000). Pathologies of brain attentional networks. *Neuroscience and Biobehavioral Reviews*, *24*(1), 3–5. https://doi.org/10.1016/S0149-7634(99)00046-9

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., Wilens, T. E., Frazier, E., & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of Psychiatry*, *159*(1), 36–42. https://doi.org/10.1176/appi.ajp.159.1.36

Bordin IAS, Rocha MM, Paula CS, Teixeira MCTV, Achenbach TM, Rescola LA, S. E., Bordin, I. A., Rocha, M. M., Paula, C. S., Teixeira, M. C. T. V., Achenbach, T. M., Rescorla, L. A., & Silvares, E. F. M. (2013). Child Behavior Checklist (CBCL), Youth Self- Report (YSR) and Teacher's Report Form (TRF): an overview of the development of the original and Brazilian versions. *Cadernos de Saúde Pública*, *29*(1), 13–28. http://www.ncbi.nlm.nih.gov/pubmed/23370021%0Ahttp://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2013000500004&lng=pt&nrm=iso&tlng=en

Bradley, M., & Lang, P. J. (1994). Self-Assessment Manikin (SAM). *J.Behav.Ther. & Exp. Psychiat.*, *25*(1), 49–59.

Brown, T. E. (2008). ADD/ADHD and impaired executive function in clinical practice. *Current Psychiatry Reports*, *10*(5), 407–411. https://doi.org/10.1007/s11920-008-0065-7

Christiansen, H., Hirsch, O., Albrecht, B., & Chavanon, M. L. (2019). Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span. *Current Psychiatry Reports*, *21*(3), 16–18. https://doi.org/10.1007/s11920-019-1003-6

Conners, B. C. K. (2014). Conners ' Continuous Performance Test II (CPT II V . 5) Profile Report Client Name : Iago Oliveira. *Musician*, 1–15.

https://www.pearsonclinical.co.uk/Psychology/ChildMentalHealth/ChildADDADHDBehaviour/ConnersContinuousPerformanceTestIIVersion5forWindows(CPTIIV5)/PDFReports/Profile.pdf

Conners, C. K. (2002). *Conners' continuous performance test for Windows*.

Costa, D. S., de Paula, J. J., Malloy-Diniz, L. F., Romano-Silva, M. A., & Miranda, D. M. (2019). Parent SNAP-IV rating of attention-deficit/hyperactivity disorder: accuracy in a clinical sample of ADHD, validity, and reliability in a Brazilian sample. *Jornal de Pediatria*, *95*(6), 736–743. https://doi.org/10.1016/j.jped.2018.06.014

Dalton, B. H., & Behm, D. G. (2007). Effects of noise and music on human and task performance: A systematic review. In *Occupational Ergonomics* (Vol. 7). IOS Press.

de Souza Almeida, R., Faria-Jr, A., & Klein, R. M. (2021). On the origins and evolution of the Attention Network Tests. *Neuroscience and Biobehavioral Reviews*, *126*(September 2020), 560–572. https://doi.org/10.1016/j.neubiorev.2021.02.028

Egermann, & Hauke. (2013). *Can parents influence children ' s music preferences and positively shape their development ? Dr Hauke Egermann*.

Fabio, R. A., & Urso, M. (2014). The analysis of Attention Network in ADHD, attention problems and typically developing subjects. *Life Span and Disability*, *17*(2), 199–221.

Fan, J., McCandliss, B. D., Sommer, T., & Raz, A., Posner, M. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. http://www.sacklerinstitute.org/users/jin.fan/publications/ANT.pdf

Greenop, K., & Kann, L. (2007). Extra-task stimulation on mathematics performance in children with and |PsyssA without ADHD. *South African Journal of Psychology*, *37*(2), 330–344.

Hall, C. L., Guo, B., Valentine, A. Z., Groom, M. J., Daley, D., Sayal, K., & Hollis, C. (2020). The Validity of the SNAP-IV in Children Displaying ADHD Symptoms. *Assessment*, *27*(6), 1258–1271. https://doi.org/10.1177/1073191119842255

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. *Music Perception*, *20*(2), 151–171. https://doi.org/10.1525/mp.2002.20.2.151

Ilieva, I. P., & Farah, M. J. (2019). Attention, Motivation, and Study Habits in Users of Unprescribed ADHD Medication. *Journal of Attention Disorders*, *23*(2), 149–162. https://doi.org/10.1177/1087054715591849

Posner, G., Polanczyk, E. S.-B. (2020). Attention-deficit hyperactivity disorder. *Lancet*, *8*(6), 450–462. https://doi.org/10.1097/00004703-200312000-00013

Johnson, K. A., Robertson, I. H., Barry, E., Mulligan, A., Dáibhis, A., Daly, M., Watchorn, A., Gill, M., & Bellgrove, M. A. (2008). Impaired conflict resolution and alerting in children with ADHD: evidence from the Attention Network Task (ANT). *Journal of child psychology and psychiatry, and allied disciplines*, *49*(12), 1339–1347. https://doi.org/10.1111/j.1469-7610.2008.01936.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Markham, W. A., & Spencer, N. (2022). Factors that mediate the relationships between household socio-economic status and childhood Attention Deficit Hyperactivity Disorder (ADHD) in children and adolescents: A systematic review. *PLoS ONE*, *17*(3 March), 1–22. https://doi.org/10.1371/journal.pone.0262988

Martella, D., Aldunate, N., Fuentes, L. J., & Sánchez-Pérez, N. (2020). Arousal and Executive Alterations in Attention Deficit Hyperactivity Disorder (ADHD). *Frontiers in Psychology*, *11*(August), 1–7. https://doi.org/10.3389/fpsyg.2020.01991

Mattos, P., Serra-Pinheiro, M. A., Rohde, L. A., & Pinto, D. (2006). MTA-SNAP-IV em português para uso no Brasil. *Revista de Psiquiatria do Rio grande do Sul*, *28*(3), 290–297.

Mendes, C. G., Diniz, L. A., & Marques Miranda, D. (2021). Does Music Listening Affect Attention? A Literature Review. *Developmental Neuropsychology*, *46*(3), 192–212. https://doi.org/10.1080/87565641.2021.1905816

Morsink, S., Sonuga-Barke, E., Van der Oord, S., Van Dessel, J., Lemiere, J., & Danckaerts, M. (2021). Task-related motivation and academic achievement in children and adolescents with ADHD. *European Child and Adolescent Psychiatry*, *30*(1), 131–141. https://doi.org/10.1007/s00787-020-01494-8

Nigg, J. T. (2005). Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: The state of the field and salient challenges for the coming decade. *Biological Psychiatry*, *57*(11), 1424–1435. https://doi.org/10.1016/j.biopsych.2004.11.011

Pasquali, L., Wechsler, S., & Bensusan, E. (2002). Matrizes progressivas do Raven Infantil: um estudo de validação para o Brasil. *Aval. psicol*, 94–110.

Pelham, W. E., Waschbusch, D. A., Hoza, B., Gnagy, E. M., Greiner, A. R., Sams, S. E., Vallano, G., Majumdar, A., & Carter, R. L. (2011). Music and video as distractors for boys with ADHD in the classroom: Comparison with controls, individual differences, and medication effects. *Journal of Abnormal Child Psychology*, *39*(8), 1085–1098. https://doi.org/10.1007/s10802-011-9529-z

Pereira, C. S., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., & Brattico, E. (2011). Music and Emotions in the Brain: Familiarity Matters. *PLoS ONE*, *6*(11). https://doi.org/10.1371/journal.pone.0027241

Pizzo, R., Urben, S., Van Der Linden, M., Borradori-Tolsa, C., Freschi, M., Forcada-Guex, M., Hüppi, P., & Barisnikov, K. (2010). Attentional networks efficiency in preterm children. *Journal of the International Neuropsychological Society*, *16*(1), 130–137. https://doi.org/10.1017/S1355617709991032

Polanczyk, G. (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry*, *164*(6), 942. https://doi.org/10.1176/appi.ajp.164.6.942

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *International Journal of Epidemiology*, *43*(2), 434–442. https://doi.org/10.1093/ije/dyt261

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(February), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040. https://doi.org/10.1016/j.neuropsychologia.2003.12.012

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*(2), 257–264. https://doi.org/10.1038/nn.2726

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE*, *4*(10). https://doi.org/10.1371/journal.pone.0007487

Schellenberg, E. G., & Hallam, S. (2005). Music listening and cognitive abilities in 10- and 11-year-olds: the blur effect. *Annals of the New York Academy of Sciences*, *1060*, 202–209. https://doi.org/10.1196/annals.1360.013

Sergeant, J. (2004). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive?energetic model. *Biological Psychiatry*. https://doi.org/10.1016/j.bps.2004.09.010

Sergeant, Joseph. (2000). Sergeant.00 Modelo cognitivo energético.pdf. *Neuroscience and Biobehavioral Reviews*, *24*, 7–12.

Siti Norazah, S., Abdullah, N., Salleh, N., Renuka, J., Azlina, M., Abd Rahman, H., & Nor Azila, N. (2017). The Effects of Music on Cognitive Performance in Attention Deficit Hyperactive Disorder (ADHD) Children: A Systematic Review. *Asian Journal of Multidisciplinary Studies*, *5*(9), 11–17. http://www.adhd-federation.org/fileadmin/user_upload/Abstract_Review/2017/10_Oktober/Treatment/The_Effects_of_Music_on_Cognitive_Performance_in_ADHD_Children_-_A_Systematic_Review.pdf

Skalski, S., Pochwatko, G., & Balas, R. (2020). Impact of Motivation on Selected Aspects of Attention in Children with ADHD. *Child Psychiatry and Human Development*, *52*(4), 586–595. https://doi.org/10.1007/s10578-020-01042-0

Smith, Z. R., & Langberg, J. M. (2018). Review of the Evidence for Motivation Deficits in Youth with ADHD and Their Association with Functional Outcomes. *Clinical Child and Family Psychology Review*, *21*(4), 500–526. https://doi.org/10.1007/s10567-018-0268-3

Smith, Z. R., Langberg, J. M., Cusick, C. N., Green, C. D., & Becker, S. P. (2020). Academic Motivation Deficits in Adolescents with ADHD and Associations with Academic Functioning. *Journal of Abnormal Child Psychology*, *48*(2), 237–249. https://doi.org/10.1007/s10802-019-00601-x

Söderlund, G., Sikström, S., & Smart, A. (2007). Listen to the noise: Noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(8), 840–847. https://doi.org/10.1111/j.1469-7610.2007.01749.x

Wan, J., & Taatgen, N. (2018). The Influence of Music and Music Familiarity on Time Perception. *CogSci 2018*, 2657–2662.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/ hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Zajenkowski, M., Goryńska, E., & Winiewski, M. (2012). Variability of the relationship between personality and mood. *Personality and Individual Differences*, *52*(7), 858–861. https://doi.org/10.1016/j.paid.2012.01.007

5.2 Artigo 3

Title: Effects of background music on attentional networks of children with and without ADHD

Authors: Camila Guimarães Mendes [a, *], Jonas Jardim de Paula[b], Débora Marques Miranda [c]

Institutional affiliation:

[a] Graduate Program in Children and Adolescent Health, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil.

[b] Department of Mental Healthy, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil;

[c] Department of Pediatrics, Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil.

***Corresponding Author:**

Camila Guimarães Mendes, Universidade Federal de Minas Gerais, Avenida Prof. Alfredo Balena, 190 Santa Efigênia, 30130-100, Belo Horizonte, MG, Brazil. Email: camilagmbh@gmail.com.

Abstract

Background: To sustain performance during a task that require attention may be challenge for children with Attention Deficit/ Hyperactivity Disorder (ADHD). It is strongly influenced the motivational salience of the task and has been integrated with the level of arousal. **Objetive**: The aim of this study was to analyze the effect of musical stimulus on attentional performance in children with ADHD and typically developing (TD) children. **Method**: Seventy-six boys (34 with ADHD and 42 typically developing) performed the Attention Network Test for Children in two experimental conditions: with music (MU) and without music (NM). Three attentional scores were calculated separately to reflect the efficiency of alertness, orienting, and conflict, and overall rate errors were obtained. **Results**: No difference in attention networks were found between the two conditions or between groups. However, when children performed the test listening to music, they made fewer number of errors than when performed in silent, whatever their group. **Conclusion:** Music seems not to interfere on attentional network in children and adolescents.

Introduction

Attention Deficit/ Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder characterized by harmful levels of inattention, impulsivity, and hyperactivity (American Psychiatric Association, 2013). Heterogeneity is a hallmark in ADHD presentation, individuals' symptoms reflect cognitive alterations (Martella et al., 2020). Impaired cognitive aspects in ADHD consist on frequent executive functions compromise (i.e working memory, inhibitory control, cognitive flexibility, planning and problem solution), self-regulation state (i.e the effortful and automatic mechanisms that enable behavior to be adapted appropriately to a changing context); motivation (li.e temporal reward discounting), and time perception (i.e the ability to discriminate and compare time intervals) (Brown, 2008; Willcutt et al., 2005; Amaravathi et al., 2019).

In attentional modelling in Posner et al. (Berger & Posner, 2000) have an appropriate theoretical framework to account for ADHD dysfunctions because most of the abilities above are conceptualized as part of the attentional networks such as alerting

(i.e arousal of the cognitive system), orienting (i.e allocating the attentional focus in the visual field) and executive control (i.e ability to control our own behavior, resolve conflict, and inhibit impulsive responses). A task that requires allocation extra of effort for the child to sustain performance may be challenge for ADHD children, especially in suboptimal conditions (J Sergeant, 2004). On the other hand, the effort is determined by the motivational salience of the task and have been integrated with the level of arousal and activation (J Sergeant, 2004; Zajenkowski et al., 2012). It explain why children with ADHD who are easily distracted while facing external stimulus may benefit from stimuli promoting increased alertness and consequently improving the performance in the task (Siti Norazah et al. 2017; Söderlund, Sikström, & Smart 2007).

A recent systematic review showed listening to music without lyrics and chosen by the listener seems to improve the performance of tasks requiring attention (Mendes, Diniz, & Marques Miranda 2021). The music enhances arousal and increases motivation, especially when are preferred by listener, potentially benefiting the learning process through emotional processes (Dalton & Behm, 2007; Husain et al., 2002). The effectiveness of music on cognitive function of ADHD is still limited due inconsistent results (Siti Norazah et al., 2017). From the studies that evaluated music as stimulation in ADHD, two of them reported improvement in mathematical problems (Abikoff et al., 1996; Greenop & Kann, 2007), and another evaluating seatwork completions (i.e math, reading, reading comprehension and language arts) showed no significant difference in cognitive function (Pelham et al., 2011). Also, the heterogeneity in the methodology of these studies has made it difficult to conclude what the real effect of music whether it leads to an improvement in task performance.

There are no data evaluating the impact of music listening on attention network of children with ADHD. The aim of this study was to explore the effects of listening to

music on the attention networks (i.e alerting, orienting and conflict) of children with ADHD and typically developing (TD) children and the relationship with attentional profile of children. Since preview studies with ADHD (Fabio & Urso, 2014, Adólfsdóttir et al., 2008, Posner et al., 2002) included measures of error types besides the conventional measures of the three attention networks we will also check if the music affects the error rate on performance. We expected that the music may improve the attention performance of children with ADHD differently from their pairs.

Method

Study design

This is an experimental repeated-measures design carried out in 2019-2022 to investigate the effects of music listening or no music listening on attention performance. We recruited boys with ADHD and boys without ADHD who completed the Attention Network Test (version for child) twice under above conditions in a randomized order. The protocol was preregistered at rebec.gov (U1111-12589039); see [https://ensaiosclinicos.gov.br/rg/RBR-8s22sh8] and approved by the University's Ethics Review Committee (CAAE: 97425218.4.0000.5149). All participants signed the consent form to participate prior to entering the trial.

Participants

Seventy-six children and adolescents (34 with ADHD and 42 without ADHD), boys, and aged 10-12 years old composed the sample. The above-mentioned age range was chosen because there is evidence that children younger than 10 years old were still developing their musical preferences, and when reaching adolescence they tend to be more open to unfamiliar music styles (Egermann & Hauke, 2013). Since the musical

stimulus in this study should be familiar and preferred by the listener, the age range from 10 to 12 years was chosen.

Participants were recruited from a university hospital where ADHD children and adolescents receive psychiatric treatment and healthy individuals receive pediatric follow-up. All children with ADHD were recruited from the same assistance service and were according to the following including criteria had the diagnosis of ADHD by the DSM-5 criteria (American Psychiatric Association, 2013) and the semi-structured Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime (K-SADS-PL) (Kaufman et al., 1997) and present a percentile equal to or greater than 10 in the Brazilian version of Raven's CPM intelligence test (Pasquali, Wechsler, & Bensusan 2002).

Since the COVID-19 pandemic emerged in 2020 the control group was recruited from the local community in 2021 and 2022. This group was paired with ADHD group in age and socioeconomic level and followed inclusion criteria: didn't have a diagnosis of ADHD or didn't present results within the cut-off points to the screening questionnaires for ADHD (i.e more than five ADHD symptoms identified by Swanson Nolandand Pelham-IV- SNAP IV or T-score above 70 on the ADHD scale of Child Behavior Checklist for Ages 6-18 (CBCL/6-18) (Bordin et al. 2013; Costa et al. 2019).

Music selection

Five songs were selected through interviews with children aged 10 to 12 years-old who reported the songs most listened by them. Interviewed children about the favorite music were not the children who participated in the study necessarily. To assess the emotional relationship between listener-songs (ie familiarity, like, mood and arousal) a questionnaire was done. All participants listened to pieces of songs and answered the

questions: “Do you know this song?” (yes, maybe, no); “Do you like this song?” (yes, neutral, no); and “How do you feel listening to these songs?”(using the adapted Self-Assessment Manikin Scale) (Bradley & Lang 1994) (see Supplement Material A). A five point likert scale was used to rate the subjective dimension of the mood (1= very sad; 2= sad; 3= neutral; 4= happy; 5= very happy) and arousal (1= non arousal; 2= low arousal; 3= neutral; 4= arousal; 5= very arousal) based on figure pointed by children. This questionnaire was applied before the ANT test so that the results are not influenced by the child's performance.

Also, to avoid influence from the experimenter, the order of plays of songs was defined through a random drawing in Microsoft Excel (see Table 1). Music was played using a Samsung Galaxy J5 and Shure® 440Hz headphones. The volume was standardized to the same level for all participants.

Table 1. Order of plays of songs.

Order	Title	Duration
1	Fortnite OST - Battle Royale Menu Music (Rock Version)[a] https://www.youtube.com/watch?v=2q-k7ScMs0k	3:50
2	Alone (Mashmallo) – Modified[b] https://www.youtube.com/watch?v=ALZHF5UqnU4	3:19
3	Free Fire New EPIC Theme Song[c] https://www.youtube.com/watch?v=oCBMY0MSiWA	3:56
4	Herobrine's Life (Instrumental)[d] https://www.youtube.com/watch?v=Qk1FDPOP8ys	4:00
5	Olha a explosão (Mc Kevinho) – Modified[b] https://www.youtube.com/watch?v=3yd_eoMOvqk	3:07

Note: [a] This song is part of Fortnite Game and used to be played in the Battle Royale Menu and when you win Battle Royale. It was composed by Rom Di Prisco and all content belongs to Epic Games.
[b] The original song was modified by Audacity Program Version 2.3.2 (audio editor) to remove the voices
[c] This song is theme song of Free Fire/2019.
[d] This song is a Minecraft parody of the song “Something Just Like This” by The Chainsmokers and Coldplay

Procedures

Parents or caregivers were contacted by the first author by phone to schedule the day of the experiment. For the ADHD group, the experimenter scheduled the same day of the appointment with the psychiatrist at the university hospital or another day in agreement with the family. The child was conducted individually in a quiet office while parents wait in the waiting room and filled out behavior scales about the children and a sociodemographic questionnaire.

For the control group, the experiment took place on the most convenient day and setting for the caregivers if the child meets all the eligibility criteria. Screening for ADHD was completed using SNAP-IV and CBCL scales filled out by parents via the internet. When the experiment took place in the participant's home, the child performed the task on a table and in the quietest place in his house in a quieter place.

Children and caregivers were invited to answer a semi-structured questionnaire (See Supplemental Material B) before the experiment. The experiment involved the performance of the Attention Network Test (ANT) version for the child (Rueda et al., 2004) under two conditions (music and no-music). The Child ANT was generated with the E-prime program (version 2.0 professional) and was downloaded on a 15.6-inch Notebook Samsung from Jin Fan's webpage (Fan 2019). All participants stood facing the laptop on the table to perform the task, maintaining a comfortable position in a chair (Fig. 1). The experimenter administered the Conner’s Continuous Performance Test – CCPT (C. K. Conners, 2002) to the children before performed the ANT. All procedure took about 1h30min.

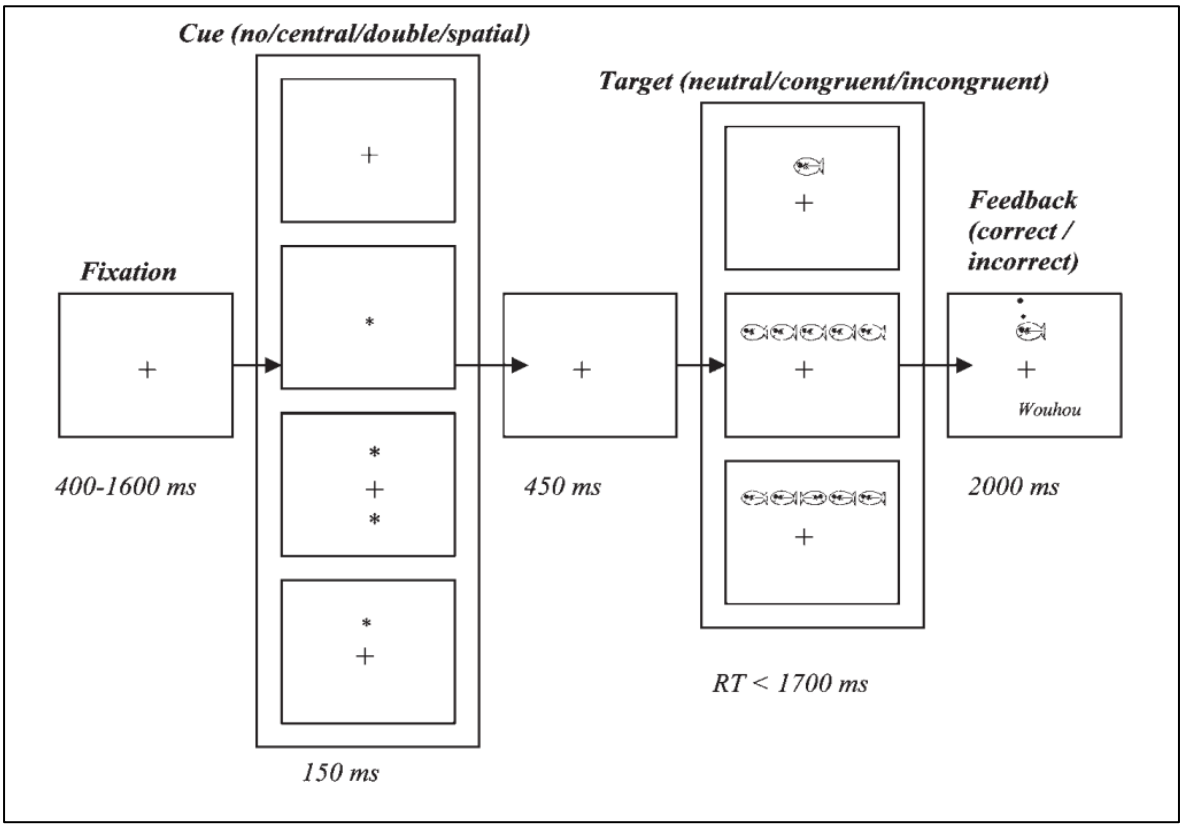
Fig.1 Experimental setup

Measures

Attention Network Test -ANT (version for child)

The ANT was developed to examine three attention networks (alerting, orienting and conflict) although of a single task based on Posner's model (Posner & Petersen, 1990). In the child version the subject is instructed to feed the central colorful fish by pressing a joystick button corresponding to the direction (left or right) in which he is swimming. The fish could appear alone or accompanied by other fish converging in the same or opposite direction from it (neutral, congruent or incongruent stimuli) combined with cueing conditions (no cue, central cue, double cue and spatial cue) (Rueda et al., 2004) (see Figure 2). Originally, the task was composed of 24 practice trials and three experimental blocks of 48 trials each. Since the child would need to perform the task twice (with music and without music), the practice tracks were applied separately, once. This procedure took approximately 45 min (i.e five minutes of practice, 15 minutes for each round of 48 trials, with 1-2 minute rest intervals).

Fig.2 Schematic of the child version of the ANT adapted from (Pizzo et al., 2010)



Note. In the actual task, the background color for every display is blue while the fish appear in yellow, and the auditory feedback was used only to practice trials.

Swanson Nolandand Pelham-IV- SNAP IV

The SNAP-IV is a screening scale for ADHD and Oppositional Defiant Disorder (ODD) based on the criteria established by the DSM IV (Costa et al., 2019). It is a questionnaire with 26 items divided into subsets of symptoms (inattention, hyperactivity/impulsivity, and ODD) rated using a 4-point Likert scale ranging from 0 (not at all) to 3 (very much). There are three methods to compute the scores such as (1) the average score in each dimension; (2) the total of the scores, and (3) the number of symptoms (Costa et al., 2019). We chose to use the number of symptoms to screen the

group without ADHD according to the cutoff point. The second and third methods were used for sample characterization.

Child Behavior Checklist for Ages 6-18 -CBCL/6-18

The CBCL is a self-report questionnaire for behaviors that comprises 118 items that can be scored as 0 (not true), 1 (somewhat or sometimes true), or 2 (very true or often true). The sum of these scores provides raw scores for eight narrow-band scales (Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, and Aggressive Behavior), and three broad-band scales (Internalizing Behavior Problems, Externalizing Behavior Problems, and Total Behavior Problems). Raw scores are transformed into T-scores based on normative data for their age and gender (Bordin et al. 2013). Through this instrument, it was possible to rule out other pathologies that could be confounding ADHD and also for the inclusion criteria of typically development children.

Conner's Continuous Performance Test – CCPT

The CCPT is a computerized test used in individuals 6 years of age and older that measures sustained attention and vigilance through analysis of hits, omissions, commissions, reaction time (RT), and reaction time variability (RTV) (Conners 2014; Conners 2002). The subject is instructed to press the spacebar of the keyboard of the computer whenever a letter appears on the screen, except when the letter "X" appears. A report is generated with omission scores, commissions, reaction time of correct answers, standard error of reaction time of correct answers, variability and detectability) (Conners 2014). This instrument was chosen as a measure of baseline attention and was applied to all children before the application of the ANT.

Brazilian Economic Classification Criterion - CCEB

The CCEB (Associação Brasileira de Empresas de Pesquisa 2019) characterizes the socioeconomic level of the families through questions about family properties and household appliances, educational attainment of the head of the family, and if there is street paving and treated water in their house. The final score can be further stratified in levels from A to E. Since more economically vulnerable children may have more symptoms of ADHD and other externalizing disorders, this assessment is an important tool for this population (Markham & Spencer, 2022). This is necessary for both groups to be paired, avoiding future bias.

In addition to the above instruments, a questionnaire collected information's about the child's previous musical experience, musical preferences and routine of listening to music at home as follow: (1) Have you ever taken a music class any time?; (2) How often do you listen to music at home?; (3) How often do you listen to music while study?; (4) What type of music do you listen to the most? In the end of study the children were asked about the condition they had most enjoyed taking the test.

Data Analysis

The sample size of 46 was estimated by the G-power 3.010 software with the following parameters: $\alpha = 0.05$; medium effect size = 0.25 and power of 90%. Statistical significance was 0.05 and statistical analyses were performed using the Statistical Package for Social Sciences for Personal Computer (SPSS 22.0).

Descriptive statistics was done to find out mean and standard deviation (SD) for all the measures characterization of sample. Attention networks (alerting, orienting and conflict) for each participant were computed by three subtractions and error rate by mean

of numbers of overall error for each cue and flanker condition (i.e all error responses such as omissions, preservations and outliers), according to Fan (2002).

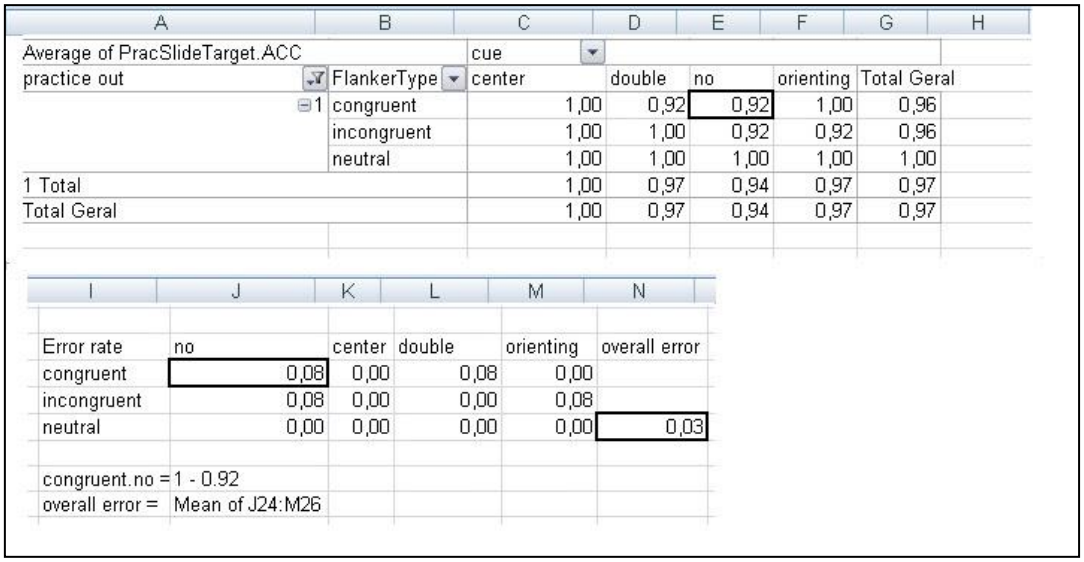
To find out the orienting and alerting scores per subject was computed the mean RT per cue condition across the flanker conditions (orienting= RT for spatial cue – RT for central cue; alerting = RT for double cue – RT for the no cue condition). To obtain the conflict score we computed the participant's mean RT for each flanker condition across cue conditions (RT for incongruent – RT for congruent). The mean score, across subjects, was then computed for each network using an Excel macro downloaded from Fan's webpage (Fan, 2019). Error rate was found by mean of error per all conditions (cue and flanker). Examples of calculations are illustrated in Figure 3 and Figure 4.

Fig. 3 Example of calculations of attentional networks of subject 1, session 2, using an Excel macro.

Average of PracSlideTarget.RT				cue				
outiler	practice	PracSli	FlankerType	center	double	no	orienting	Total Geral
1	1	1	congruent	578	682	644	666	641
			incongruent	611	740	882	670	724
			neutral	592	633	573	653	613
		1 Total		594	685	696	663	659
	1 Total			594	685	696	663	659
1 Total				594	685	696	663	659
Total Geral				594	685	696	663	659
subject:	**1**	session:	**2**					
		no	center	double	orienting		Alerting	**11**
	congruent	644	578	682	666		Orienting	**-69**
	incongruen	882	611	740	670		Conflict	**82**
	neutral	573	592	633	653	660		
Alerting (696 - 685) = 11								
Orienting (594 - 663) = -69								
Conflict (724 - 641) = 82								

Note. Excel macro downloaded from Fan's webpage (Fan, 2019).

Fig. 4 Example of calculations of overall errors of subject 1, session 2, using an Excel macro.



Average of PracSlideTarget.ACC		cue				
practice out	FlankerType	center	double	no	orienting	Total Geral
1	congruent	1,00	0,92	0,92	1,00	0,96
	incongruent	1,00	1,00	0,92	0,92	0,96
	neutral	1,00	1,00	1,00	1,00	1,00
1 Total		1,00	0,97	0,94	0,97	0,97
Total Geral		1,00	0,97	0,94	0,97	0,97

Error rate	no	center	double	orienting	overall error
congruent	0,08	0,00	0,08	0,00	
incongruent	0,08	0,00	0,00	0,08	
neutral	0,00	0,00	0,00	0,00	0,03
congruent.no =	1 - 0.92				
overall error =	Mean of J24:M26				

Note. Excel macro downloaded from Fan's webpage (Fan, 2019). Squares in bold indicate the values used for the calculations in the example.

Analysis of variance (ANOVA) with repeated measures was used to investigate the effects of music on attention. Music was the within-subjects variable and ADHD diagnosis was the between-subjects variable. Attention networks and error rate measures were entered separately as dependent variables and influencing factors were controlled such as omission and commission values by CCPT.

Results

Descriptive behavioral characteristics of eligible participants can be seen in Table 2. Complementary information's about previous musical experience and emotional relationships with the music selection can be seen in Supplement Material B and Supplement C, respectively. Most of 50% of children reported to know and to like the list of songs used in this study. Still, 76% of children reported they enjoyed the test more while listening to music than in the no-music condition (data not show).

Independent sample tests detected no significant age difference between the control and ADHD groups, t(74) = 0.47, p=0.634. Also, no significant economic level differences were found between the groups, t (71)= -1.158, p=0.251).

Table 2. Demografic characteristics of sample.

	TD group (n=42)	**ADHD group (n=34)**
Age (years)[a]	11.0 (0.85)	10.9 (0.75)
Socioeconomic family score (CCEB)[a,*]	28.5 (11.32)	31.5 (11.15)
SNAP-IV Symptoms Score[c]		
Inattention	1 (>5)	6 (>5)
Hyperactivity/impulsivity	0 (>5)	5 (>5)
CBCL-ADHD Scale[d]	44.7 (>70)	61.6 (>70)
CCPT[a]		
Omissions	11.7 (9.5)	11.9 (8.6)
Comissions	25.0 (6.0)	25.4 (7.3)

Note. [a] Numbers indicate mean and (standard deviation)
[c] Categorization of each SNAP-IV item as present (1 point, which mean all answers equivalente to 2= quite a bit or 3=very much) and absente (0 point, which mean all answers equivalent to 0=not all or 1=just a little), where present. * Numbers indicate symptoms and (cut-off point to screening of ADHD)
[d] T-scores calculated with reference to Brazilian normative data (Bordin et al. 2013). Numbers indicate mean t-score and (cut-off point to screening of ADHD).

* CCEB = Brazilian Criteria of Economic Classification (0-16 = Class D and E; 17-22 = Class C2; 23-28= Class C1; 29-37 = Class B2; 38-44 = Class B1; 44-100 = A). SNAP-IV = Swanson Nolandand Pelham -IV. CBCL = Child Behavior Checklist. CCPT = Conner's Continuous Performance Test.

Effect of music on attention networks and error rate

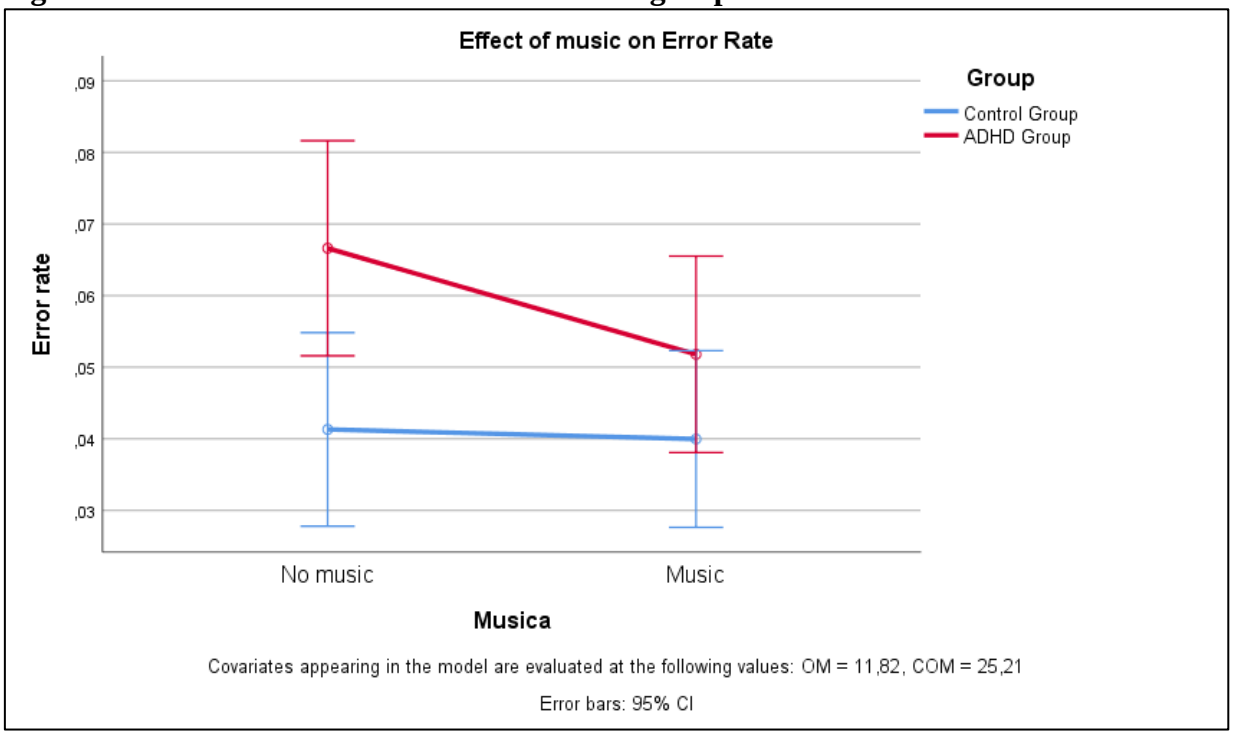
Table 3 shows the mean of the RTs for correct responses and standard deviations for each condition and groups. The analysis of variance showed non-significant effect of music on attention networks controlling by commission and omission variables (see in Table 3), indicating that the efficiency of alerting, orienting and conflict were not affected by experimental condition. None of the main effects of Group or effect of Group by Music interaction was found.

INSERT TABLE 3

INSERT TABLE 4

Analyses revealed a significant main effect of music for error rate as seen in the Figure 2 such that both groups decreased number of errors during the music condition. Because was no significant effect of the interaction between group and condition, it is not possible to know for which group (ADHD or non-ADHD) the reduction in the number of errors was greater. However, it seems that there is a tendency for this change to have been greater in the ADHD group (see Figure 5).

Fig.5 Error rate as a function of condition and group.



Note. ADHD= Attention Deficit Hyperactivity Disorder; OM= omissions; COM= comissions

Table 3: Mean of the RTs and standard deviations for correct responses

	TD group															
	No music								Music							
	center		double		no		orienting		center		double		no		orienting	
Congruent	639	(120)	626	(266)	692	(130)	619	(192)	635	(135)	614	(177)	675	(229)	612	(296)
Incongruent	702	(106)	689	(343)	736	(201)	680	(62)	674	(75)	680	(177)	723	(109)	660	(203)
Neutral	621	(167)	597	(115)	664	(227)	590	(182)	634	(205)	612	(255)	657	(63)	598	(246)

	ADHD group															
	No music								Music							
	center		double		no		orienting		center		double		no		orienting	
Congruent	686	(120)	668	(266)	743	(130)	663	(192)	689	(120)	672	(266)	734	(130)	648	(192)
Incongruent	763	(106)	722	(343)	796	(201)	693	(62)	759	(106)	708	(343)	781	(201)	710	(62)
Neutral	672	(167)	658	(115)	732	(227)	647	(182)	651	(167)	648	(115)	709	(227)	629	(182)

Note. TD= typically development; ADHD= Attention Deficit Hyperactivity Disorder

Table 4. ANOVA analysis showing the difference between the music condition and group on attention networks and error rate.

	TD group (N=42)		**ADHD group (N=34)**			
	No Music ***M (SD)***	**Music** ***M (SD)***	**No Music** ***M (SD)***	**Music** ***M (SD)***	**Main effect of Music *F***	**Interaction Music*Group *F***
Attention Networks						
Alerting	68.62 (52.67)	60.33 (81.28)	79.56 (54.64)	62.32 (64.75)	1.200	0.155
Orienting	26.69 (47.6)	24.29 (40.88)	38.62 (50.33)	44.03 (57.8)	0.858	0.279
Conflict	58.02 (47.06)	53.81 (38.28)	56.18 (47.35)	56.50 (38,28)	0.111	0.122
Error rate	0.041 (0.036)	0.039 (0.049)	0.066 (0.058)	0.052 (0.042)	**4.832**	1.787

Note. Performance data controlling by omission and comission values. F values in bold indicate significance at $p < 0.05$ level.
M= mean; SD= standard deviation; TD= typically development; ADHD= Attention Deficit Hyperactivity Disorder

Discussion

The results across both ADHD and control groups revealed no significant main effects of music in attention networks as indexed by the ANT neither than a significant interaction between music and group. However, a significant main effect was found in the overall number of errors during ANT performance, suggesting listening to music decreases the error rate.

This study hypothesized that listening to music during the test may improve attention performance while increasing the arousal state. However, our findings did not fully support this hypothesis. We found listening to music can improve the accuracy of the performance by decreasing the number of errors and this may have happened for other reasons that are not necessarily related to attentional networks. The deficits in the attentional networks of children with ADHD assessed through the ANT are still controversial and there are previous studies that also did not find differences in the efficiency of their networks when compared to non-ADHD (Johnson et al., 2008; Adólfsdóttir et al., 2008). Also, higher alertness seems to be associated with increased error rates (de Souza Almeida et al., 2021; Adólfsdóttir et al., 2008; Fabio & Urso, 2014), so the music effect made the alertness level an optimal condition to not affect the accuracy of this study or its generated weak effect sizes to detect differences.

The effects of music on cognitive performance are affected by motivation especially if it's a favorite song (Hallam et al., 2002). In this study, most of the participants reported positive feelings (i.e like the song, feelings of happiness) about the pieces of music used and they preferred to perform the ANT listening to music. This may have increased the motivation to complete the task, consequently contributing to making fewer mistakes while listening to music, but this is only speculative. In the case of ADHD, they

may have lower levels of motivation and self-regulation problems, which lead to the devaluing of rewards that are not immediate in comparison to those typically developing (Ilieva & Farah, 2019; Smith & Langberg, 2018). Although we did not find a significant difference between the groups, our results suggested a tendency for the effect of music to be more significant in the group with ADHD, which corroborates studies on the role of motivation in achieving school tasks (Morsink et al., 2021; Skalski et al., 2020; Smith et al., 2020). Children with ADHD when motivated are more likely to try harder when faced with difficulties or not to give up when something is difficult to finish or is not in their interests (Ventouri, 2020). So, it is important to understand that strategies that motivate these children can directly affect the performance of a task and this does not necessarily have to be through an attentional route.

Also, previous studies demonstrated that when the music had lyrics it might impair performance attention (Shih et al., 2012; Shih et al., 2016), which can be another important factor that contributed to the reduction of errors during the performance of the task in our study. Still, our musical stimulus was composing of songs that could have create an atmosphere to captivate the player even three songs are part of games that are in the routine of these children. This may have generated the feeling of reward and motivated the children more during the test.

Since was developed, the ANT has been widely used by the scientific community in diverse cultures and investigations (i.e anxiety, ADHD, bilingualism, borderline personality disorder, deafness, mindfulness training, schizophrenia, time of day) (de Souza Almeida et al., 2021; Vázquez-Marrufo et al., 2019; Arora et al., 2020) and the variant for the child (Rueda et al., 2004) is the gold standard in this population, being

more engaging and visually stimulating. Thus, it was the best tool to assess the effect of music on performance attention.

Limitations

The current study has some limitations. First, the results are only generalizable to the specific music employed in this study and potentially to other music in the same genre and with a specific visual task in a laboratory setting. It would be necessary to carry out the same study with the same type of music while performing school tasks or in the classroom. Second, the sample of children with ADHD was recruited from only one clinical care setting and this may have generated biases. With the covid 19 pandemic in 2020, many families did not feel comfortable participating in the study when recruited.

Conclusion

Our findings are preliminary, but music seems not to interfere on attentional network. However, they show listening to music may reduce the number of errors during a directed attention task such as ANT. Can the same result be found while performing an academic task? Can listening to music be a way to motivate the child and consequently improve their engagement in the task to improve its accuracy? More studies are needed to help us answer these questions.

Finally, the results of this research point to the importance of exploring alternative and even complementary treatments for ADHD who use music, given that music itself has a motivating potential and is accessible in people's daily lives.

Context of Research

This research was conducted as part of the first author's Ph.D. research project. The same author recently published a review of the literature on the effect of music on the attention of children and adolescents (Mendes et al., 2021), which already pointed to gaps in this and to the need for new studies that could be replicated in the future. Also, this review showed that there was still more to be understood about music, specifically that it would be important to study the effect of music on attentional networks. Therefore, for children with ADHD, the current study was important as it reinforced the importance of using non-malefic strategies, such as music, to assist in engaging in attention tasks.

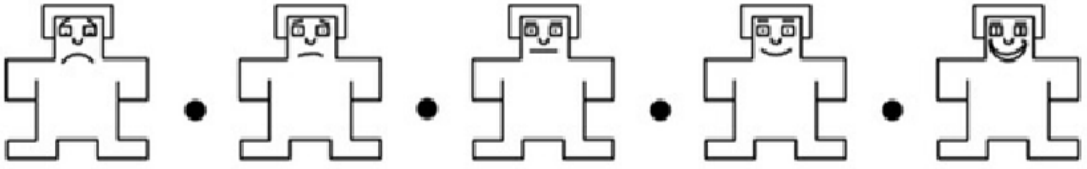
Moving forward we plan to increase the sample size of our study to enable more conclusive results and replicates our experiment with academic tasks. Further studies are necessary to increase knowledge about the effect of music on the motivation of children with low motivation and interest in attention tasks. This can be of great value not only to family members of children who have problems engaging in schoolwork at home, but as well as healthcare professionals attending children with neurodevelopment disorders.

Supplemental Material A. Assessment of Emotional State

1. Do you this song?

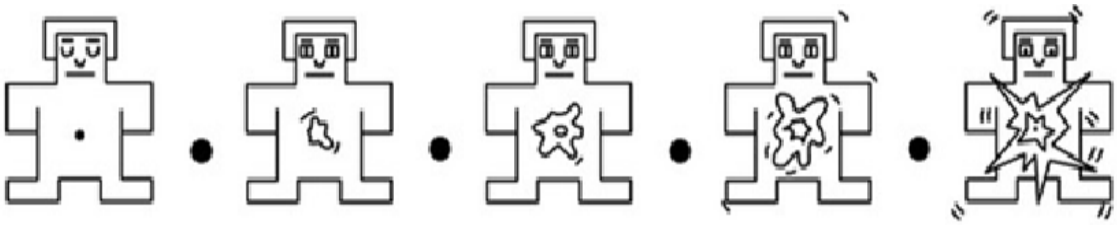
☐ Yes ☐ Maybe ☐ No

2. How do you feel when you listen this song?



1 2 3 4 5

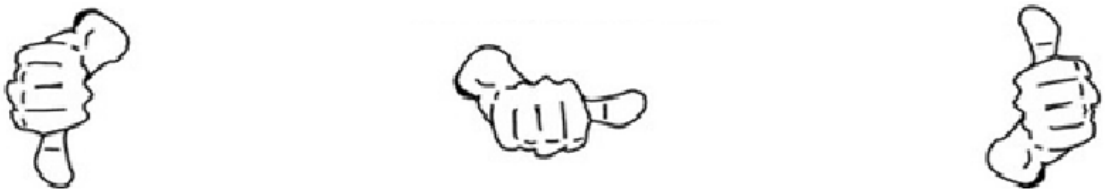
Valence



1 2 3 4 5

Arousal

3. Do you like this song?



No Neutral Yes

Supplemental Material B. Frequency (percentage) of answers of questionnaire to assess the emotional relationship between listener-songs

		F	(%)
Do you know this song?			
	Yes	41	53
	Maybe	14	18
	No	21	5
Do you like this song?	Don't like	4	5
	Neutral	25	33
	Like	47	62
How do you feel listening this song?[a]			
Valence	Very Sad/Sad	1	1.3
	Neutral	15	9
	Happy/very happy	60	78
Arousal	Non arousal/Low	5	6.5
	Neutral	17	22
	Arousal/very arousal	54	71.5

[a]*Note.* We grouped the likert scale rate into 3 categories, 1 and 2 points, 3 points, and 4 and 5 points, for arousal and valence.

Supplement Material C. Frequency (percentage) of answers of preview musical Experience Questionnaire

		F	(%)
Have you ever taken a music class?			
	Yes	44	57
	No	32	43
How often do you listen to music at home?			
	Always	24	31
	Sometimes	43	56
	Almost never	9	13
How often do you listen to music while study?			
	Always	5	8
	Sometimes	18	23
	Almost never	53	69
What type of music do you listen to the most? *			
	Funk	19	25
	Pop (international)	13	17
	Pop (brazilian music)	4	5.2
	Hip-hop	9	12
	Sertanejo	7	9.2
	Eletronic music	18	23.6
	Gospel music	3	4
	Others (gender not identificated, i.e rap of anime, soundtracks of games)	3	4

[a]*Note.* We indicate only the genres mentioned by children. In case of more than one gender mentioned by child, we took their first option reported.

References

Abikoff, H., Courtney, M. E., Szeibel, P. J., & Koplewicz, H. S. (1996). Abikoff 1996. *Journal of Learning Disabilities*, *29*(3), 238–246.

Achenbach, T. M., & Ruffle, T. M. (2000). The child behavior checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review*, *21*(8), 265–271. https://doi.org/10.1542/pir.21-8-265

Adólfsdóttir, S., Sørensen, L., & Lundervold, A. J. (2008). The attention network test: A characteristic pattern of deficits in children with ADHD. *Behavioral and Brain Functions*, *4*, 1–9. https://doi.org/10.1186/1744-9081-4-9

Amaravathi, T., Murugan, M., Subramanian, A., & Geetha, A. P. S. (2019). Attention deficit hyperactivity disorder. *Trends in Biosciences*, 214–221. https://doi.org/10.4324/9780203754818-11

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)* (5th ed).

Antshel, K. M., & Barkley, R. (2020). Attention deficit hyperactivity disorder. In *Handbook of Clinical Neurology* (1º ed, Vol. 174). Elsevier B.V. https://doi.org/10.1016/B978-0-444-64148-9.00003-X

Associação Brasileira de Empresas de Pesquisa (ABEP). ([s.d.]). *Dados com Base no Levantamento Sócio Econômico – IBOPE.* 2015. http://www.abep.org/new/criterioBrasil.aspx

Barkley, R. A. (1997). Behavioral Inhibition, Sustained Attention, and Executive Functions: Constructing a Unifying Theory of ADHD. In *Psychological Bulletin* (Vol. 121, Número 1). Routledge. https://doi.org/10.1037/0033-2909.121.1.65

Berger, A., & Posner, M. I. (2000). Pathologies of brain attentional networks. *Neuroscience and Biobehavioral Reviews*, *24*(1), 3–5. https://doi.org/10.1016/S0149-7634(99)00046-9

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., Wilens, T. E., Frazier, E., & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of Psychiatry*, *159*(1), 36–42. https://doi.org/10.1176/appi.ajp.159.1.36

Bordin IAS, Rocha MM, Paula CS, Teixeira MCTV, Achenbach TM, Rescola LA, S. E., Bordin, I. A., Rocha, M. M., Paula, C. S., Teixeira, M. C. T. V., Achenbach, T. M., Rescorla, L. A., & Silvares, E. F. M. (2013). Child Behavior Checklist (CBCL), Youth Self- Report (YSR) and Teacher's Report Form (TRF): an overview of the development of the original and Brazilian versions. *Cadernos de Saúde Pública*, *29*(1), 13–28. http://www.ncbi.nlm.nih.gov/pubmed/23370021%0Ahttp://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2013000500004&lng=pt&nrm=iso&tlng=en

Bradley, M., & Lang, P. J. (1994). Self-Assessment Manikin (SAM). *J.Behav.Ther. & Exp. Psychiat.*, *25*(1), 49–59.

Brown, T. E. (2008). ADD/ADHD and impaired executive function in clinical practice. *Current Psychiatry Reports*, *10*(5), 407–411. https://doi.org/10.1007/s11920-008-

0065-7

Christiansen, H., Hirsch, O., Albrecht, B., & Chavanon, M. L. (2019). Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span. *Current Psychiatry Reports*, *21*(3), 16–18. https://doi.org/10.1007/s11920-019-1003-6

Conners, B. C. K. (2014). Conners ' Continuous Performance Test II (CPT II V . 5) Profile Report Client Name : Iago Oliveira. *Musician*, 1–15. https://www.pearsonclinical.co.uk/Psychology/ChildMentalHealth/ChildADDADHDBehaviour/ConnersContinuousPerformanceTestIIVersion5forWindows(CPTII V5)/PDFReports/Profile.pdf

Conners, C. K. (2002). *Conners' continuous performance test for Windows*.

Costa, D. S., de Paula, J. J., Malloy-Diniz, L. F., Romano-Silva, M. A., & Miranda, D. M. (2019). Parent SNAP-IV rating of attention-deficit/hyperactivity disorder: accuracy in a clinical sample of ADHD, validity, and reliability in a Brazilian sample. *Jornal de Pediatria*, *95*(6), 736–743. https://doi.org/10.1016/j.jped.2018.06.014

Dalton, B. H., & Behm, D. G. (2007). Effects of noise and music on human and task performance: A systematic review. In *Occupational Ergonomics* (Vol. 7). IOS Press.

de Souza Almeida, R., Faria-Jr, A., & Klein, R. M. (2021). On the origins and evolution of the Attention Network Tests. *Neuroscience and Biobehavioral Reviews*, *126*(September 2020), 560–572. https://doi.org/10.1016/j.neubiorev.2021.02.028

Egermann, & Hauke. (2013). *Can parents influence children ' s music preferences and positively shape their development ? Dr Hauke Egermann*.

Fabio, R. A., & Urso, M. (2014). The analysis of Attention Network in ADHD, attention problems and typically developing subjects. *Life Span and Disability*, *17*(2), 199–221.

Fan, J., McCandliss, B. D., Sommer, T., & Raz, A., Posner, M. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. http://www.sacklerinstitute.org/users/jin.fan/publications/ANT.pdf

Greenop, K., & Kann, L. (2007). Extra-task stimulation on mathematics performance in children with and |PsyssA without ADHD. *South African Journal of Psychology*, *37*(2), 330–344.

Hall, C. L., Guo, B., Valentine, A. Z., Groom, M. J., Daley, D., Sayal, K., & Hollis, C. (2020). The Validity of the SNAP-IV in Children Displaying ADHD Symptoms. *Assessment*, *27*(6), 1258–1271. https://doi.org/10.1177/1073191119842255

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. *Music Perception*, *20*(2), 151–171. https://doi.org/10.1525/mp.2002.20.2.151

Ilieva, I. P., & Farah, M. J. (2019). Attention, Motivation, and Study Habits in Users of Unprescribed ADHD Medication. *Journal of Attention Disorders*, *23*(2), 149–162. https://doi.org/10.1177/1087054715591849

Posner, J., Polanczyk, E. S.-B. (2020). Attention-Deficit Hyperactivity Disorder. *Lancet*, *8*(6), 450–462. https://doi.org/10.1097/00004703-200312000-00013

Johnson, K. A., Robertson, I. H., Barry, E., Mulligan, A., Dáibhis, A., Daly, M., Watchorn, A., Gill, M., & Bellgrove, M. A. (2008). Impaired conflict resolution and alerting in children with ADHD: evidence from the Attention Network Task (ANT). *Journal of child psychology and psychiatry, and allied disciplines*, *49*(12), 1339–1347. https://doi.org/10.1111/j.1469-7610.2008.01936.x

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Markham, W. A., & Spencer, N. (2022). Factors that mediate the relationships between household socio-economic status and childhood Attention Deficit Hyperactivity Disorder (ADHD) in children and adolescents: A systematic review. *PLoS ONE*, *17*(3 March), 1–22. https://doi.org/10.1371/journal.pone.0262988

Martella, D., Aldunate, N., Fuentes, L. J., & Sánchez-Pérez, N. (2020). Arousal and Executive Alterations in Attention Deficit Hyperactivity Disorder (ADHD). *Frontiers in Psychology*, *11*(August), 1–7. https://doi.org/10.3389/fpsyg.2020.01991

Mattos, P., Serra-Pinheiro, M. A., Rohde, L. A., & Pinto, D. (2006). MTA-SNAP-IV em português para uso no Brasil. *Revista de Psiquiatria do Rio grande do Sul*, *28*(3), 290–297.

Mendes, C. G., Diniz, L. A., & Marques Miranda, D. (2021). Does Music Listening Affect Attention? A Literature Review. *Developmental Neuropsychology*, *46*(3), 192–212. https://doi.org/10.1080/87565641.2021.1905816

Morsink, S., Sonuga-Barke, E., Van der Oord, S., Van Dessel, J., Lemiere, J., & Danckaerts, M. (2021). Task-related motivation and academic achievement in children and adolescents with ADHD. *European Child and Adolescent Psychiatry*, *30*(1), 131–141. https://doi.org/10.1007/s00787-020-01494-8

Nigg, J. T. (2005). Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: The state of the field and salient challenges for the coming decade. *Biological Psychiatry*, *57*(11), 1424–1435. https://doi.org/10.1016/j.biopsych.2004.11.011

Pasquali, L., Wechsler, S., & Bensusan, E. (2002). Matrizes progressivas do Raven Infantil: um estudo de validação para o Brasil. *Aval. psicol*, 94–110.

Pelham, W. E., Waschbusch, D. A., Hoza, B., Gnagy, E. M., Greiner, A. R., Sams, S. E., Vallano, G., Majumdar, A., & Carter, R. L. (2011). Music and video as distractors for boys with ADHD in the classroom: Comparison with controls, individual differences, and medication effects. *Journal of Abnormal Child Psychology*, *39*(8), 1085–1098. https://doi.org/10.1007/s10802-011-9529-z

Pereira, C. S., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., & Brattico, E. (2011). Music and Emotions in the Brain: Familiarity Matters. *PLoS ONE*, *6*(11). https://doi.org/10.1371/journal.pone.0027241

Pizzo, R., Urben, S., Van Der Linden, M., Borradori-Tolsa, C., Freschi, M., Forcada-Guex, M., Hüppi, P., & Barisnikov, K. (2010). Attentional networks efficiency in preterm children. *Journal of the International Neuropsychological Society*, *16*(1), 130–137. https://doi.org/10.1017/S1355617709991032

Polanczyk, G. (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry*, *164*(6), 942. https://doi.org/10.1176/appi.ajp.164.6.942

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *International Journal of Epidemiology*, *43*(2), 434–442. https://doi.org/10.1093/ije/dyt261

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(February), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040. https://doi.org/10.1016/j.neuropsychologia.2003.12.012

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*(2), 257–264. https://doi.org/10.1038/nn.2726

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE*, *4*(10). https://doi.org/10.1371/journal.pone.0007487

Schellenberg, E. G., & Hallam, S. (2005). Music listening and cognitive abilities in 10- and 11-year-olds: the blur effect. *Annals of the New York Academy of Sciences*, *1060*, 202–209. https://doi.org/10.1196/annals.1360.013

Sergeant, J. (2004). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive?energetic model. *Biological Psychiatry*. https://doi.org/10.1016/j.bps.2004.09.010

Sergeant, Joseph. (2000). Sergeant.00 Modelo cognitivo energético.pdf. *Neuroscience and Biobehavioral Reviews*, *24*, 7–12.

Siti Norazah, S., Abdullah, N., Salleh, N., Renuka, J., Azlina, M., Abd Rahman, H., & Nor Azila, N. (2017). The Effects of Music on Cognitive Performance in Attention Deficit Hyperactive Disorder (ADHD) Children: A Systematic Review. *Asian Journal of Multidisciplinary Studies*, *5*(9), 11–17. http://www.adhd-federation.org/fileadmin/user_upload/Abstract_Review/2017/10_Oktober/Treatment/The_Effects_of_Music_on_Cognitive_Performance_in_ADHD_Children_-_A_Systematic_Review.pdf

Skalski, S., Pochwatko, G., & Balas, R. (2020). Impact of Motivation on Selected Aspects of Attention in Children with ADHD. *Child Psychiatry and Human Development*, *52*(4), 586–595. https://doi.org/10.1007/s10578-020-01042-0

Smith, Z. R., & Langberg, J. M. (2018). Review of the Evidence for Motivation Deficits in Youth with ADHD and Their Association with Functional Outcomes. *Clinical Child and Family Psychology Review*, *21*(4), 500–526. https://doi.org/10.1007/s10567-018-0268-3

Smith, Z. R., Langberg, J. M., Cusick, C. N., Green, C. D., & Becker, S. P. (2020). Academic Motivation Deficits in Adolescents with ADHD and Associations with Academic Functioning. *Journal of Abnormal Child Psychology*, *48*(2), 237–249. https://doi.org/10.1007/s10802-019-00601-x

Söderlund, G., Sikström, S., & Smart, A. (2007). Listen to the noise: Noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(8), 840–847. https://doi.org/10.1111/j.1469-7610.2007.01749.x

Wan, J., & Taatgen, N. (2018). The Influence of Music and Music Familiarity on Time Perception. *CogSci 2018*, 2657–2662.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/ hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Zajenkowski, M., Goryńska, E., & Winiewski, M. (2012). Variability of the relationship between personality and mood. *Personality and Individual Differences*, *52*(7), 858–861. https://doi.org/10.1016/j.paid.2012.01.007

6 DISCUSSÃO

Este estudo investigou o efeito do estímulo musical na atenção de crianças e adolescentes com TDAH e com desenvolvimento típico. Para tal foi realizada inicialmente uma revisão na literatura em relação ao tema, que apontou as primeiras lacunas que foram fundamentais para a elaboração do protocolo de estudo e consequentemente o nosso experimento. Já se sabia que estudos sobre os efeitos da música eram diversos e alguns benefícios já conhecidos pelo senso comum e pela comunidade científica. Sendo a música algo tão corriqueiro no nosso dia a dia e havendo tanto interesse em seus benefícios e possibilidades também na área da saúde, era preciso ter uma pergunta mais direta e simples, para partirmos de algum lugar, tamanha a heterogeneidade metodológica dos estudos prévios e a presença de resultados inconclusivos. Além disso, não existem dúvidas que a música por si só tem um potencial motivador e de ativar áreas cerebrais relacionadas ao nosso sistema de recompensa, o que justifica sua influência nas nossas emoções. Então, qual seria o efeito de ouvir música durante uma tarefa de atenção?

Esta tese foi apresentada em formato de artigos. O artigo 1 trouxe o panorama da literatura atual acerca do efeito da música na atenção, tema que não é novidade, tendo em vista que foram encontrados estudos desde o ano de 2006. Além disso, os resultados sugeriram que a escuta musical durante a realização de uma tarefa de atenção pode melhorar o desempenho dessa tarefa, no caso de música sem letra, conhecida e preferida pelo ouvinte (Mendes et al., 2019). O artigo 2 e 3 buscaram reproduzir a ideia dos experimentos relatados na revisão de literatura, porém com uma população específica: crianças com TDAH, e fazendo o uso do Attention Network Test, um instrumento que tem sido amplamente utilizado pela comunidade científica desde 2002 (de Souza Almeida et al., 2021). Particularmente, o artigo 2 descreveu o protocolo de acordo com o SPIRIT

(Standard Protocol Items: Recommendations for Interventional Trials) (Chan et al., 2013) e foi registrado pelo Registro Brasileiro de Ensaios Clínicos (REBEC).

Nós esperávamos que a música melhoraria o desempenho atencional das crianças com TDAH diferentemente das crianças sem TDAH. Nossos resultados suportaram essa hipótese apenas em parte, uma vez que a escuta musical reduziu o número de erros realizados durante a tarefa de atenção e isso acorreu independente de ter TDAH. De acordo com Sergeant (2000), o uso de estímulos externos para melhorar seu desempenho, poderia ser explicado pelo Modelo Cognitivo-Energético que sugere que levaria ao aumento do estado de alerta dessas crianças, mas isso não foi testado no nosso estudo. Por outro lado, a saliência motivacional da tarefa é um aspecto importante para alocação de esforço extra necessário para a sustentação da atenção, e isso pode ter aumentado a motivação das crianças durante a realização do ANT, levando a um menor número de erros cometidos.

7 CONSIDERAÇÕES FINAIS

Durante toda minha trajetória no Ambulatório Borges da Costa, no desenvolvimento do meu Trabalho de Conclusão de Curso da graduação, Dissertação de Mestrado e desta Tese de Doutorado, tive a oportunidade de estar em contato direto com pacientes e seus familiares durante o acompanhamento periódico psiquiátrico para o TDAH. Não eram raras as queixas dos pais com relação ao engajamento dos filhos nas tarefas escolares em casa e até mesmo dúvidas sobre hábitos das crianças durante a realização dessas tarefas que para o senso comum seria prejudicial (ex. estudar ouvindo música). Essa realidade trouxe uma motivação ainda maior para a realização desse estudo, para saber se música seria um distrator durante a realização de tarefas escolares ou não.

Nossos resultados mostraram que o estímulo musical, composto por músicas conhecidas e preferidas por seus ouvintes, em formato instrumental, reduzem o número de erros durante a realização de uma tarefa atencional. E isso ocorre independente da criança ter TDAH ou não. Ainda não sabemos se o mesmo poderia ser generalizado para outras tarefas ou mesmo diante de outros tipos de música. É preciso ressaltar que esse experimento sofreu algumas interferências devido o acometimento da pandemia em 2020 e, portanto, apresentou limitações quanto ao tamanho da amostra e a possibilidade de um segundo experimento que pudesse testar os mesmos efeitos encontrados durante a realização de uma tarefa escolar.

Espera-se que as perguntas já respondidas pelos resultados preliminares desse estudo e as novas que ainda não são possíveis de responder, possam contribuir para posteriores pesquisas na área, bem como produzir efeitos na prática clínica com crianças com TDAH.

REFERÊNCIAS

Chan, A. W., Tetzlaff, J. M., Altman, D. G., Laupacis, A., Gøtzsche, P. C., Krleža-Jerić, K., Hróbjartsson, A., Mann, H., Dickersin, K., Berlin, J. A., Doré, C. J., Parulekar, W. R., Summerskill, W. S. M., Groves, T., Schulz, K. F., Sox, H. C., Rockhold, F. W., Rennie, D., & Moher, D. (2013). SPIRIT 2013 statement: Defining standard protocol items for clinical trials. *Annals of Internal Medicine*, *158*(3), 200–207. https://doi.org/10.7326/0003-4819-158-3-201302050-00583

Sergeant, J. (2000). Sergeant.00 Modelo cognitivo energético.pdf. *Neuroscience and Biobehavioral Reviews*, *24*, 7–12.

ANEXO I –SWANSON NOLAN AND PELHAM-IV (SNAP IV)

MTA-SNAP-IV – Escala sobre o comportamento da CRIANÇA/ADOLESCENTE

Nome da **criança/adolescente**:_____

Data de Nascimento:_____/_____/_____ Idade: _____ Ano/Série:_____/_____ Sala:_____

Nome do Informante:_____ ☐ Responsável ☐ Professor(a)

Contato do informante (telefone e/ou e-mail):_____ Data de hoje:_____/_____/_____

*Por favor, responda as questões abaixo referentes à **criança/adolescente** participante. Se ele/ela iniciou alguma medicação para controle de sintomas cognitivos ou de comportamento, é importante que você responda de acordo com o comportamento **anterior** à introdução da medicação. Para cada item, escolha a coluna que **melhor** descreve a criança/adolescente. (MARQUE UM **X**):*	**Nem um pouco**	**Só um pouco**	**Bastante**	**Demais**
1. Não consegue prestar muita atenção a detalhes ou comete erros por descuido nos trabalhos da escola ou tarefas.	0	1	2	3
2. Tem dificuldade de manter a atenção em tarefas ou atividades de lazer.	0	1	2	3
3. Parece não estar ouvindo quando se fala diretamente com ele.	0	1	2	3
4. Não segue instruções até o fim e não termina deveres de escola, tarefas ou obrigações.	0	1	2	3
5. Tem dificuldade para organizar tarefas e atividades.	0	1	2	3
6. Evita, não gosta ou se envolve contra a vontade em tarefas que exigem esforço mental prolongado.	0	1	2	3
7. Perde coisas necessárias para atividades (p.ex.: brinquedos, deveres da escola, lápis ou livros).	0	1	2	3
8. Distrai-se com estímulos externos.	0	1	2	3
9. É esquecido em atividades do dia-a-dia.	0	1	2	3
10. Mexe com as mãos ou os pés ou se remexe na cadeira.	0	1	2	3
11. Sai do lugar na sala de aula ou em outras situações em que se espera que fique sentado.	0	1	2	3
12. Corre de um lado para outro ou sobe demais nas coisas em situações em que isto é inapropriado.	0	1	2	3
13. Tem dificuldade em brincar ou envolver-se em atividades de lazer de forma calma.	0	1	2	3
14. Não pára ou freqüentemente está a "mil por hora".	0	1	2	3
15. Fala em excesso.	0	1	2	3
16. Responde as perguntas de forma precipitada antes delas terem sido terminadas.	0	1	2	3
17. Tem dificuldade de esperar sua vez.	0	1	2	3
18. Interrompe os outros ou se intromete (por exemplo, mete-se nas conversas/jogos).	0	1	2	3
19. Descontrola-se.	0	1	2	3
20. Discute com adultos.	0	1	2	3
21. Desafia ativamente ou se recusa a atender pedidos ou regras de adultos.	0	1	2	3
22. Faz coisas de propósito que incomodam outras pessoas.	0	1	2	3
23. Culpa os outros pelos seus erros ou mau comportamento.	0	1	2	3
24. É irritável ou facilmente incomodado pelos outros.	0	1	2	3
25. É zangado e ressentido.	0	1	2	3
26. É maldoso ou vingativo.	0	1	2	3

ANEXO II - PARECER CONSUBSTANCIADO DO COMITÊ DE ÉTICA

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Efeitos da música na atenção de crianças e adolescentes com e sem Transtorno do Déficit de Atenção com Hiperatividade (TDAH)

Pesquisador: Débora Marques de Miranda

Área Temática:

Versão: 3

CAAE: 97425218.4.0000.5149

Instituição Proponente: UNIVERSIDADE FEDERAL DE MINAS GERAIS

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.340.365

Apresentação do Projeto:

Busca-se investigar os efeitos entre estímulos musicais através de fone de ouvido (com diferentes perfis de organização sonora e de laço afetivo do participante com determinado repertório) e concentração/dissipação de crianças, especialmente com Transtorno do Déficit de Atenção com Hiperatividade (TDAH), durante a realização de um exame de português e ou matemática de aproximadamente 1h15min, em computador. Serão abordadas aproximadamente 30 crianças e adolescentes com idade entre 8 e 12 anos, apresentando ou não diagnóstico de TDAH. Será avaliado o desempenho desse público em uma tarefa de atenção (Attention Network Test – ANT) em três condições experimentais: com música familiar, com música não familiar e sem música.

Objetivo da Pesquisa:

Avaliar os efeitos da música na atenção de crianças com e sem TDAH.

Avaliar a diferença dos efeitos da música na atenção de crianças com e sem TDAH.

Avaliação dos Riscos e Benefícios:

A tarefa proposta pode ser cansativa para as crianças, principalmente aquelas apresentando TDAH. Elas podem se sentir frustradas se não conseguirem realizar completamente a tarefa proposta,com duração estimada de 1h30min.

Caso a pesquisa comprove mudança de desempenho das crianças de acordo com estímulos

Endereço: Av. Presidente Antônio Carlos,6627 2º Ad SI 2005
Bairro: Unidade Administrativa II **CEP:** 31.270-901
UF: MG **Município:** BELO HORIZONTE
Telefone: (31)3409-4592 **E-mail:** coep@prpq.ufmg.br

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Plataforma Brasil

musicais, pode haver beneficios diretos para as familias. Independentemente disto, o estudo traz beneficios indiretos, ligados a um maior conhecimento das relacoes (ou ausencia de relacoes) entre estimulo musical e mudanca no perfil de concentracao.

Comentários e Considerações sobre a Pesquisa:

A pesquisa nos parece equilibrada de um ponto de vista etico.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados

- folha de rosto
- parecer aprovado por camara departamental - informacoes basicas do projeto - protocolo de pesquisa
- TCLE e TALE
- carta resposta às solicitações de parecer da CONEP
- informações básicas do projeto

Conclusões ou Pendências e Lista de Inadequações:

Todas as solicitações levantadas em pareceres anteriores (primeiramente do CEP e em seguida da CONEP) foram satisfatoriamente implementadas. S.M.J., somos favoráveis à aprovação do projeto.

Considerações Finais a critério do CEP:

Tendo em vista a legislação vigente (Resolução CNS 466/12), o CEP-UFMG recomenda aos Pesquisadores: comunicar toda e qualquer alteração do projeto e do termo de consentimento via emenda na Plataforma Brasil, informar imediatamente qualquer evento adverso ocorrido durante o desenvolvimento da pesquisa (via documental encaminhada em papel), apresentar na forma de notificação relatórios parciais do andamento do mesmo a cada 06 (seis) meses e ao término da pesquisa encaminhar a este Comitê um sumário dos resultados do projeto (relatório final).

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BASICAS_DO_PROJETO_988800.pdf	11/05/2019 15:55:07		Aceito
Parecer Anterior	PB_PARECER_CONSUBSTANCIADO_CONEP_3274020.pdf	11/05/2019 15:49:21	CAMILA GUIMARAES MENDES	Aceito
Outros	Carta_resposta_2.docx	11/05/2019	CAMILA	Aceito

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Continuação do Parecer: 3.340.365

Outros	Carta_resposta_2.docx	15:42:10	GUIMARAES MENDES	Aceito
Projeto Detalhado / Brochura Investigador	Protocolo_de_Pesquisa_Plataforma_Brasil_2.doc	11/05/2019 15:40:49	CAMILA GUIMARAES MENDES	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_para_pais_e_responsaveis.docx	11/05/2019 15:40:32	CAMILA GUIMARAES MENDES	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TALE_menor.docx	11/05/2019 15:40:12	CAMILA GUIMARAES MENDES	Aceito
Folha de Rosto	folha_rostocamila.pdf	28/08/2018 17:18:51	Débora Marques de Miranda	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BELO HORIZONTE, 22 de Maio de 2019

Assinado por:
Eliane Cristina de Freitas Rocha
(Coordenador(a))

Endereço: Av. Presidente Antônio Carlos,6627 2º Ad SI 2005
Bairro: Unidade Administrativa II **CEP:** 31.270-901
UF: MG **Município:** BELO HORIZONTE
Telefone: (31)3409-4592 **E-mail:** coep@prpq.ufmg.br

ANEXO III – CRITÉRIO DE CLASSIFICAÇÃO ECONÔMICA BRASIL (CCEB)

CRITÉRIO DE CLASSIFICAÇÃO ECONÔMICA BRASIL

ABEP associação brasileira de empresas de pesquisa

Alterações na aplicação do Critério Brasil, válidas a partir de 01/09/2020

A metodologia de desenvolvimento do Critério Brasil que entrou em vigor no início de 2015 está descrita no livro *Estratificação Socioeconômica e Consumo no Brasil* dos professores Wagner Kamakura (Rice University) e José Afonso Mazzon (FEA /USP), baseado na Pesquisa de Orçamento Familiar (POF) do IBGE.

A regra operacional para classificação de domicílios, descrita a seguir, resulta da adaptação da metodologia apresentada no livro às condições operacionais da pesquisa de mercado no Brasil.

As organizações que utilizam o Critério Brasil podem relatar suas experiências ao Comitê do CCEB. Essas experiências serão valiosas para que o Critério Brasil seja permanentemente aprimorado.

A transformação operada atualmente no Critério Brasil foi possível graças a generosa contribuição e intensa participação dos seguintes profissionais nas atividades do comitê:

Luis Pilli (Coordenador) - LARC Pesquisa de Marketing
Bianca Ambrósio - Kantar
Bruna Suzzara – IBOPE Inteligência
Luciano Pontes – Kantar IBOPE Media
Margareth Reis – GFK
Paula Yamakawa – IBOPE Inteligência
Renata Nunes - Data Folha
Sidney Fernandes - Kantar IBOPE Media

A ABEP, em nome de seus associados, registra o reconhecimento e agradece o envolvimento desses profissionais.

SISTEMA DE PONTOS

Variáveis

	Quantidade				
	0	1	2	3	4 ou +
Banheiros	0	3	7	10	14
Empregados domésticos	0	3	7	10	13
Automóveis	0	3	5	8	11
Microcomputador	0	3	6	8	11
Lava louca	0	3	6	6	6
Geladeira	0	2	3	5	5
Freezer	0	2	4	6	6
Lava roupa	0	2	4	6	6
DVD	0	1	3	4	6
Micro-ondas	0	2	4	4	4
Motocicleta	0	1	3	3	3
Secadora roupa	0	2	2	2	2

Grau de instrução do chefe de família e acesso a serviços públicos

Grau de instrução do chefe da família	
Analfabeto / Fundamental I incompleto	0
Fundamental I completo / Fundamental II incompleto	1
Fundamental II completo / Médio incompleto	2
Médio completo / Superior incompleto	4
Superior completo	7

Serviços públicos		
	Não	Sim
Água encanada	0	4
Rua pavimentada	0	2

Distribuição das classes

As estimativas do tamanho dos estratos atualizados referem-se ao total Brasil e resultados das macrorregiões, além do total das 9 Regiões Metropolitanas e resultados para cada uma das RM's (Porto Alegre, Curitiba, São Paulo, Rio de Janeiro, Belo Horizonte, Brasília, Salvador, Recife e Fortaleza).

As estimativas para o total do Brasil e macrorregiões são baseadas em estudos probabilísticos nacionais do Datafolha e IBOPE Inteligência. E as estimativas para as 9 Regiões Metropolitanas se baseiam em dados de estudos probabilísticos do Kantar IBOPE Media (base 2019).

Classe	Brasil	Sudeste	Sul	Nordeste	Centro Oeste	Norte
1 – A	2,5%	3,1%	2,9%	1,4%	4,0%	1,1%
2 - B1	4,9%	6,2%	5,9%	2,6%	6,0%	2,3%
3 - B2	16,4%	20,3%	20,5%	9,1%	18,9%	9,3%
4 - C1	21,1%	24,3%	26,4%	14,5%	21,9%	14,9%
5 - C2	26,4%	27,0%	26,2%	25,7%	26,7%	26,1%
6 - D - E	28,7%	19,1%	18,1%	46,7%	22,5%	46,3%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Classe	9 RM'S	POA	CWB	SP	RJ	BH	BSB	SSA	REC	FOR
1 – A	4,8%	5,6%	6,0%	5,2%	2,5%	6,2%	13,0%	3,5%	3,4%	3,8%
2 - B1	6,7%	6,7%	10,2%	7,6%	5,2%	7,9%	10,5%	4,3%	4,3%	3,9%
3 - B2	19,8%	20,7%	24,5%	22,7%	18,1%	20,2%	26,0%	16,7%	11,1%	11,5%
4 - C1	22,0%	22,7%	27,0%	24,4%	21,5%	22,6%	20,5%	18,7%	15,9%	14,4%
5 - C2	27,0%	29,2%	22,4%	27,5%	29,0%	25,8%	18,2%	28,3%	26,4%	26,6%
6 – D-E	19,7%	15,1%	9,9%	12,6%	23,7%	17,3%	11,8%	28,5%	38,9%	39,8%
total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Cortes do Critério Brasil

Classe	Pontos
1 – A	45 - 100
2 - B1	38 - 44
3 - B2	29 - 37
4 - C1	23 - 28
5 - C2	17 - 22
6- D – E	0 - 16

Estimativa para a Renda Média Domiciliar para os estratos do Critério Brasil

Abaixo são apresentadas as estimativas de renda domiciliar mensal para os estratos socioeconômicos. Os valores se baseiam na **PNADC 2019** e representam aproximações dos valores que podem ser obtidos em amostras de pesquisas de mercado, mídia e opinião. A experiência mostra que a variância observada para as respostas à pergunta de renda é elevada, com sobreposições importantes nas rendas entre as classes. Isso significa que a pergunta de renda não é um estimador eficiente de nível socioeconômico e não substitui ou complementa o questionário sugerido abaixo. O objetivo da divulgação dessas informações é oferecer uma ideia de característica dos estratos socioeconômicos resultantes da aplicação do Critério Brasil.

Estrato Sócio Econômico	Renda média domiciliar
A	22.716,99
B1	10.427,74
B2	5.449,60
C1	3.042,47
C2	1.805,91
DE	813,56
TOTAL	**3.153,40**

PROCEDIMENTO NA COLETA DOS ITENS

É importante e necessário que o critério seja aplicado de forma uniforme e precisa. Para tanto, é fundamental atender integralmente as definições e procedimentos citados a seguir.

Para aparelhos domésticos em geral:

Devem ser considerados todos os bens que estão dentro do domicílio em funcionamento (incluindo os que estão guardados) independente da forma de aquisição: compra, empréstimo, aluguel, etc. Se o domicílio possui um bem que emprestou a outro, este não deve ser contado pois não está em seu domicílio atualmente. Caso não estejam funcionando, considere apenas se tiver intenção de consertar ou repor nos próximos seis meses.

Banheiro

O que define o banheiro é a existência de vaso sanitário. Considerar todos os banheiros e lavabos com vaso sanitário, incluindo os de empregada, os localizados fora de casa e os da(s) suíte(s). Para ser considerado, o banheiro tem que ser privativo do domicílio. Banheiros coletivos (que servem a mais de uma habitação) não devem ser considerados.

Empregados Domésticos

Considerar apenas os empregados mensalistas, isto é, aqueles que trabalham pelo menos cinco dias por semana, durmam ou não no emprego. Não esqueça de incluir babás, motoristas, cozinheiras, copeiras, arrumadeiras, considerando sempre os mensalistas.

Note bem: o termo empregado mensalista se refere aos empregados que trabalham no domicílio de forma permanente e/ou contínua, pelo menos cinco dias por semana, e não ao regime de pagamento do salário.

Automóvel

Não considerar táxis, vans ou pick-ups usados para fretes, ou qualquer veículo usado para atividades profissionais. Veículos de uso misto (pessoal e profissional) não devem ser considerados.

Microcomputador

Considerar os computadores de mesa, laptops, notebooks e netbooks. **Não considerar**: calculadoras, agendas eletrônicas, tablets, palms, smartphones e outros aparelhos.

Lava-Louça

Considere a máquina com função de lavar as louças.

Geladeira e Freezer

No quadro de pontuação há duas linhas independentes para assinalar a posse de geladeira e freezer respectivamente. A pontuação será aplicada de forma independente:

Havendo uma geladeira no domicílio, serão atribuídos os pontos (2) correspondentes a posse de geladeira;
Se a geladeira tiver um freezer incorporado – 2ª porta – ou houver no domicílio um freezer independente serão atribuídos os pontos (2) correspondentes ao freezer. Dessa forma, esse domicílio totaliza 4 pontos na soma desses dois bens.

Lava-Roupa

Considerar máquina de lavar roupa, somente as máquinas automáticas e/ou semiautomática. O tanquinho NÃO deve ser considerado.

DVD

Considere como leitor de DVD (Disco Digital de Vídeo ou Disco Digital Versátil) o acessório doméstico capaz de reproduzir mídias no formato DVD ou outros formatos mais modernos, incluindo videogames, computadores, notebooks. Inclua os aparelhos portáteis e os acoplados em microcomputadores.
Não considere DVD de automóvel.

Micro-ondas

Considerar forno micro-ondas e aparelho com dupla função (de micro-ondas e forno elétrico).

Motocicleta

Não considerar motocicletas usadas exclusivamente para atividades profissionais. Motocicletas apenas para uso pessoal e de uso misto (pessoal e profissional) devem ser consideradas.

Secadora de roupas

Considerar a máquina de secar roupa. Existem máquinas que fazem duas funções, lavar e secar. Nesses casos, devemos considerar esse equipamento como uma máquina de lavar e como uma secadora.

Modelo de Questionário sugerido para aplicação

P.XX Agora vou fazer algumas perguntas sobre itens do domicílio para efeito de classificação econômica. Todos os itens de eletroeletrônicos que vou citar devem estar funcionando, incluindo os que estão guardados. Caso não estejam funcionando, considere apenas se tiver intenção de consertar ou repor nos próximos seis meses.

INSTRUÇÃO: Todos os itens devem ser perguntados pelo entrevistador e respondidos pelo entrevistado.
Vamos começar? No domicílio tem_____ (LEIA CADA ITEM)

		QUANTIDADE QUE POSSUI			
ITENS DE CONFORTO	NÃO POSSUI	1	2	3	4+
Quantidade de automóveis de passeio exclusivamente para uso particular					
Quantidade de empregados mensalistas, considerando apenas os que trabalham pelo menos cinco dias por semana					
Quantidade de máquinas de lavar roupa, excluindo tanquinho					
Quantidade de banheiros					
DVD, incluindo qualquer dispositivo que leia DVD e desconsiderando DVD de automóvel					
Quantidade de geladeiras					
Quantidade de *freezers* independentes ou parte da geladeira duplex					
Quantidade de microcomputadores, considerando computadores de mesa, laptops, notebooks e netbooks e desconsiderando tablets, palms ou smartphones					
Quantidade de lavadora de louças					
Quantidade de fornos de micro-ondas					
Quantidade de motocicletas, desconsiderando as usadas exclusivamente para uso profissional					
Quantidade de máquinas secadoras de roupas, considerando lava e seca					

A água utilizada neste domicílio é proveniente de?	
1	Rede geral de distribuição
2	Poço ou nascente
3	Outro meio

Considerando o trecho da rua do seu domicílio, você diria que a rua é:	
1	Asfaltada/Pavimentada
2	Terra/Cascalho

Qual é o grau de instrução do chefe da família? Considere como chefe da família a pessoa que contribui com a maior parte da renda do domicílio.

Nomenclatura atual	Nomenclatura anterior
Analfabeto / Fundamental I incompleto	Analfabeto/Primário Incompleto
Fundamental I completo / Fundamental II incompleto	Primário Completo/Ginásio Incompleto
Fundamental completo/Médio Incompleto	Ginásio Completo/Colegial Incompleto
Médio completo/Superior Incompleto	Colegial Completo/Superior Incompleto
Superior completo	Superior Completo

OBSERVAÇÕES IMPORTANTES

Este critério foi construído para definir grandes classes que atendam às necessidades de segmentação (por poder aquisitivo) da grande maioria das empresas. Não pode, entretanto, como qualquer outro critério, satisfazer todos os usuários em todas as circunstâncias. Certamente há muitos casos em que o universo a ser pesquisado é de pessoas, digamos, com renda pessoal mensal acima de R$ 30.000. Em casos como esse, o pesquisador deve procurar outros critérios de seleção que não o CCEB.

A outra observação é que o CCEB, como os seus antecessores, foi construído com a utilização de técnicas estatísticas que, como se sabe, sempre se baseiam em coletivos. Em uma determinada amostra, de determinado tamanho, temos uma determinada probabilidade de classificação correta, (que, esperamos, seja alta) e uma probabilidade de erro de classificação (que, esperamos, seja baixa).

Nenhum critério estatístico, entretanto, tem validade sob uma análise individual. Afirmações frequentes do tipo *"... conheço um sujeito que é obviamente classe D, mas pelo critério é classe B..."* não invalidam o critério que é feito para funcionar estatisticamente. Servem, porém, para nos alertar, quando trabalhamos na análise individual, ou quase individual, de comportamentos e atitudes (entrevistas em profundidade e discussões em grupo respectivamente). Numa discussão em grupo um único caso de má classificação pode pôr a perder todo o grupo. No caso de entrevista em profundidade os prejuízos são ainda mais óbvios. Além disso, numa pesquisa qualitativa, raramente uma definição de classe exclusivamente econômica será satisfatória.

Portanto, é de fundamental importância que todo o mercado tenha ciência de que o CCEB, ou qualquer outro critério econômico, não é suficiente para uma boa classificação em pesquisas qualitativas. Nesses casos deve-se obter além do CCEB, o máximo de informações (possível, viável, razoável) sobre os respondentes, incluindo então seus comportamentos de compra, preferências e interesses, lazer e hobbies e até características de personalidade.

Uma comprovação adicional da adequação do Critério de Classificação Econômica Brasil é sua discriminação efetiva do poder de compra entre as diversas regiões brasileiras, revelando importantes diferenças entre elas.

APÊNDICE A – TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Termo de Consentimento Livre e Esclarecido
(PAIS, MÃES OU RESPONSÁVEIS DE CRIANÇAS DE 10 a 12 ANOS)

Prezados pais, mães ou responsáveis, vocês estão sendo convidados a participar deste estudo. O nosso objetivo é avaliar se o desempenho em uma tarefa de atenção de suas crianças pode ser influenciado a depender da escuta ou não de músicas em fone de ouvido simultaneamente. Este estudo será desenvolvido pelo Programa de Pós Graduação em Saúde da Criança e do Adolescente, da Escola de Medicina da Universidade Federal de Minas Gerais (UFMG).

Para realizar essa pesquisa nós precisamos que vocês dêem o seu consentimento, permitindo a sua participação e a de seu filho na pesquisa. Após a obtenção do consentimento, vocês deverão responder a algumas perguntas sobre a sua criança, para caracterização de sintomas de Transtorno do Déficit de Atenção com Hiperatividade (TDAH) e sintomas associados (Child Behavior Checklist 6-18 e o Swanson Nolandand Pelham-IV). Também aplicaremos a você um questionário para caracterização da condição socioeconômica da sua família, onde você irá responder sobre os itens que possui em sua casa. O tempo estimado para a realização da entrevista é de 1h e 15 minutos. Vocês podem se sentir cansados ou desconfortáveis com algumas perguntas sobre suas crianças. Se, por quaisquer motivos, vocês não desejarem responder a uma pergunta, será respeitada essa vontade e interromperemos a pesquisa, sem nenhum constrangimento ou ônus para vocês. Para garantir o sigilo das suas respostas utilizaremos um número para fazer a identificação da criança, ao invés do nome. Ressaltamos que a participação nesta pesquisa é inteiramente voluntária e vocês não receberão nenhum pagamento para participar. Apesar disso, caso sejam identificados e comprovados danos provenientes desta pesquisa, vocês têm assegurado o direito à indenização. Se for necessário deslocamento extra, em função do estudo, será garantido o ressarcimento das despesas do participante da pesquisa e de seu acompanhante com o estudo.

A participação neste estudo nos ajudará a compreender se o uso de estímulos externos, como a escuta de uma música, poderia trazer implicações importantes para intervenção com crianças e adolescentes com TDAH, possibilitando, dessa forma, melhorar indicações terapêuticas e em contexto escolar a eles futuramente. É importante ressaltar que vocês são livres para consentir na participação ou no abandono do estudo a qualquer momento. Vocês poderão obter qualquer informação deste estudo com os pesquisadores e com o Comitê de Ética em pesquisa da UFMG, caso se refiram às questões éticas. Os contatos estão listados abaixo.

Estaremos à disposição para responder perguntas ou prestar esclarecimentos sobre o andamento do trabalho. Caso vocês concordem em participar do estudo, por favor, assinem no espaço indicado abaixo. Agradecemos a colaboração. Atenciosamente,

_____

Profª Débora Marques Miranda, Departamento de Pediatria da UFMG

Consentimento

Eu, _____, responsável por_____ declaro que li e entendi todas as informações sobre o estudo, sendo os objetivos e procedimentos explicados claramente. Tive tempo suficiente para pensar e escolher participar do estudo e tive oportunidade de tirar todas as minhas dúvidas. Estou assinando este termo voluntariamente e tenho direito de, agora ou mais tarde, discutir qualquer dúvida em relação ao projeto.

_____

Assinatura da mãe, pai ou responsável

Belo Horizonte, ____ de _____ de 20___.

Pesquisadores Responsáveis:

Profa. Dra. Débora Marques Miranda, Professora Adjunta, Departamento de Pediatria, Programa de Pós-Graduação em Saúde da Criança e do Adolescente (tel: 3409-4592). Comitê de Ética em Pesquisa da UFMG: Telefax. (31) 3409-4592. Endereço: Av. Presidente Antônio Carlos 6627, Unidade Administrativa II, 2º andar – sala 2005, CEP: 31270-901, BH – MG. e-mail:coep@prpq.ufmg.br. Comissão Nacional de Ética em Pesquisa: Telefone: (61) 3315-5877. Endereço: SRNTV 701, Via W 5 Norte - Edifício PO 700, 3º andar, Asa Norte. CEP: 70.719-049, Brasília – DF. E-mail: conep@saude.gov.br.

APÊNDICE B – TERMO DE ASSENTIMENTO LIVRE DO MENOR

TERMO DE ASSENTIMENTO LIVRE DO MENOR

Prezado participante,

Você está sendo convidado para participar da pesquisa “Efeitos da música na atenção de crianças e adolescentes com e sem Transtorno do Déficit de Atenção com Hiperatividade (TDAH)”.

Se você aceitar participar desta pesquisa você irá realizar algumas atividades na Escola de Medicina da Universidade Federal de Minas Gerais (UFMG), durante dois dias. No primeiro dia nós lhe perguntaremos sobre os tipos de músicas que você gosta e pediremos que você realize uma atividade em um computador, para avaliarmos o quanto você consegue prestar atenção. No segundo dia, você terá outras atividades para fazer, também no computador, e você vai estar usando um fone de ouvido. Você vai realizar a mesma tarefa três vezes, sendo que cada uma das vezes você poderá escutar algo diferente no fone de ouvido.

Se, por quaisquer motivos, você ficar cansado durante as tarefas, daremos a você o tempo de descanso que precisar. Não tem problema algum se você quiser desistir antes ou durante a pesquisa. Você pode não se sentir muito bem durante as atividades, caso encontre alguma dificuldade e pode se sentir cansado ao final. Por isso você poderá ter o tempo que precisa para melhorar ou mesmo decidir se quiser continuar ou não. Há coisas boas que podem acontecer depois desse estudo. A realização desse projeto nos ajudará a entender melhor se ouvir música enquanto realiza uma tarefa pode ser bom para algumas crianças, especialmente crianças com TDAH. Ninguém saberá que você está participando da pesquisa, não falaremos a outras pessoas, nem daremos a estranhos as informações que você nos der. Os resultados da pesquisa deverão ser publicados, mas sem identificar quem participou da pesquisa.

Se você tiver alguma dúvida, você pode nos perguntar ou pode perguntar também para as pesquisadoras Camila Guimarães Mendes (camilagmbh@gmail.com) e Profa. Débora Miranda (debora.m.miranda@gmail.com).

Eu, _____, aceito participar da pesquisa “Efeitos da música na atenção de crianças e adolescentes com e sem Transtorno do Déficit de Atenção com Hiperatividade (TDAH)”, que tem o objetivo de avaliar o meu desempenho em uma tarefa de atenção enquanto escuto ou não, algo em um fone de ouvido. Entendi as coisas ruins e as coisas boas que podem acontecer. Entendi que posso dizer “sim” e participar, mas que, a qualquer momento, posso dizer “não” e desistir que ninguém vai ficar furioso. Os pesquisadores tiraram minhas

dúvidas e conversaram com os meus responsáveis. Recebi uma cópia deste termo, li e concordo em participar.

Este termo encontra-se impresso em duas vias, sendo que uma das vias ficará com você ou o(a) seu(a) responsável e a outra será arquivada.

Belo Horizonte, ____de _____de _____.

_____ _____

Assinatura do menor Assinatura da pesquisadora

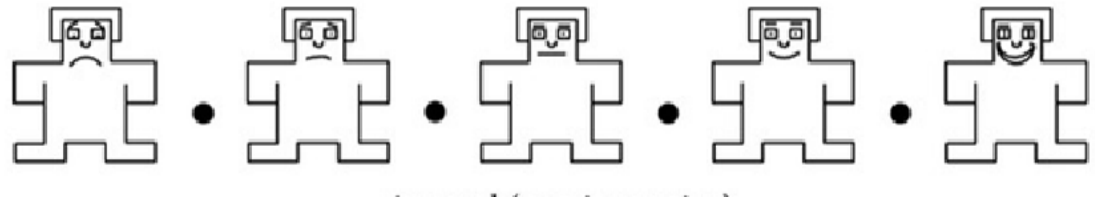
Comitê de Ética em Pesquisa da UFMG: Telefax. (31) 3409- 4592. Endereço: Av. Presidente Antônio Carlos 6627, Unidade Administrativa II, 2o andar – sala 2005, CEP: 31270-901, BH – MG. e-mail:coep@prpq.ufmg.br. Comissão Nacional de Ética em Pesquisa: Telefone: (61) 3315-5877. Endereço: SRNTV 701, Via W 5 Norte - Edifício PO 700, 3º andar, Asa Norte. CEP: 70.719-049, Brasília – DF. E-mail: conep@saude.gov.br.

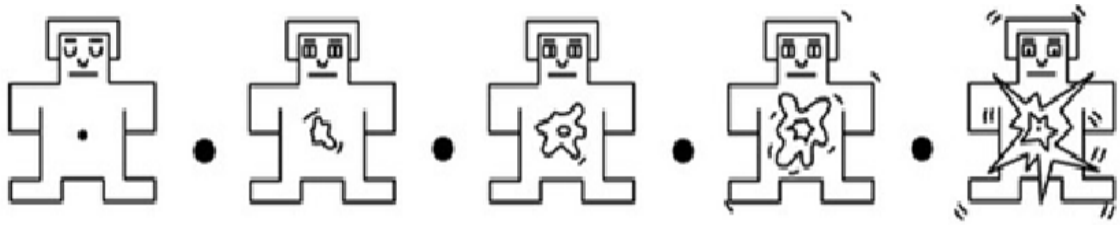
APÊNDICE C - AVALIAÇÃO DO ESTADO EMOCIONAL

4. Você conhece esta música?

☐ SIM TALVEZ ☐ NÃO ☐

5. Mostre como você se sente ao ouvir essa música





6. Mostre o quanto você gosta dessa música

APÊNDICE D - QUESTIONÁRIO SEMI-ESTRUTURADO

Questionário Socio-Demográfico

Nome da criança: _____Data de nasc.:_____

Nome do responsável:_____Telefone:_____

Relação com a criança:

	Mãe		Pai		Avô(a)		Outros

1. Sobre a criança

-Possui algum diagnóstico?

_____

-Faz uso de algum medicamento? Se sim, qual.

_____

-Já apresentou algum problema auditivo? (ex. infecção auditiva de repetição, alteração em exames de audiometria) Se sim, especifique:_____

_____

-Já fez aula de música alguma vez? Se sim, especifique por quanto tempo e o curso (ex. musicalização, violão, piano, etc)

_____

-Com que frequência ouve música em casa?

	Sempre		Às vezes		Quase nunca

-Qual tipo de música mais escuta?

	Pop internacional		MPB
	Pop nacional		Música erudita
	Hip-hop		Música religiosa
	Funk		Música eletrônica
	Sertanejo		Outros:

-Com que frequência ouve música enquanto estuda? (também inclui tarefas escolares)

	Sempre		Às vezes		Quase nunca

2. Sobre o responsável e a família

-Data de nascimento:_____ Idade:_____

-Marque sua escolaridade:

	Não estudou
	Ensino fundamental incompleto (1ª a 9ª série)
	Ensino fundamental completo (1ª a 9ª série)
	Ensino Médio incompleto
	Ensino Médio completo
	Ensino Superior completo
	Pós Graduação
	Outros. Especifique