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ENSINO DE HABILIDADES MUSICAIS AUDITIVAS POR MEIO DE TREINOS BASEADOS EM EMPARELHAMENTO DE ACORDO COM O MODELO

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Ensino de habilidades musicais auditivas por meio de treinos baseados em emparelhamento de acordo com o modelo

Versão final

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Resumo

A presente tese tem como objetivo propor e investigar procedimentos para o ensino de habilidades musicais que dependem de discriminação auditiva. Para tanto, primeiramente, realizamos um levantamento de estudos experimentais sobre o ensino de habilidades musicais, realizados entre os anos de 2000 e 2022, que empregaram procedimentos embasados em conceitos da Análise do Comportamento. Essa revisão da literatura revelou que os procedimentos para o ensino de habilidades musicais têm se dedicado mais ao estabelecimento de discriminações visuais e menos ao estabelecimento de discriminações auditivas. Além disso, os participantes destes estudos apresentaram melhor desempenho em testes com relações visual-visuais do que em testes com relações auditivo-visuais. E, ainda, os estímulos auditivos musicais compostos por notas tocadas sequencialmente – como, por exemplo, escalas e melodias – parecem ser mais facilmente discrimináveis quando comparados aos estímulos musicais compostos por notas tocadas simultaneamente – como por exemplo, acordes musicais. A fim de contornar algumas das dificuldades relacionadas ao estabelecimento de habilidades de classificação e nomeação de estímulos auditivos musicais, foram conduzidos três experimentos para o estabelecimento de relações condicionais auditivo-visuais entres diferentes estímulos auditivos musicais e palavras impressas. As fases de treino dos três experimentos foram similares, a maior diferença entre estas foram os estímulos auditivos musicais utilizados em cada uma, isto nos permitiu verificar o desempenho dos participantes durante treinos com acordes (Experimento 1), trechos musicais (Experimento 2) e melodias (Experimento 3). Nos três experimentos foram conduzidos testes para verificar a ocorrência da generalização do controle de estímulos. No Experimento 1, os testes de generalização foram com acordes diferentes daqueles utilizados durante o treino. No Experimento 2, os testes de generalização foram com trechos musicais diferentes daqueles utilizados no treino e, além disso, durante os testes foram apresentadas tentativas em que os estímulos auditivos foram progressões harmônicas. No Experimento 3, as fases de teste de generalização foram com melodias diferentes daquelas utilizadas no treino e, similar ao Experimento 2, foram apresentadas tentativas em que os estímulos auditivos foram progressões harmônicas. Os resultados advindos dessa série de experimentos indicam que os treinos discriminativos em MTS com trechos musicais e melodias produziram desempenhos mais acurados quando comparados aos treinos discriminativos com acordes. Quando comparados os dados obtidos com trechos

musicais em relação aos obtidos com melodias, foi possível observar que mais participantes atingiram os critérios de ensino durante o experimento com trechos musicais. Por outro lado, os participantes expostos ao experimento com melodias foram capazes de discriminar e nomear progressões harmônicas durante as fases de teste de generalização, o que não foi observado em relação aos participantes expostos aos treinos com trechos musicais. Por fim, diante do conjunto de dados obtidos, parece-nos pertinente supor que o ensino de habilidades de classificação e nomeação de trechos musicais deve preceder o ensino de classificação e nomeação de melodias. De forma similar, o ensino da classificação e nomeação de melodias deve preceder o ensino de classificação e nomeação de progressões harmônicas. Talvez, por meio desta sequência de ensino seja possível promover o estabelecimento rápido, pouco custoso e mais ameno de habilidades musicais que dependem da discriminação de estímulos auditivos.
Descritores: estímulos auditivos musicais, discriminação auditiva, treino de emparelhamento ao modelo.

Abstract

The aim of this thesis was propose and investigate procedures to teaching musical skills that depends on auditory discrimination. To this end, firstly, we carried out a scoping review of musical training with the methods from the Experimental Analysis of Behavior. The purpose of this study was to review research articles that used teaching procedures to train musical skills based on the methods of the Experimental Analysis of Behavior, in papers that were published between 2000 and 2022. In general terms, it is possible to argue that methods to teaching visual discrimination are more frequently than methods to teaching auditory discrimination. In addition, participants perform better in tests that present visual-visual relations than in tests with auditory-visual and, finally, musical notes played sequentially (e.g., scales, melodies) are easier to discriminate than notes played simultaneously (e.g., musical chords). In order to solve some of these difficulties, we conducted three experiments to establish auditory-visual conditional relationships between different auditory musical stimuli and printed words. The training phases of the three experiments were similar. The main difference between them was the musical auditory stimuli used in each one. In this way, we assessed the performance of the participants during trainings with different musical auditory stimuli (chords – Experiment 1; musical excerpts – Experiment 2; and melodies – Experiment 3). In the three experiments, we conducted tests to verify the occurrence of stimulus control generalization. In Experiment 1, the generalization tests were performed with different chords from those used during training. In Experiment 2, the generalization tests were with different musical excerpts from those used in training, in addition, were presented trials with harmonic progressions. In Experiment 3, the generalization tests were with different melodies from those used in training, in addition, were presented trials with harmonic progressions. The results indicate that a discriminative training using MTS and musical excerpts produced performances that are more accurate, when compared to a similar discriminative training with chords. Also in this sense, the training with melodies produced a more accurate performance when compared to the training with chords. When comparing the data obtained with musical excerpts in relation to those obtained with melodies, we observed more participants reached the teaching criteria during the experiment with musical excerpts. On the other hand, differently from the participants exposed to training with musical excerpts, the participants exposed to the training with melodies were able to discriminate and labeling harmonic progressions during the generalization tests. Finally, given the set of data obtained, it seems pertinent to assume that the teaching of classification and labeling of musical excerpts must precede the teaching of classification and labeling of melodies. Likewise, the teaching of classification and labeling of melodies must precede the teaching of classification and labeling of harmonic progressions. Perhaps, this teaching sequence can promote a fast and inexpensive establishment of musical skills that relies on the discrimination of musical auditory stimuli.

Keywords: musical auditory stimuli, auditory discrimination, matching-to-sample training.

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Ensino de Habilidades Auditivas Musicais por meio de Treinos de Emparelhamento ao Modelo

Para se tornar musicista, uma pessoa precisa adquirir uma série de habilidades relacionadas a discriminação de estímulos auditivos. Alguém que aprende a tocar um instrumento musical, por exemplo, precisa ser capaz de reconhecer os sons de acordes, escalas, melodias, progressões harmônicas, padrões rítmicos. Além disto, o aspirante a musicista precisa aprender a identificar e tocar a música no ritmo correto, identificar o tom e a tonalidade da música a ser tocada, tocar cada nota com a intensidade determinada (forte, fraco etc.), entre outras. Todas essas habilidades envolvem discriminação de estímulos, sendo que boa parte delas requer refinamento da discriminação de estímulos auditivos (acordes, escalas, melodias, progressões harmônicas, padrões rítmicos, dentre outros) para tocar ou cantar adequadamente. Pode-se dizer, portanto, que o ensino de habilidades de discriminação de estímulos auditivos musicais é parte essencial e crucial para o musicista, de modo que o desenvolvimento de estratégias de ensino de tais habilidades se mostra relevante e, até certo ponto, necessário.

Pesquisas demonstraram o quão difícil pode ser ensinar habilidades de classificação e nomeação de estímulos auditivos musicais (e.g., notas e acordes musicais) para participantes não músicos (Hanna et al., 2016; 2017; Madeira et al., 2017; Reis et al., 2017). Em alguns desses estudos, durante as fases de treino, aos participantes era solicitado escolher um estímulo visual após apresentação de um estímulo visual, ou um estímulo visual após a apresentação de um auditivo. Durante a fase de testes, haviam tentativas em que os mesmos participantes eram solicitados a escolher um estímulo visual após apresentação de um visual, e em algumas tentativas o participante era solicitado a escolher um estímulo auditivo após a apresentação de um estímulo visual. De forma recorrente, os participantes destes estudos demonstraram índices de acertos ao nível do acaso durantes os blocos de tentativas que envolveram estímulos auditivos e demonstraram altos índices de acertos nos blocos de tentativas que utilizaram apenas estímulos visuais, tanto nas fases de treino quanto nas fases de testes.

Em um estudo recente, Cedro et al. (2019) tiveram por objetivo ensinar classificação de acordes maiores e menores para um grupo (Grupo 1) de participantes e acordes consonante e dissonantes para outro grupo (Grupo 2). Diferente de estudos anteriores (Madeira et al., 2017; Reis et al., 2017), em Cedro et al., as tarefas de treino e teste apresentavam o mesmo formato, ou seja, o participante deveria escolher um estímulo visual logo após a apresentação de um estímulo auditivo. Mesmo nestas circunstâncias, mais da metade dos participantes do Grupo 1 não foi capaz de atingir o critério de aprendizagem durante a primeira fase de ensino. Mais participantes do Grupo 2 foram capazes de superar a primeira fase de ensino e obtiveram resultados um pouco superiores em relação ao Grupo 1. Desta forma, parece que os participantes foram capazes de classificar acordes consonantes e dissonantes mais facilmente, se comparados aos participantes que deveriam classificar acordes maiores e menores. Mas, de forma geral, os resultados de Cedro et al. demonstraram que os participantes de ambos os grupos não foram capazes de classificar a maioria dos estímulos auditivos apresentados durante os treinos e testes, um indicativo do quão difícil pode ser ensinar habilidades auditivas musicais de classificação de acordes.

Diante da aparente dificuldade de ensinar habilidades de classificação de estímulos auditivos musicais, o objetivo maior da presente Tese foi propor e investigar experimentalmente formas de ensinar habilidades musicais deste tipo para participantes não músicos. Primeiramente, por meio de revisão da literatura, foi possível traçar um breve histórico das pesquisas nesta área, descrever alguns dos métodos para ensino de habilidades musicais diversas e, também, apresentar um panorama sobre as pesquisas realizadas durante os últimos 20 anos. A análise crítica dos experimentos parece indicar que: *(i)* o ensino de habilidades musicais que dependem de discriminação visual é mais recorrente quando comparado ao ensino de habilidades que dependem de discriminação auditiva; *(ii)* os participantes apresentam desempenhos superiores nos testes com tentativas com relações do tipo visual-visuais, quando comparado aos desempenhos em tentativas com relações do tipo auditivo-visuais; *(iii)* participantes parecem atingir percentagens de acertos mais elevadas em tentativas de ensino em que os estímulos são notas musicais tocas sequencialmente (p.ex., escalas, melodias), e percentagens próximos ao nível do acaso nas tarefas em que os estímulos são notas tocadas simultaneamente (p.ex., acordes musicais).

Neste sentido, talvez seja pertinente uma retomada de procedimentos que visam principalmente o ensino de habilidades musicais que dependem de discriminação auditiva. Vale ressaltar aqui, as pesquisas sobre ensino de habilidades musicais por meio de métodos da Análise do Comportamento que foram conduzidas durantes as décadas de 1960 e 1970 (Edmonson III, 1972; Greer, Dorow, & Hanser, 1973; Greer, Randall, & Timberlake, 1971; Madsen, 1966; Madsen, Wolfe, & Madsen, 1969; Porter, 1977) pareciam estar mais direcionadas para o ensino de habilidades musicais que dependiam principalmente da discriminação de estímulos auditivos.

Ainda sobre habilidades musicais que dependem da discriminação de estímulos auditivos, por meio da revisão da literatura foi possível observar que uma minoria de participantes obtém 100% de acertos em testes com tentativas do tipo auditivo-visual, mais especificamente, a maioria destes participantes apresentam desempenhos ao nível do acaso em tentativas desse tipo. De acordo com estes dados, habilidades musicais que dependem de discriminação de estímulos auditivos parecem ser mais custosas de serem estabelecidas se comparadas às habilidades que dependem de discriminação visual. Neste sentido, nos parecem necessárias mudanças nos procedimentos que têm por objetivo ensinar habilidades musicais que dependem da discriminação de estímulos auditivos. Assim, por meio desta tese buscamos propor, testar e ampliar métodos para o estabelecimento de habilidades musicais que dependem de discriminação auditiva. Inclusive, desta forma, podemos demonstrar como métodos criados no âmbito da Análise do Comportamento podem ser utilizados para o estabelecimento de uma infinidade de habilidades musicais. Para tanto, foram conduzidos três experimentos envolvendo estímulos auditivos musicais.

O primeiro experimento teve por objetivo ensinar para participantes não músicos habilidades de classificação de acordes consonantes e dissonantes. A seguir, apontamos os motivos que nos levaram a ensinar a discriminação e nomeação de acordes consonantes e dissonantes ao invés de ensinar a discriminação de acordes maiores e menores. Primeiramente, em Cedro et al. (2019), os participantes apresentaram resultados um pouco superiores nas tentativas com acordes consonantes e dissonantes quando comparados às tentativas com acordes maiores e menores. Além disto, pesquisas demonstraram que bebês e crianças apresentam preferência por acordes consonantes quando comparados aos dissonantes (e.g., Di Stefano et al., 2016; Masataka, 2006; Schelenberg & Trehub, 1996; Trainor & Heinmiller, 1998; Trainor, Tsang, & Cheung, 2002), demonstrando que a discriminação entre os sons desses acordes parece ser mais facilmente estabelecida do que a discriminação entre sons de acordes maiores e menores. Por fim, pesquisas demonstraram que em tarefas do tipo *oddball*, nas quais foram apresentadas sequências de acordes consonantes de vários tipos (p.ex., maiores e menores), quando esta sequência de acordes foi interrompida pela apresentação de um acorde dissonante (p.ex., diminuto ou aumentado), foi registrado o potencial de resposta MMN (*mismatch-negativity* – pico negativo que surge entre 150ms e 250ms após a apresentação do estímulo auditivo desviante). Por outro lado, quando esta sequência de acordes foi interrompida por um acorde maior invertido, não foi observado o MMN, estes resultados foram observados em bebês, crianças e adultos (e.g., Virtala et al., 2011, 2012, 2013). Estes dados apontam que os participantes diferenciaram entre acordes consonantes e dissonantes em nível pré-atentivo, independentemente de qualquer treino anterior.

Em razão destes motivos, o experimento com acordes teve por objetivo ensinar 20 participantes a discriminar e nomear acordes consonantes e dissonantes. Desta forma, após a apresentação de um acorde, os participantes deveriam escolher uma palavra impressa (CONSONANTE ou DISSONANTE) para classificar o acorde apresentado. Tarefa similar foi aplicada durante as etapas de teste, com a diferença de que não foram apresentadas consequências diferenciais para erros e acertos e, além disto, durante as fases de teste foram utilizados acordes diferentes daqueles utilizados durante as fases de treino, com o intuito de verificar generalização entre estímulos diferentes, mas do mesmo de tipo. Os resultados obtidos foram superiores aos obtidos em Cedro et al. (2019), provavelmente devido à estrutura do procedimento de ensino aplicado. Em cedro et al, o número de estímulos comparação aumentava gradualmente durante as fases de treino. No presente experimento, desde o primeiro bloco de ensino foram apresentados três exemplares diferentes de um mesmo tipo de estímulo, ou seja, foram utilizados três acordes consonantes e três dissonantes desde o primeiro bloco de treino.

Conduzimos um segundo experimento a fim de verificar se os resultados seriam diferentes se alterássemos apenas os estímulos auditivos. Neste sentido, foram utilizados trechos musicais ao invés de acordes. Vale destacar aqui os motivos pelos quais foram utilizados trechos musicais durante a segunda coleta de dados. Em primeiro lugar, pesquisas anteriores (Cedro et al., 2019; Madeira et al., 2017; Reis et al., 2017) demonstraram o quão difícil pode ser ensinar habilidades auditivas de classificação de acordes. Em segundo lugar, inúmeros autores (para revisão, consultar Eerola & Vuoskoski, 2013) utilizaram trechos musicais em procedimentos para averiguar a relação entre a música e as emoções eliciadas por ela e a maioria dos participantes desses estudos foram capazes de classificar os trechos musicais de acordo com palavras ou imagens de valência positiva ou negativa, sem necessidade de treino para tanto. Além disso, trechos musicais são estímulos compostos por um conjunto de notas musicais (e.g., melodia), um conjunto de acordes (e.g., progressão harmônica), tocados de acordo com determinado ritmo. Neste sentido, o trecho musical é o estímulo musical com mais características diferentes que, eventualmente, podem ser discriminadas pelo participante. Assim, pareceu-nos promissor propor um procedimento de ensino que utilizasse trechos musicais como estímulos auditivos, pela aparente facilidade de discriminação auditiva.

Outro aspecto relevante do segundo experimento foi que buscamos verificar se o treino com um tipo de estímulo auditivo seria suficiente para o participante classificar outro tipo de estímulo auditivo durante os testes. Nesta perspectiva, o segundo experimento teve por objetivo ensinar 20 participantes a discriminar e nomear trechos musicais maiores e menores. Desta forma, após a apresentação de um trecho musical, os participantes deveriam escolher uma palavra impressa (MAIOR ou MENOR) para classificar o trecho apresentado. Durante as fases de teste foram aplicadas tarefas similares, com a diferença de que não foram apresentadas consequências diferenciais para erros e acertos e foram utilizados trechos musicais diferentes daqueles utilizados durante as fases de treino. Além disto, também foram apresentadas tentativas de teste com progressões harmônicas. Neste sentido, foram aplicados dois tipos de testes de generalização: *(i)* testes com trechos musicais – estímulos do mesmo tipo dos que foram utilizados durante o treino; *(ii)* testes com progressões harmônicas – estímulos de um tipo diferente dos que foram utilizados durante o treino. Os resultados do nosso experimento apontaram que 16 participantes atingiram acima de 80% de acertos durante todas as fases treino e, além disto, obtiveram entre 80% e 100% de acertos nos testes com trechos musicais. Contudo, estes mesmos participantes apresentam entre 40% e 60% de acertos nos testes com progressões harmônicas. Estes resultados são superiores aos encontrados durante o experimento com acordes relatado na presente Tese, tanto nas fases de treino quanto nas fases de teste. Mais do que isso, estes resultados indicam que o procedimento de ensino com trechos musicais possibilitou aos participantes classificar trechos diferentes daqueles utilizados durante os treinos. Entretanto, o treino com trechos musicais não possibilitou aos participantes discriminar e nomear as progressões harmônicas durante as fases de teste. Neste sentido, temos indícios de generalização entre estímulos de um mesmo tipo, ou seja, entre trechos musicais distintos. Porém, não obtivemos indícios de generalização entre estímulos de tipos diferentes, ou seja, entre trechos musicais e progressões harmônicas.

Uma possibilidade para explicar estes resultados está associada à velocidade de execução dos trechos musicais. Trechos musicais maiores tendem a ser mais rápidos – elevado número de batimentos por minuto (BPMs) associado a figuras rítmicas que determinam acima de duas notas musicais a cada BPM. Por outro lado, trechos musicais menores tendem a ser mais lentos – reduzido número de BPMs associado a figuras rítmicas que determinam uma nota musical com duração de dois BPMs ou mais (Levine, 2013; Mulholland & Hojnakci, 2013; Schmeling, 2011; Guest, 2006). Alguns estudos demonstraram que participantes sem treino musical são capazes de classificar trechos musicais a partir das características rítmicas desses trechos (Dalla-bela et al., 2001; Kerer et al., 2014; Thompson & Opfer, 2014). Neste sentido, não é possível determinar com tanta clareza se as respostas dos participantes do segundo experimento estavam sob controle das características rítmicas do trecho musical ou se estavam sob controle das características associadas à tonalidade do trecho musical – ser do tipo maior ou menor. Provavelmente, a resposta do participante foi controlada por ambas as características, rítmicas e de tonalidade, afinal, como dito antes, o trecho musical é o estímulo auditivo musical com mais características discrimináveis. Inclusive, esta elevada quantidade de características pode dificultar averiguar qual destas características (ou propriedades) do estímulo estão exercendo controle sobre o responder do participante. A partir destes achados, o terceiro experimento foi realizado a fim de tentar promover generalização entre estímulos musicais de diferentes tipos e, além disto, se configurou como um esforço para tentar controlar a influência de algumas características rítmicas dos estímulos auditivos utilizados.

De acordo com o exposto anteriormente, o terceiro experimento teve por objetivo ensinar para 30 participantes as habilidades de discriminar e nomear melodias maiores e menores. Durante os treinos, os participantes deveriam escolher uma palavra impressa (MAIOR ou MENOR) para classificar a melodia apresentada. Durante as fases de teste foram aplicadas tarefas similares, a diferença é que não foram apresentadas consequências diferenciais para erros e acertos e foram utilizadas melodias diferentes daquelas utilizadas durante as fases de treino. Além disto, similar ao experimento com trechos musicais, também foram aplicados testes de generalização com progressões harmônicas. A única diferença entre os pares de melodias utilizados durante o terceiro experimento foi em relação às características de tonalidade, mantendo-se as características rítmicas idênticas entre os pares. Além disso, entre as melodias de um determinado par também foram mantidas idênticas as características como dinâmica, intensidade, ataque, duração, volume e timbre. Dezoito participantes atingiram mais de 80% acertos durantes as fases de treino. Dentre estes, nove atingiram entre 80% e 100% de acertos durante os testes de generalização com novas melodias. Além disto, nove participantes também atingiram entre 80% e 100% de acertos nos testes de generalização com progressões harmônicas. Estes dados indicam que o procedimento de ensino aplicado promoveu a discriminação e nomeação dos estímulos auditivos apresentados tanto durante os treinos, quanto durante os testes. Além disto, o procedimento de ensino com melodias permitiu aos participantes classificar estímulos auditivos de um tipo diferente, ou seja, um treino apenas com melodias promoveu generalização de tal forma que os participantes foram capazes de classificar progressões harmônicas. Diferente do treino com trechos musicais, no qual os participantes apresentaram resultados ao nível do acaso nos testes com progressões harmônicas.

Após esta breve introdução geral, seguiremos para a apresentação detalhada dos estudos que compõem essa Tese. Cada um deles será apresentado na forma de artigo. Primeiramente, será apresentada a revisão de literatura feita sobre o ensino de habilidades musicais por meio de métodos da Análise do Comportamento e, posteriormente, apresentaremos os estudos experimentais.

ARTIGO 1

A scoping review of musical training with the methods of the Experimental Analysis of Behavior[1]

Abstract

Music is exclusively comprised of auditory stimuli. Over the years, as to the Behavior Analysis research in the context of music education, the teaching of auditory musical stimuli discrimination seems to have been replaced by the teaching of conditional relationships involving visual stimuli. The objective of this study was to review the methods based on the Experimental Analysis of Behavior of research articles on musical training, published between 2000 and 2022 in peer-reviewed journals. Five databases were consulted: PePsic, PsychINFO, SciELO, Scopus, and Web of Science. Forty pairs of descriptors were used during the research, with common musical terms (e.g., chords, scales) and Experimental Behavior Analysis terminology (e.g., conditional discrimination, teaching). Seventeen articles written in English, Portuguese, and Spanish were referenced. In general terms, it is possible to argue that teaching methods based on visual discrimination for training musical skills are more frequently used than methods based on auditory discrimination. In addition, participants perform better in tests that present visual-visual relations than in tests with auditory-visual or visual-auditory relations and, finally, musical notes played sequentially (e.g., scales, melodies) are easier to discriminate than notes played simultaneously (e.g., musical chords). The discussions highlight the importance of using methods focused on teaching musical skills that rely on auditory musical stimuli discrimination.

Keywords: teaching procedures, musical skill, Experimental Analysis of Behavior, auditory discrimination, auditory musical stimuli.

[1] Submetido à revista Trends in Psychology. O artigo foi aceito para publicação. A versão revisada foi submetida à revista e estamos à espera da versão final de acordo com o layout da revista.

Numerous and varied aspects related to the musical domain can be studied through different theoretical approaches as research topics. Psychophysics, for example, allows us to understand how human perception (e.g., Costal, 2012; Kamiyama et al., 2013; Sollberge et al., 2003) and emotions (e.g., Dalla-Bella et al., 2001; Gagnon & Peretz, 2003; Kastner & Krowder, 1990) are modulated by different characteristics of musical stimuli. That said, music education methods are formally examined in the educational field (e.g., Miyazaki & Ogawa, 2006; Sakakibara, 2014). Regarding the Experimental Analysis of Behavior, in the 1960s and 1970s, many experiments were carried out to investigate whether behavior modification methods could be used to establish musical skills (Edmonson III, 1972; Greer, Dorow et al., 1973; Greer, Randall et al., 1971; Madsen, 1966; Madsen et al., 1969; Porter, 1977). According to the authors, several approaches have been conceived over the years for the development of musical skills. However, a combination of the sophisticated experimental methods' development with the need to conduct more controlled studies on musical training still seemed to be necessary, in order to clarify some of the doubts that permeated - and still permeate - the teaching and maintenance of musical skills.

As an example of this combination of sophisticated experimental methods and controlled studies, Madsen et al. (1969) conducted an experiment to teach children how to sing notes with musical scales. In this study, the same scale was used in two different keys (i.e., C# and B), in an ascending sequence (i.e., from the lower to the higher register note), and in a descending sequence (i.e., from the higher to the lower register note). In summary, four sets of musical notes were used, each set consisting of eight notes. During the pre- and post-tests, in order to prepare their voices, the children' first task consisted of singing a folk song in C major, accompanied by the experimenter. After this preparation, the children were asked to pay attention while the experimenter played one of the four scales described above. At last, the experimenter played only the first note of the same scale and asked the children to sing the remaining notes. To analyze the mistakes, the experimenters used a stroboscope to measure the difference between the notes sung by the participants and the notes from the scale. After the pre-tests, participants with similar results were assigned in one of four different teaching conditions: 1 – training with ascending scales; 2 – training with descending scales; 3 – training with ascending and descending scales; and 4 – training with musical excerpts. In addition, they were also assigned into two bigger groups:

group 1 – singing trials without reinforcement; and group 2 – participants received 1 penny for every correct approximation of the samples' notes.

After the training, participants of all four teaching conditions exhibited an improvement in performance. An interesting point emphasized by the experimenters is that the participants who trained with musical excerpts performed better during the post-tests with musical scales than the participants who trained with musical scales. Surprisingly, there were no statistically relevant differences in the numbers of correct answers when comparing the groups with and without reinforcement learning. According to the initial hypothesis, it was possible to argue that the use of reinforcement in trials could increase in the number of correct answers given by the participants in group 2. On the other hand, the intrinsic reinforcement of learning a new musical skill for the participants in group 1 (trials without reinforcement) may have been strong enough to engender a number of correct answer similar to that achieved by participants in group 2 (trials with reinforcement).

Considering the performance improvement of all participants, even in the trials without reinforcement, the procedure used by Madsen et al. (1969) demonstrated that it is feasible to teach a widely recognized musical skill – the ability to sing – with an educational program that is fully supported by the methods developed by the Experimental Analysis of Behavior. It is also worth noting that the musical skill taught in this experiment required auditory discriminations among the scales' notes. In other words, the participants needed to accurately distinguish the notes on the scale before singing them. Other experiments, which also date from this same period, were equally interested in teaching singing skills or how to play an instrument through an approach based mainly on auditory stimuli discriminations (e.g., Edmonson III, 1972; Greer, Dorow et al., 1973; Greer, Randall et al., 1971; Madsen, 1966; Porter, 1977). Together, these experiments exemplify the possibility of having a musical training with high ecological value, in this case, singing or playing a musical instrument. Furthermore, it demonstrates the importance of auditory musical stimuli discrimination. For both musical skills – singing or playing –, the participants were able to give the requested responses only after accurately discriminating the auditory musical stimuli. After all, it is necessary to discriminate an immeasurable number of auditory stimuli to sing a song or play a piece on an instrument, which are musical skills recognized as valuable in various cultural and social contexts (Behr et al., 2016; Van der Hoeven & Hitters, 2019).

Still, in the Behavior Analysis context, the development of the stimulus equivalence paradigm (Sidman & Tailby, 1982) in the early 1980s opened new possibilities for the study of various behavioral processes, including for the teaching of musical skills. Briefly, the stimulus equivalence paradigm defines that after teaching a limited set of arbitrary conditional relations between abstract stimuli, a new set of conditional relations will emerge from these same stimuli without any additional training. For example, a hypothetical musical training approach according to this paradigm would involve three sets of stimuli: set A – three musical notes written on the score; set B – three printed names of the musical notes (e.g., do, re, mi); and set C – three representations of these musical notes with printed alphabet letters (e.g., C, D, E). Consequently, by using a matching-to-sample (MTS; Cumming & Berryman, 1961) teaching procedure, the following conditional relations would be approached: (i) AB relations – between the note in the score and its name; (ii) and BC relations – between the notes' names and their respective representation as letters. To establish conditional relations between stimuli from Set A (i.e., musical notes representation in the score named as A1, A2, and A3 stimuli) and stimuli from Set B (i.e., printed words DO, RE, and MI named B1, B2, and B3 stimuli), for example, trials should begin with the presentation of one stimulus from Set A, named sample stimulus. After that, all stimuli from Set B are presented as comparisons. According to an arbitrary rule, the choice of comparison B1 is considered correct whenever A1 is presented as the sample, the choice of comparison B2 is considered correct whenever A2 is presented as the sample, and the choice of comparison B3 is considered correct whenever A3 is presented as the sample. Correct responses are reinforced, and incorrect responses are extinguished. And the same logic would be applied to establish the BC conditional relations.

If the equivalence classes are formed, participants will be able to relate stimuli in combinations that are not directly taught during the training. First, participants will be able to associate each stimulus to itself (AA, BB, CC) in a relational property named reflexivity. Second, they will be able to reverse the conditional and discriminative functions of stimuli (BA and CB), in a relational property named symmetry. Finally, they will be able to identify stimuli that were not directly associated to each other during the training phases (A and C), but that were associated to a third common stimulus (B), in a relational property named transitivity. In some cases, it is common to test the emergence of the CA conditional relation, which is considered a simultaneous demonstration of the symmetry and transitivity relational properties. Thus, after teaching two conditional relations during training (i.e., AB and BC), based on the equivalence paradigm statements, it is possible to predict that, at least, seven new conditional relations will emerge during the testing phases (Sidman & Tailby, 1982; Sidman, 1994, 2000).

Hayes, Thompson, and Hayes (1989), for example, demonstrated the establishment of musical skills through an equivalence-based teaching procedure with participants assigned to three different conditions. In the first condition, named timing, the participants trained conditional relations between: (i) the sounds of rhythmic patterns (set A); (ii) the musical symbols that represent these patterns (set B); and (iii) the names of the musical symbols (e.g., half-note, whole-note, eighth-notes – set C). In the second condition, named placement, the participants trained conditional relations between: (iv) the notations in the score of the notes F, G, A, and B (set D); (v) the pictures of piano keys of the notes F, G, A, and B (set E); (vi) the pictures of the fingers that must press each key (set F); and (vii) the printed letters F, G, A, B (set G). In the third condition, the participants trained all the conditional relations described for the timing and placement conditions. The conditional relations evaluated in the pre- and post-tests were in accordance with the teaching procedure. That is, participants in the timing condition were exposed to a test to verify the emergence of BC and CB relations. While the participants in the placement condition were exposed to a test to verify the emergence of relations EF/FE, FG/GF, EG/GE. Finally, participants in the 'timing + placement' condition were exposed to a test to verify the emergence of relations BC/CB, EF/FE, FG/GF, EG/GE. Lastly, all participants were exposed to the same keyboard-playing test. The results showed that there was an emergence of equivalence classes during the post-tests, as well as a statistically significant decrease in the number of errors when comparing pre- and post-test results on the keyboard-playing test. It is worth emphasizing that Hayes et al. chose to teach auditory discriminations related to rhythmic patterns rather than auditory discriminations among musical notes, as performed in previous experiments (e.g., Edmonson III, 1972; Greer, Dorow et al., 1973; Greer, Randall et al., 1971; Madsen, 1966; Porter, 1977).

Procedures to establish musical skills in the 1990s seem to be more similar to those used by Hayes et al. (1989) than to those used during the 1960s and 1970s. That is, discrimination training involving musical notes or other auditory musical stimuli seems to have become less and less frequent over the years. For example, Tommis and Fazey (1999) conducted a study to teach children without previous experience with formal music education to play notes on a musical keyboard with a score. During the equivalence-based teaching procedure two sets of conditional relations were established: in the AB training, multiple tasks were used to teach conditional relations between fictional names to notes and the representation of the note in a score. In the AC training, other multiple tasks were used to teach conditional relations between the fictional names to the musical notes and fictional names to the piano keys. During the pre- and post-test, children were asked to (i) play in keyboard the melodies presented in a score. Melodies that could vary from two (do, re) to five musical notes (do, re, mi, fa, sol). The analysis demonstrated a statistically significant decrease in numbers of errors when comparing pre- and post-test results. It is noteworthy, however, that auditory discrimination between musical notes in this context seems to become a secondary consequence of establishing the relationship between notation in the score and their respective piano keys.

In conclusion, the prominent position that the teaching of auditory musical stimuli discrimination (e.g., Edmonson III, 1972; Greer, Dorow et al., 1973; Greer, Randall et al., 1971; Madsen, 1966; Porter, 1977), in 1960s' and 1970s' studies, seems to have been replaced over the years by the teaching of conditional relationships mostly involving visual stimuli (e.g., Tena & Velazquéz, 1997; Tommis & Fazey, 1999). In this context, the purpose of this study was to review research articles that used teaching procedures to train musical skills based on the methods of the Experimental Analysis of Behavior in papers that were published between 2000 and 2022 in peer-reviewed journals. The findings provided by this review can help to outline which music skills are being taught, what type of stimuli and methods are being used, helping to identify possible obstacles to overcome and future paths to be followed.

Method

Online research was carried out between June 01 and June 08, 2022, in the following databases: PePsic, PsycINFO, SciELO, Scopus, and Web of Science. Once inside the database system, two lines of descriptors were used, one for each descriptor. We inserted the descriptors using quotation marks ("…") with the logical operator "AND" between lines. The descriptors were a pair of terms commonly related to teaching procedures that are based on the Experimental Analysis of Behavior, such as “conditional discrimination”, “equivalence relations”, “multiple exemplar training”, “training” and “teaching”, combined with a second term commonly used in music theory such as “musical notes”, “musical chords”, “chords”, “melodies”, “musical melodies”, “harmonic progression”, “musical excerpts”. Table 1 presents all terms combinations along with the numbers of associated articles in each database.

Table 1.

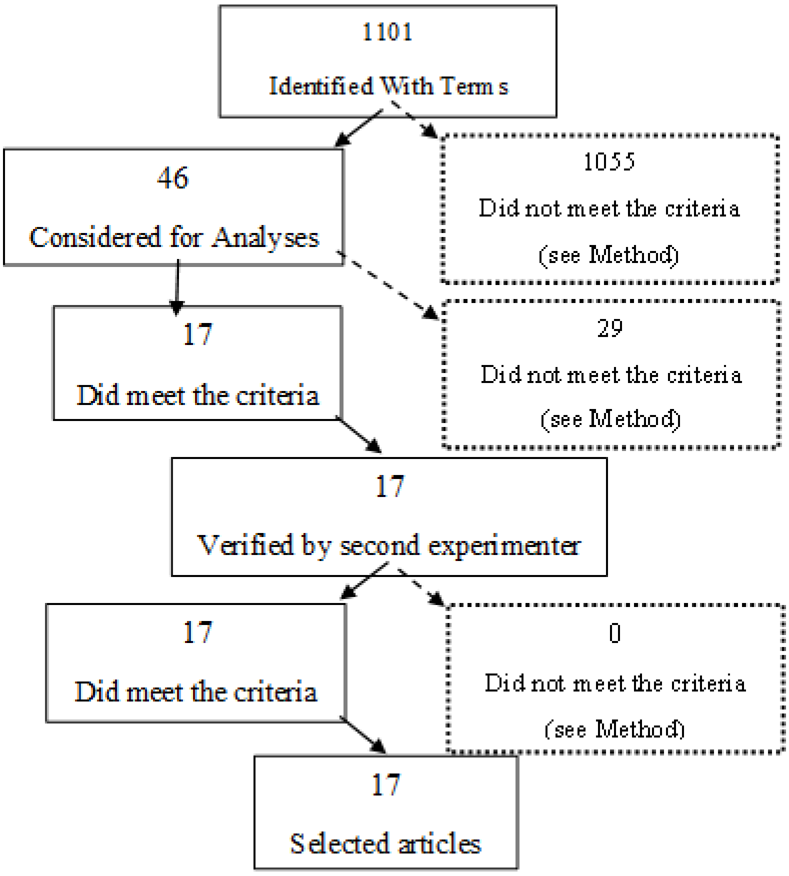
Descriptors and Number of Identified Articles

Search Terms			Databases				
			Pepsic	**PsycINFO**	**Scielo**	**Scopus**	**Web Of Science**
Line 1		**Line 2**	**Number of Identified Articles**				
Conditional Discrimination	**AND**	Musical Notes		8		1	
		Musical Chords	1	2		1	
		Chords	1			1	1
		Musical Melodies					
		Melodies					
		Harmonic Progression					
		Musical Excerpts				1	
Equivalence Relations	**AND**	Musical Notes		6	1		
		Musical Chords		3			1
		Chords				5	5
		Musical Melodies					
		Melodies		1			
		Harmonic Progression					
		Musical Excerpts			1		
Multiple Exemplar Training	**AND**	Musical Notes		1			
		Musical Chords		1		1	2
		Chords				1	2
		Musical Melodies					
		Melodies					
		Harmonic Progression					
		Musical Excerpts					
Training	**AND**	Musical Notes		23		5	55
		Musical Chords		6	1	11	9
		Chords		45	1	49	92
		Musical Melodies			4	10	6
		Melodies	1	99	4	97	163
		Harmonic Progression		3	1	6	2
		Musical Excerpts		21	4	23	28
Teaching	**AND**	Musical Notes		5	1	10	14
		Musical Chords	1	1	1	3	1
		Chords	1	10	4	36	25
		Musical Melodies		1	1	3	2
		Melodies	1	33	1	89	36
		Harmonic Progression		1		1	3
		Musical Excerpts	1	4		2	2
		Total	**7**	**274**	**25**	**356**	**449**

The following inclusion criteria were adopted: (i) full research articles, published in a scientific journal indexed to the reference database, written in English, Portuguese, or Spanish; (ii) research articles that described training procedures for musical training based on the methods of the Experimental Analysis of Behavior; (iii) research articles published from 2000 to 2022. Articles that met all these criteria were included. A flowchart describing the study selection methods along with the number of studies included at each stage of the inclusion/exclusion criteria is shown in Figure 1.

Figure 1.

Flowchart of the Searching Process



Note. Dashed lines indicate points at which articles were excluded.

Regarding the selection process, the presence of the descriptors in the title and/or abstract was the criteria for a research article to be considered for this analysis. Based on the articles' title, a second selection phase was carried out. Specifically, if any term of the title indicated that the article was within the scope of the review, the abstract was read. When the information of the abstract was not enough to determine the inclusion of the article, both the Methods and the Results sections were also read. Two experimenters conducted the selection process of the articles. The first experimenter was responsible for accessing the databases, inserting the terms in the systems, considering articles for analysis, reading the titles and abstracts of articles and performing an initial selection of the articles. After this initial searching-screening, the second experimenter reevaluated the articles based on the same criteria. When both experimenters agreed that the article did meet all of the criteria, then it was included in the scoping review. Table 2 shows the number of articles identified by the descriptors, the number of articles considered for analysis, the number of articles selected after reading title and abstract, the number of articles selected after reading methods and results, and finally, the number of articles that met all criteria.

Table 2.

Numbers of Articles During Searching-Screening

Database	Identified with Search Terms*	Considered for Analyses**	Selected by title/abstract	Selected by methods/results	Final
PePSIC	7	2	2	0	2
PsycINFO	274	8	6	0	4
SciELO	25	4	0	0	0
Scopus	356	21	4	2	6
Web of Science	449	11	4	1	5
				Articles that meet all the criteria	17

*Mostly the articles identified with search terms not used the teaching procedures based on Experimental Analysis Behavior.
**Mostly of the articles considered for analyses not used the teaching procedures based on Experimental Analysis Behavior.

Results

After the initial searching-screening process, 1101 research articles were found. Only 17 articles, however, were selected to be examined in detail. Among them, seven were written in Portuguese, nine were written in English, and one was written in Spanish. The main criteria for excluding articles after the initial search was the presence of teaching procedures that were not based on the methods of the Experimental Analysis of Behavior. Furthermore, many studies did not present a description of the teaching procedures used in their experiments. In the absence of such a description, it was not possible to determine the theorical basis used to develop the referred training approach, so these articles were also excluded. This high initial number of articles is probably due to the use of the words 'training' and 'teaching' as search terms (see Table 1), which are used in many knowledge fields besides Experimental Analysis of Behavior.

The databases with the most articles meeting the proposed criteria were Scopus, Web of Science, and PsycINFO (see Table 2). Table 3 presents the authors' names along with publication year, participant characteristics, stimuli used, discriminations trained, method used, and main results. As for the participants' performance, some of the results indicate that the percentage of correct responses tend to decrease in tasks involving the discrimination of auditory musical stimuli (Acín et al., 2006; Cedro et al., 2019; Hanna et al., 2016, 2017; Madeira et al., 2017; de Sousa & Micheleto, 2020). For example, in the testing phases of the study conducted by Hanna et al., most of the 10 participants performed at chance level in tasks in which they were asked to choose note representations in a musical score, or to press piano keys after listening to sets of three or four musical notes. Similarly, Cedro et al. showed that most participants achieved correct responses at chance level on chord labeling tasks (i.e., to classify a chord as 'major' or 'minor' after listening to it).

Regarding equivalence class formation, auditory musical stimuli discrimination seems to modulate the results in some of the emergent relations' tests. For example, Madeira et al. (2017) showed that 10 out of 11 participants achieved a high percentage of correct responses when they performed tests in which the trial required a selection of a visual comparison stimulus after presenting a visual sample stimulus. On the other hand, only three participants achieved a high percentage of correct responses in tests presenting auditory comparison stimuli and visual sample stimulus.

Broadly speaking, the participants' performance on conditional relations involving only visual stimuli (visual-visual trial type) is better than on conditional relations involving auditory and visual stimuli (auditory-visual or visual-auditory trial types).

Table 3.

Characteristics of Included Studies

Authors / Year	Participants	Stimuli-Used	Discrimination Training		Teaching-Method	Posttest Results
			Visual-Stimuli	Auditory-Stimuli		
Acin et al., 2006	10 children (four/six years-old) One teenager (17 years-old/autism-spectrum-disorder)	Printed Words Score Sound of three notes	Note in the score Note name	Sound of a single musical note	MTS	70/90% hits - undistinguished the visual-visual and auditory-visual results
Arntzem et al., 2010	One teenager (16 years-old/down-syndrome)	Printed/dictated Words Score Piano Keys Images	Chord name Chord in the score Chord Keys	Chord dictated name	MTS	Visual-visuals 80/100% hits
Cedro et al., 2019	40 undergraduate (18/35 years-old)	Printed Words Sound of 48 chords	Chord name	Chord Sound	MTS	Auditory-visuals 30/60% hits
Griffith et al., 2018	Six undergraduate (21/27 years-old)	Printed Word Chord-Cipher Score Pianos keys Images	Chord in the scores Chords Keys	Chord dictated name	MTS	Visual-visuals 80/100% hits
Hanna et al., 2016	Four undergraduate (18/20 years-old)	Sound of six notes Score Piano Keys Images	Notes in the score Notes Keys	Sequences of three musical notes	MTS	Visual-visuals 80/100% hits
Hanna et al, 2017	Five undergraduate (18/24 years-old)	Sound of six notes Score Piano Keys Images	Notes in the score Notes Keys	Sequences of three or four musical notes	MTS	Visual-visuals 100% hits Auditory-visuals 65/75% hits

(continued)

Authors / Year	Participants	Stimuli-Used	Discrimination Training		Teaching-Method	Posttest Results
			Visual-Stimuli	Auditory-Stimuli		
Hill et al., 2020	Eight children (four=6/8 years old four down syndrome =11 years old)	Dictated words Score Piano Keys Images	Notes in the score Note name Piano Keys Images	Dictated name of note	MTS	Visual-Visuals 100% hits Auditory-visuals 0/40% hits
Langendonck, Asnis, & Elias, 2020	One child (4 years-old/autism-spectrum-disorder)	Dictated words Score Piano Key	Colored-cards with notes in the score Piano Keys	Dictated name of note	MTS	Visual-Visuals (colored-cards and piano keys) 100% Visual-Visuals (score and pianos keys) 10/25%
Langton et al., 2020	12 undergraduate (21/25 years-old)	Dictated words Score Piano Keys Images	Notes in the score Note name Piano Keys Images	Dictated name of note	MTS	Visual-Visuals 100% hits Auditory-visuals 0/40% hits
Machado & Borloti, 2009	Nine undergraduate (18/22 years-old)	Sounds of 12 notes	Not applied	Sequences of five musical notes	Go/No-Go	Auditory-visuals 0/100% hits
Madeira et al., 2017	11 high school students	Score Printed Word Sounds of seven notes	Note name Note in the score	Sound of a single musical note	MTS	Visual-visuals 90% hits Auditory-visuals 45/90% hits
De Sousa & Micheleto, 2020	6 undergraduate and 2 post-graduated	Score Printed Word Sounds of four notes	Note name Note in the score	Sound of a single musical note	MTS	Visual-visuals 25/100% hits Auditory-visuals 0/100% hits
						Continued

Authors / Year	Participants	Stimuli-Used	Discrimination Training		Teaching-Method	Posttest Results
			Visual-Stimuli	Auditory-Stimuli		
Perez & de Rose, 2010	One undergraduate (25 year-old)	Score Sound of three notes	Notes in the score	Sequences of three or four musical notes	MTS	Auditory-visuals 0/100% hits
Reis et al., 2017	Seven adults (ages not cited)	Guitar chord-chart Printed-Words Sounds of 12 chords	Guitar chord-chart Chord name	Sounds of chords	MTS	10/60% – undistinguished the visual-visual and auditory-visual results
Rodrigues et al., 2017	17 undergraduate students (18/30 years old)	Printed Words Sounds of 20 chords	Chord name	Chord Sound	MTS	Auditory-Visual 30/45% hits (training-results)
Thompson & Opfer, 2014	64 adults 64 children (10 years-old) 48 children (5 years-old)	Printed Words 16 musical scales 16 musical scales with alterations	Printed Words	Sound of a musical scale	MTS	Auditory-Visual 40/80% hits

Note. MTS = Matching-To-Sample.

For instance, when faced to visual-visual trial type, most participants achieved a percentage of correct responses ranging from 80% to 100% during the testing phases (Acín et al., 2006; Arntzen et al., 2010; Griffith et al., 2018; Hanna et al., 2016; Hanna et al., 2017; Hill et al., 2020; Langton et al., 2020; de Sousa & Micheleto, 2020; Madeira et al., 2017; Reis et al., 2017; Salvatori et al., 2012). In some cases, the evaluation of equivalence class formation is hampered by using auditory musical stimuli. More specifically, the participants obtained a high percentage of correct responses in the transitivity tests involving visual-visual trials, while they did not achieve the learning criteria in the symmetry tests involving visual-auditory trials (Acín et al., 2006; Hill et al., 2020; Madeira et al., 2017). Considering that the emergence of these three relational properties (i.e., symmetry, transitivity, and reflexivity) is necessary to document equivalence class formation, the use of auditory musical stimuli seems to add a complicating aspect to these experiments.

Interestingly, it seems that participants present more difficulties in discriminating auditory stimuli when notes are played simultaneously, as in musical chords, when comparing to melodies and scales. In melodies and scales, the musical notes are played sequentially rather than simultaneously. For example, Thompson and Opfer (2014) carried out a study in which musical scales were presented as auditory stimuli in MTS tasks. In this context, participants achieved 80% correct responses in training trials that required to choose a visual comparison stimulus when faced with an auditory sample stimulus (auditory-visual trial type). Similar results were observed in Hanna et al. (2017), in a procedure where participants were given testing trials that presented auditory musical stimuli as comparisons and visual stimuli as samples. Meanwhile, Cedro et al. (2019) carried out a study in which musical chords were used as auditory stimuli in MTS tasks. During the testing phases, participants achieved accuracy levels that ranged from 30% to 60%. Similarly, Rodrigues et al. (2017) used major and minor chords to teach auditory discriminations based on chord tonalities, and participants achieved percentage of correct responses that ranged from 30% to 45% during the training phases.

Regarding the behavioral process addressed in these articles, 14 of the 17 studies used the stimulus equivalence paradigm to propose methods for teaching different musical skills. The remaining three articles (Cedro et al., 2019; Rodrigues et al., 2017; Thompson & Opfer, 2014) were interested in teaching chord and scale labeling in different contexts. Cedro et al. aimed at evaluating the concept formation and the abstraction process (Herrnstein & Loveland, 1964; Holth, 2017; Skinner, 1953) based on the labeling of different types of chords (i.e., major, minor, consonant, and dissonant chords). Thompson and Opfer verified the extent to which music scales characteristics can interfere in the process of learning to label them as major and minor. Finally, Rodrigues et al. evaluated whether the timbre could modulate the acquisition process of labeling chords.

As for the methods used in these articles, most of them used the MTS teaching procedure to establish the conditional relations. It is remarkable that only one article used the go/no-go paradigm (Vaughan, 1988). In the go/no-go task, participants are asked to emit a response (go) when the stimulus considered to be correct is presented, and do not emit this same response (no-go) when the incorrect stimulus is presented. Hence, only one stimulus is presented per trial, which, in turn, must control a participant's response. In the study conducted by Machado and Borloti (2009), participants were asked to press a button when identifying a melody in major key, and to not press the same button with a melody in minor key.

In most experiments, at least one discrimination response involving auditory musical stimuli was carried out during the training phases. For example, Reis et al. (2017) trained auditory discriminations using three different types of musical chords (i.e., major, minor, and major with seventh). Similarly, Cedro et al. (2019) taught participants to discriminate between major and minor chords (Group 1) or between consonant and dissonant chords (Group 2). In the studies conducted by Hanna and colleagues (Hanna et al., 2016, 2017), participants learned to discriminate sequences of three musical notes. De Sousa and Micheleto (2020) taught participants to choose the correspondent score notation after listening to sound of a musical note. Thompson and Opfer (2014), in turn, taught participants to discriminate major and minor musical scales. Conversely, some experiments did not use auditory musical stimuli in their teaching procedure. Arntzen et al. (2010), for example, carried out a method to establish conditional relations between dictated words, representations in the score and figures of piano keys. Griffith et al. (2020) and Hill et al. (2020) taught participants to press the corresponding key on the musical keyboard after listening to the dictated name of a musical note, and Langton et al. (2018) taught participants to name the notation in the score, as well as to press the correspondent piano key during the training phases. Langendonck et al. (2020) taught participants to press the correspondent piano key when faced with the notation in music scores. It is worth mentioning that auditory musical stimuli were presented when the participants pressed the piano key. However, despite this teaching procedure characteristic, it not likely that a discriminative training involving auditory musical stimuli occurred, since learning outcomes directly related to these stimuli were not perceived. It is equally important to mention that, in general terms, these articles aimed at establishing a musical skill named sight reading, which consists of recognizing notations in the music score. Indeed, such a skill do not require discriminative training of auditory musical stimuli.

The results demonstrated that much of the research reported trained conditional relations between two sets of visual stimuli. Typically, there are five types of conditional relations between sets of visual stimuli. First, between notation of the score and words, or vice-versa (Acín et al., 2006; Arntzen et al., 2010; Madeira et al., 2017; de Sousa & Micheleto, 2020; Salvatori et al., 2012). Second, between notation of the score and musical cipher, or vice-versa (Griffith et al., 2018; Hill et al., 2020; Madeira et al., 2017). Third, between musical cipher and printed words, or vice-versa (Madeira et al., 2017; Reis et al., 2017; Rodrigues et al., 2017). Fourth, between images of piano keys– or guitar chord charts – and printed words, or vice versa (Acín et al., 2006; Arntzen et al., 2010; Reis et al., 2017) Fifth, between images of piano keys and scores, or vice-versa (Acín et al., 2006; Arntzen et al., 2010; Hanna et al., 2016; Hanna et al., 2017; Langendonck et al., 2020; Langton et al., 2020). At this point, research in the area focused more on teaching skills that rely on visual discrimination, considering the amount and variety of visual stimuli used.

None of the studies consulted for this review used two distinct sets of auditory musical stimuli during training phases. For example, never was used a set of auditory stimuli consisting of musical chords and a set of auditory stimuli consisting of musical scales; or a set of auditory stimuli consisting of musical notes and a set of auditory stimuli consisting of musical melodies. On the other hand, as we said before, in most studies two sets of visual stimuli were used. For example, a set of visual stimuli consisting of notes in the score and a set of visual stimuli consisting of the printed words (Acín et al., 2006; Arntzen et al., 2010; Madeira et al., 2017; de Sousa & Micheleto, 2020); or a set of visual stimuli consisting of the images of piano keys and a set of visual stimuli consisting of notes in the score (Hanna et al., 2016; Hanna et al., 2017; Langendonck et al., 2020; Langton et al, 2020;). Hence, teaching musical skills that rely on visual discrimination is more frequent than teaching musical skills that rely on auditory discrimination.

Discussion

The critical analysis of the experiments seems to indicate that, firstly, teaching musical skills that rely on visual discrimination of musical stimuli is more frequent than teaching skills that rely on auditory discrimination of musical stimuli. Secondly, the participants presented superior results in test trials with visual-visual relations than in trials with auditory-visual or visual-auditory relations. Lastly, it seems that participants achieved more expressive results in tasks using musical notes played sequentially (e.g., scales, melodies) than in tasks using notes played simultaneously (e.g., musical chords).

In most studies, the participant spent more time exposed to visual-visual trials than exposed to auditory-visual or even to visual-auditory trials. For example, it is very common to teach conditional relations using notations on the score as samples and printed words as comparisons (or vice-versa) in MTS procedures (e.g., Acín et al., 2006; Arntzen et al., 2010; Madeira et al., 2017; Salvatori et al., 2012). After all, in most of these studies, the experimenters used two sets of visual stimuli, while using only one set of auditory musical stimuli, and, as mentioned before, none of studies used two sets of musical stimuli in training or even in test phases.

Still on the matter of skills that rely on auditory stimuli discrimination, we can observe that the participants presented different results, and a minority of them achieved 100% correct answers in tests with auditory-visual or visual-auditory trials. Specifically, most of the participants presented results at chance level on trials with auditory musical stimuli. According to these results, it is possible to argue that musical skills that rely on auditory musical stimuli discrimination are more costly to establish than skills that rely on visual discrimination. In this sense, it seems plausible to indicate some changes for future research targeting musical training. First, to develop methods to teach musical skills that rely on discriminating auditory musical stimuli. Second, to use more than one set of auditory musical stimuli during the training and testing phases. At last, to teach conditional relations between different sets of auditory stimuli (i.e., auditory-auditory relations). Such changes would give the participants a chance to spend more time interacting with auditory stimuli such as musical notes, chords, melodies, scales, and harmonic progressions.

Training musical skills that rely on auditory discrimination is very important because music consists of auditory stimuli. Ergo, for anyone who wants to produce music – playing an instrument, singing, composing, arranging, and improvising – the ability to discriminate auditory stimuli is crucially important. The auditory stimuli in this case are musical notes, intervals between musical notes, musical chords, harmonic progressions, musical scales, melodies, and rhythmic patterns. For example, identifying the musical notes that composed a guitar solo or a musical note of a melody of a current popular song depends on an accurate auditory discrimination. The reinforcing value of this musical skill seems to be very obvious considering that it allows music learners to play or sing unfamiliar songs. This ecological value is the main reason why we exhaustively repeat the importance of teaching auditory stimuli discrimination for musical training.

It is worth mentioning that the experiments on teaching musical skills through the methods of the Experimental Analysis of Behavior, based on 1960s' and 1970s' studies, seemed to be more focused on teaching musical skills that rely on discriminating auditory stimuli (e.g., Edmonson III, 1972; Greer, Dorow et al., 1973; Greer, Randall et al., 1971; Madsen, 1966; Madsen et al., 1969; Porter, 1977). Perhaps, a renewal of procedures mostly targeting teaching skills that rely on auditory discrimination can enrich the area in at least two ways. First, to demonstrate that through the paradigms of the Experimental Analysis of Behavior is possible to teach multiple musical skills in an agile, amenable, and accessible way. Second, to enrich the literature in the sense of proposing, testing, and expanding methods for the establishment of musical skills that rely on auditory discrimination. Consequently, researchers of different areas could apply methods of the Experimental Analysis of Behavior to establish a multitude of skills, including musical skills that rely on both auditory and visual discrimination.

In conclusion, the present work did not intend, at any time, to exhaust the discussion on this topic. Indeed, our main objective was to propose a discussion about the teaching procedures and the skills being taught, based on the identified references. Our hope with this discussion is contribute in some way to future research, mainly research aimed at establishing musical skills that rely on auditory discrimination.

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ARTIGO 2

Ensino de Classificação de Acordes Consonantes e Dissonantes por meio um de Treino de Múltiplos Exemplares[2]

Resumo

Pesquisas demonstraram que bebês preferem ouvir sons de acordes consonantes do que sons de acordes dissonantes. Estudos com eletroencefalografia demonstraram que acordes consonantes e dissonantes evocam padrões de ondas diferentes, mesmo em participantes sem treino musical algum. Apoiados nestas premissas, buscamos verificar se seria possível ensinar 20 estudantes universitários, sem treino musical anterior, a identificar acordes consonantes e dissonantes. Foram utilizados 12 acordes musicais consonantes e 12 acordes musicais dissonantes. Quatro fases de treinos foram intercaladas com quatro fases de testes, e a cada fase de treino os participantes foram treinados a discriminar acordes consonantes e dissonantes diferentes daqueles que seriam apresentados durante as fases de testes 1 e 2. Não foi possível observar homogeneidade nos resultados obtidos pelos participantes. Contudo, a maioria deles demonstrou uma evolução gradual nas porcentagens de acertos ao longo dos treinos e testes. Estudos anteriores demonstraram que a habilidade de discriminar estímulos musicais auditivos é de difícil aquisição e tal processo parece demandar mais pesquisas. Neste sentido, quando analisados em conjunto, os resultados aqui relatados parecem indicar que o procedimento pode ser promissor para o estabelecimento de relações condicionais entre estímulos auditivos musicais e estímulos visuais.

Descritores: acordes musicais, relações condicionais, estímulos auditivos, discriminação auditiva, habilidades musicais.

[2] Submetido à revista Acta Comportamentalia. O artigo foi aceito para publicação. A versão revisada foi submetida à revista e estamos à espera da versão final de acordo com o layout da revista.

Teaching the Classification of Consonant and Dissonant Chords through a Multiple-Exemplary Training

Abstract

The experimental procedure aimed to teach non-musician participants to classify musical chords regarding consonance and dissonance. Twenty (12 woman) undergraduate students aged between 20-27 years (M: 21.45; SD: 2.08) participated in the present experiment. Consonant chords were composed of fundamental, perfect fifth, and octave; dissonant chords, in turn, were composed of fundamental, triton, and octave. Consonant and dissonant chords from 12 notes of occidental chromatic scale, ranging from C3 to B3, were used. During each of the four training phases, participants were taught to identify consonant and dissonant chords of three different fundamental notes. These four training phases were interspersed by four test phases to verify if the participants could identify consonant and dissonant chords with fundamental notes different from those used during training. Although we cannot observe a homogeneity in the participants' performance, most of them demonstrated a gradual evolution in the number of correct choices throughout the training and, to some extent, also in the test phases. When taken together, these results showing that this training procedure can be promising, mainly if performed for a greater number of sessions. Classifying chords into consonance and dissonance can be a prerequisite for learning to classify chords in terms of more complex characteristics, such as major, minor, augmented, and diminished chords.

Keywords: musical chords, conditional relations, auditory stimuli, auditory discrimination, musical skills.

Um acorde musical se constitui a partir da execução simultânea de duas ou mais notas musicais. A nota principal do acorde é a nota fundamental, por meio dela é possível nomear o acorde, bem como é ela a referência para o estabelecimento das outras notas que vão formar o acorde. Uma característica dos acordes musicais é a consonância ou dissonância, que são definidas pelos intervalos entre notas musicais que determinam a formação de padrões harmônicos (para mais informações, ver Guest, 2006; Levine, 2011; Schmeling, 2011). Intervalos denominados de quarta justa, quinta justa e oitava (i.e., repetição da nota fundamental em registro mais agudo) são característicos de acordes consonantes. Acordes maiores e menores, por exemplo, também são acordes consonantes, pois são formados por um intervalo entre a nota fundamental e a quinta justa (Guest, 2006; Levine, 2011; Schmeling, 2011). Inclusive, este intervalo é reconhecido como puramente consonante desde a época de Pitágoras (Abdounur, 2007; Porres et al., 2006). Por outro lado, acordes formados por intervalos entre fundamental e quinta diminuta ou quinta aumentada são reconhecidos como acordes dissonantes. O intervalo entre fundamental e quinta diminuta – a depender do contexto, também chamada de quarta aumentada, ou mais comumente, intervalo de trítono – é, inclusive, reconhecido como um dos intervalos mais dissonantes da música ocidental (Di Stefano et al., 2016; Guest, 2006; Levine, 2011; Schmeling, 2011; Sollberger, Reber, & Eckstein, 2003).

Acordes consonantes formados por nota fundamental, quinta justa e oitava são comumente apresentados em estudos que utilizam medidas de eletroencefalografia (EEG) para verificar a atividade do córtex cerebral após a apresentação de um estímulo auditivo musical – o mesmo é válido para acordes dissonantes formados por fundamental, quinta diminuta e oitava (e.g., Costa, 2012; Zhou et al., 2019). Acordes destes mesmos tipos – consonantes e dissonantes – também são utilizados em estudos sobre priming afetivo, em que é verificado o quanto a apresentação de um determinado estímulo antecedente interfere na velocidade de emissão de resposta do participante, resposta esta que deve ser emitida diante de um segundo estímulo (visual ou auditivo). Em alguns casos, os estímulos antecedentes (ou primings) são acordes consonantes ou dissonantes (e.g., Costa, 2012; Sollberge et al., 2003).

Estudos experimentais demonstraram que crianças e bebês preferem ouvir intervalos e acordes consonantes quando comparados a intervalos e acordes dissonantes (Masataka, 2006; Trainor, Tsang, & Cheung, 2002). No estudo conduzido por Di Stefano et al. (2016), por exemplo, 22 bebês com idades entre 19 e 40 meses foram expostos a um brinquedo que emitia sons de intervalos consonantes e dissonantes. Basicamente, o brinquedo era um dispositivo retangular com uma alavanca que, quando girada para um lado, produzia os sons de intervalos consonantes e, quando girado para o lado inverso, produzia sons de intervalos dissonantes. Na Fase 1, o experimentador entregava o brinquedo para o bebê e o estimulava a manipulá-lo, de modo a produzir os sons, como descrito previamente. Na Fase 2, o brinquedo era novamente entregue ao bebê, mas o giro da alavanca não produzia sons. Na Fase 3, as condições da Fase 1 eram reestabelecidas. A análise dos resultados apontou que os pequenos participantes manipularam o brinquedo por mais tempo nas Fases 1 e 3, quando comparados à Fase 2, indicando que a produção de sons era uma consequência reforçadora para a resposta de girar a alavanca. Além disso, eles giravam a alavanca mais vezes e a deixavam por mais tempo na posição que gerava intervalos consonantes. Com base nesses resultados, parece possível argumentar que a capacidade de diferenciar entre intervalos consonantes e dissonantes desenvolve-se muito precocemente no repertório dos indivíduos, pois tal diferenciação seria um pré-requisito necessário para que os bebês pudessem demonstrar a preferência pelos intervalos consonantes.

Outro aspecto importante que parece estar relacionado com a pergunta de pesquisa do presente experimento é de que seres humanos reagem a acordes consonantes e dissonantes de forma tão acentuada que o participante sequer precisa estar acordado ou atento para que a reação seja observada e mensurada por meio de EEG (e.g., Costa, 2012; Virtala et al., 2011; Virtala, Huotilainen, Putkinen, Makkonen, & Tervaniemi, 2012; Virtala, Huotilainen, Partanen, Fellman, & Tervaniemi, 2013, Zhou et al., 2019). Em termos gerais, para o registro de tais medidas, eletrodos são colocados no couro cabeludo de um participante, enquanto o procedimento experimental demanda a realização de alguma tarefa ou simplesmente apresenta algum estímulo visual ou auditivo (Kutas & Federmeier, 2011; Luck & Kappenman, 2011). Para estudar a atividade neural associada a estímulos auditivos, e consequentemente acordes musicais, o padrão de ondas denominado mismatch negativity (MMN) tem sido amplamente utilizado em diversos estudos (para revisão ver Näätänen, Paavilainen, Rinne, & Alho, 2007). Em geral, o MMN é medido em tarefas do tipo oddball, em que a apresentação de uma sequência de estímulos padrão (e.g., 12 acordes do tipo consonantes que são diferentes entre si) é interrompida randomicamente por um estímulo desviante (e.g., um acorde dissonante). O MMN consiste em uma onda de tendência negativa que ocorre entre 150 ms e 250 ms após a apresentação de estímulo auditivo desviante e reflete uma incompatibilidade entre as características sonoras do estímulo desviante quando comparada aos estímulos padrão (Näätänen et al., 2007).

Em uma série de estudos conduzidos por Virtala et al. (2011, 2013), a ocorrência do MMN foi descrita utilizando-se acordes maiores (que também são consonantes) como estímulos padrão e acordes dissonantes como estímulos desviantes, tanto em participantes que não possuíam histórico de treinos de habilidades musicais quanto em recém-nascidos. Além disso, utilizando esses mesmos estímulos, Virtala el al. (2012) demonstraram que participantes musicistas apresentam registros de ondas negativas com maior amplitude quando comparados aos participantes não-musicistas. Portanto, estes dados sugerem que a ocorrência do MMN não necessita de histórico de treinos de habilidades musicais, mas pode ser modulado/potencializado por ele.

Seria possível argumentar que o controle comportamental e eletrofisiológico obtido em tarefas utilizando acordes consonantes e dissonantes poderia se constituir em uma condição favorecedora para a aprendizagem da habilidade musical de ouvir um acorde e nomeá-lo conforme proposto pela literatura musical. Em outras palavras, tanto os resultados comportamentais (e.g., Di Stefano et al., 2016; Masataka, 2006; Trainor et al., 2002) quanto os registros de EEG (e.g., Costa, 2012; Virtala et al., 2011, 2012, 2013; Zhou et al., 2019) pareciam indicar que adultos com desenvolvimento auditivo típico seriam capazes de aprender a classificar e nomear acordes consonantes e dissonantes sem grandes dificuldades. Contudo, tal expectativa não foi confirmada pelos resultados obtidos em estudos tentaram ensinar a nomeação de acordes musicais (e.g., Cedro et al., 2019; Reis et al., 2017; Rodrigues et al., 2017).

O estudo conduzido por Cedro et al. (2019), por exemplo, teve por objetivo ensinar aos participantes discriminar e nomear acordes de quatro tipos: *(i)* maiores e *(ii)* menores (ver Guest, 2006; Levine, 2001; Schmeling, 2011; para obter definições de acordes maiores e menores); *(iii)* consonantes e *(iv)* dissonantes – idênticos aos que foram descritos anteriormente. Em termos gerais, o experimento propôs ensinar para os participantes do Grupo 1 relações condicionais entre sons de acordes musicais maiores e menores e, respectivamente, as palavras impressas MAIOR e MENOR. Para os participantes do Grupo 2 foram ensinadas relações condicionais entre sons de acordes musicais consonantes e dissonantes e, respectivamente, as palavras impressas CONSONANTE e DISSONANTE. Em ambos os grupos, durante as fases de treinos, o procedimento de ensino foi composto por cinco acordes de cada tipo (Grupo 1 = cinco maiores, cinco menores; Grupo 2 = cinco consonantes e cinco dissonantes). Além disso, intercalados entre as fases de treino, foram conduzidos testes de generalização com acordes diferentes daqueles utilizados nas fases de treino.

A racional do experimento estava baseada no fato de que acordes consonantes possuem características sonoras comuns e, portanto, as relações condicionais estabelecidas durante o treino para um conjunto limitado de acordes consonantes poderiam ser generalizadas ou abstraídas para um conjunto diferente de acordes consonantes durante os testes (e.g., Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001a, 2001b; Holth, 2017; Range, Aust, Steurer, & Huber, 2008), sendo esse mesmo raciocínio válido para os acordes dissonantes. Contudo, dentre os 40 participantes do estudo de Cedro et al. (2019), 19 não atingiram os critérios de aprendizagem estipulados para os passos de ensino iniciais (fases 1 e 2). Especificamente, oito participantes não atingiram os critérios da primeira fase (sete do Grupo 1) e 11 participantes (oito do Grupo 2) não atingiram os critérios da segunda fase de ensino. Tais resultados, portanto, contrariaram as expectativas quanto à facilidade de aquisição de tais repertórios.

Um processo de generalização bem-sucedido ocorre em situações nas quais um mesmo comportamento é controlado por um valor específico ou uma propriedade específica comum a uma ampla variedade de diferentes estímulos (Holth, 2017; Skinner, 1953/2003). Skinner (1953/2003) afirmou, inclusive, que a quantidade de variação das propriedades irrelevantes dos estímulos utilizados no treino está diretamente relacionada com a probabilidade do estabelecimento do controle pela propriedade de interesse. Por exemplo, em estudos que buscaram verificar se faces humanas expressando diferentes emoções exerceriam controle sobre o responder do participante, várias faces expressando uma mesma emoção são utilizadas durante o procedimento, ou seja, múltiplos exemplares de um mesmo tipo de estímulo (e.g., Bortoloti, Almeida, & de Rose, 2019; Kamiyama, Abla, Iwanaga, & Okanoya, 2013; Logeswaran & Bhattacharya, 2009). Tal manipulação tem por objetivo aumentar a probabilidade de que o controle seja exercido pela emoção apresentada nas várias faces, ao invés de ser exercido por alguma característica específica de alguma face utilizada que não estaria relacionada às emoções.

Relacionado a essa questão, o procedimento de ensino proposto por Cedro et al. (2019) pode ter, inadvertidamente, dificultado a ocorrência da generalização. O referido procedimento de ensino foi planejado para ocorrer em passos formados por dois blocos, um primeiro bloco de treino específico e um segundo bloco de treino cumulativo. Por exemplo, o terceiro passo de ensino tinha por objetivo estabelecer relações condicionais entre os acordes consonantes e dissonantes formados a partir da nota fundamental mi e as palavras impressas CONSONANTE e DISSONANTE, respectivamente. Nesse contexto, o bloco de treino específico era composto por oito tentativas em que apenas acordes com a nota mi eram apresentados. Atingir o critério de aprendizagem nesse primeiro bloco era condição para que o participante fosse exposto ao bloco de treino cumulativo, em que eram alternadas tentativas com acordes consonantes e dissonantes formados a partir das notas dó, ré e mi (i.e., acordes utilizados até aquele momento do procedimento). Portanto, a existência de blocos de treino específicos pode ter induzido os participantes a ficarem sob controle de características sonoras específicas de cada acorde consonante (ou dissonante) no momento do estabelecimento das relações condicionais, não atentando para as características sonoras comuns a todos eles, as quais permitiriam a ocorrência da generalização. Assim sendo, o aspecto principal de um processo de generalização, a saber, o controle por propriedades comuns a todos os estímulos utilizados (e.g., Barnes-Holmes et al., 2001a, 2001b; Holth, 2017; Range et al., 2008; Skinner, 1953/2003), não teria ocorrido. Em outras palavras, é provável que o procedimento de ensino utilizado possa ter influenciado a ocorrência de uma topografia de controle de estímulos diferente daquela planejada pelos autores (Dube & McIlvane, 1996; McIlvane & Dube, 2003).

Com o intuito de desenvolver um procedimento de ensino para o estabelecimento de relações condicionais entre acordes musicais consonantes e dissonantes e as palavras impressas CONSONANTE e DISSONANTE, aplicamos um treino em que foi apresentado ao participante três exemplares de acordes consonantes e três exemplares de acordes dissonantes desde o primeiro passo de ensino, tendo sido utilizados diferentes exemplares de acordes a cada novo passo. Considerando as análises desenvolvidas anteriormente, tal modificação poderia resultar em um aumento nas porcentagens de acertos tanto durante os passos de treino quanto nos passos de teste.

O presente experimento se configura em estudo experimental exploratório e, neste sentido, tenta contribuir com a área ao apontar possíveis parâmetros para programação de tarefas que pretendam ensinar as habilidades musicais que envolvam discriminação de estímulos auditivos. Nesta perspectiva, não foi exigido que os participantes atingissem critérios de acertos para avançarem entre as fases de treino. Como observado em vários estudos que tentaram ensinar relações condicionais entres estímulos auditivos musicais e estímulos visuais diversos (e.g., Cedro et al., 2019; Hanna et al., 2016; Madeira et al., 2017; Reis et al., 2017; Rodrigues et al., 2017), os participantes geralmente apresentam porcentagens de acertos ao nível do acaso em tarefas de discriminação de estímulos auditivos musicais. Em Rodrigues et al. (2017), durante as tentativas dos tipos auditivo-visual (acorde musical – palavras impressas), os participantes apresentaram resultados entre 30-45% de acertos. Situação similar pode ser observada em Reis et al. (2017), em que os participantes obtiveram porcentagens de acertos que variaram entre 10% e 60% de acertos. No pior dos casos, os participantes sequer realizaram os passos de ensino programados para o treino, mesmo tendo passado por pré-testes anteriores às fases de treino, como é o caso de Cedro et al. (2019). Como descrito anteriormente, 19 dentre 40 participantes que passaram no pré-teste foram dispensados após a segunda fase de ensino por não atingir um critério de acertos relativamente baixo (i.e., 75% de acertos no bloco).

Além disto, excluir participantes a partir de critérios de acertos pré-concebidos pode impossibilitar a observação de um aumento gradual de acertos ao longo de todo o procedimento e, também, impossibilitar análises sobre o próprio processo de aprendizagem que poderia ocorrer ao longo dos passos de ensino. Assim, tendo em vista a dificuldade associada à discriminação de estímulos auditivos musicais, (Cedro et al., 2019; Hanna et al., 2016; Madeira et al., 2017; Reis et al., 2017; Rodrigues et al., 2017), e por se tratar de estudo exploratório para o levantamento dos parâmetros necessários para elaboração de um procedimento de ensino, optamos por não utilizar critérios de aprendizagem para determinar se o participante continuaria a participar do procedimento.

O ensino de habilidades de classificação de acordes consonantes e dissonantes pode se configurar em habilidade necessária para a aquisição de discriminações mais complexas, como dito anteriormente, os acordes maiores e menores são tipos de acordes consonantes e os acordes aumentados e diminutos são tipos de acordes dissonantes. Estes quatro tipos de acordes são a base para formação da maioria dos outros acordes conhecidos, de acordo com a tradição da música ocidental (Guest, 2006; Levine, 2011; Schmeling, 2011). Tais habilidades de discriminação de estímulos auditivos musicais são imprescindíveis para estudantes de música, musicistas ou qualquer pessoa que pretenda cantar ou tocar um instrumento musical.

Método

Participantes

Foram selecionados 20 estudantes universitários (12 do sexo feminino) com idades variando entre 19 e 27 anos (M: 21,45; DP: 2,08). Todos os participantes leram e assinaram um Termo de Consentimento Livre e Esclarecido, além disso, os procedimentos de ensino e teste propostos no presente experimento foram avaliados e aprovados pelo Comitê de Ética em Pesquisa, processo CAAE: 44508615.2.0000.5149.

Local e equipamentos

Os dados foram coletados em uma sala de 4m x 6m, provida de boa iluminação e com baixos níveis de ruído, localizada em uma instituição de ensino superior. Foram utilizados computadores com telas de 23”, teclado e mouse. Para apresentação dos estímulos auditivos foram utilizados fones de ouvido bilaterais, de alta fidelidade, com som estéreo, com capacidade para reproduzir todas as ondas de frequência entre 10Hz e 23.000Hz, com impedância de 32Ω, saída máxima de 50mW e sensibilidade de 96dB. Para programação dos blocos de pré-teste, treino e teste foi utilizado o software Stimulus Control (Picanço, 2017).

Estímulos

Os estímulos auditivos foram os acordes consonantes e dissonantes formados a partir das notas fundamentais dó3, ré3, mi3, fá3, sol3, lá3, si3, réb3, mib3, solb3, láb3 e sib3. Os acordes consonantes foram formados pelos intervalos entre nota fundamental, quinta justa e oitava. O acorde consonante de dó3, por exemplo, foi composto pelas notas dó3 (fundamental), sol (quinta justa) e dó4 (oitava). E as notas mi3 (fundamental), si (quinta justa) e mi4 (oitava) foram utilizadas para compor o acorde consonante de mi3. Assim sendo, apesar de serem compostos por notas diferentes, os intervalos entres as notas permanecem os mesmos, motivo pelo qual todos esses acordes são classificados como sendo consonantes.

Os acordes dissonantes, por sua vez, foram formados pelos intervalos entre fundamental, quinta diminuta e oitava. Nesse caso, as notas dó3 (fundamental), sol*b* (quinta diminuta) e dó4 (oitava) foram utilizadas para compor o acorde dissonante de dó3. E, utilizando os mesmos valores de intervalo entre as notas, mi3 (fundamental), si*b* (quinta diminuta) e mi4 (oitava) compunham o acorde dissonante de mi3. Uma vez mais, por apresentarem esses mesmos intervalos, ambos os acordes são classificados como sendo dissonantes.

Os acordes foram compostos e gravados no software Ableton® (versão 9.4.7 – 64 bits) com tecnologia MIDI (Musical Instrument Digital Interface). Todos os acordes foram compostos e gravados com timbre de piano clássico, utilizando os mesmos parâmetros de intensidade, volume, duração e ataque.

Finalmente, os estímulos visuais foram as palavras impressas CONSONANTE e DISSONANTE, escritas em caixa alta, com fonte Arial, tamanho 100.

Procedimento

A tentativa era iniciada com a apresentação simultânea de um estímulo modelo auditivo (i.e., som de acorde) e de um retângulo azul na parte superior central da tela do computador. O estímulo auditivo, com duração de 3s, era repetido até o momento em que o participante clicasse com o mouse sobre esse retângulo. A emissão dessa resposta produzia a apresentação de dois estímulos de comparação visuais (i.e., palavras impressas) nos vértices inferiores direito e esquerdo na tela, enquanto a apresentação do estímulo modelo era encerrada. As posições de apresentação dos estímulos de comparação variavam de forma semi-aleatória. Durante as fases de ensino, respostas corretas eram consequenciadas com a apresentação de um check verde e respostas incorretas com a apresentação de um “X” vermelho, na parte central da tela do computador. A apresentação das consequências diferenciais para acertos e erros durava 1s e era seguida por um intervalo entre tentativas (IET) também com duração de 1 s, período no qual a tela permanecia em branco. Durante as fases de teste, as respostas do participante eram seguidas apenas pelo IET.

A Tabela 1 apresenta a sequência de fases de treino e teste a qual todos os participantes foram expostos. Inicialmente, os participantes realizavam um Pré-teste Geral e, em seguida, Treino 1, Teste1, Treino 2, Teste 2, Treino 3, Teste 3, Treino 4, finalizando o procedimento com o Teste 4. A seguir, cada uma dessas fases de treino e teste será descrita em detalhes.

Tabela 1

Sequência de Fases de Treino e Teste, Tons, Tipos/Nº Tentativas, e Critérios Utilizados

Sequência de Fases	**Tons**	**Tipo-Nº Tentativas**	**Critérios**
Pré-Teste	ré3*b*, mi3*b*, sol3*b*, lá3*b*, si3*b*	20 em extinção	Não se aplica
1 – Treino	dó3, ré3, mi3	12 com sinal 24 sem sinal	90% de acertos em um bloco ou três exposições ao bloco
1 – Teste	ré3*b*, mi3*b*, sol3*b*, lá3*b*, si3*b*	10 em extinção	Não se aplica
2 – Treino	fá3, sol3, lá3	12 com sinal 24 sem sinal	90% de acertos em um bloco ou três exposições ao bloco
2 – Teste	ré3*b*, mi3*b*, sol3*b*, lá3*b*, si3*b*	10 em extinção	Não se aplica
3 –Treino	si3, ré*b*3, mi*b*3	12 com sinal 24 sem sinal	90% de acertos em um bloco ou três exposições ao bloco
3 – Teste	ré3*b*, mi3*b*, sol3*b*, lá3*b*, si3*b*	10 em extinção	Não se aplica
4 – Treino	sol3*b*, lá3*b*, si3*b*	12 com sinal 24 sem sinal	90% de acertos em um bloco ou três exposições ao bloco
4 – Teste	ré3*b*, mi3*b*, sol3*b*, lá3*b*, si3*b*	10 em extinção	Não se aplica

O pré-teste foi composto por um bloco com 20 tentativas para as quais não foram apresentadas consequências diferenciais para erros ou acertos. Os acordes consonantes e dissonantes utilizados como estímulos modelo auditivos foram formados a partir das notas réb3, mib3, solb3, láb3 e sib3 e as palavras impressas CONSONANTE e DISSONANTE foram utilizadas como estímulos de comparação visuais. Os participantes que atingiram até 65% de acertos durante o pré-teste foram expostos às fases de treino e teste posteriores.

O Treino com Múltiplos Exemplares era composto por quatro fases. Cada fase apresentava três acordes diferentes de cada tipo (três consonantes e três dissonantes) e era dividido em dois blocos de tentativas, o primeiro bloco com 12 tentativas sinalizadas e o segundo com 24 tentativas sem sinalização. O bloco de tentativas sinalizadas era composto de forma a apresentar seis tentativas com acordes consonantes e seis tentativas com acordes dissonantes. Além disso, essas 12 tentativas eram igualmente divididas entre os três exemplares de cada tipo de acorde – consonante ou dissonante – treinados em cada fase. Durante esse bloco, o estímulo de comparação correto, o qual deveria ser escolhido pelo participante, era sinalizado por uma moldura verde. Não foi exigido critério de acertos para este bloco.

Após o bloco com tentativas sinalizadas, foi aplicado um bloco com 12 tentativas com acordes consonantes e 12 tentativas com acordes dissonantes, nas quais não havia sinalização do estímulo de comparação a ser escolhido. Novamente, essas 24 tentativas eram igualmente divididas entre os três exemplares de cada tipo de acordes treinados na fase. O encerramento da fase estava condicionado à ocorrência de um dentre dois critérios: *(i)* obtenção de porcentagem de acertos igual ou superior a 90% em um único bloco; ou *(ii)* exposição de forma consecutiva a três blocos de treino sem alcançar o critério de acertos estipulado. Em ambos os casos, o participante era encaminhado para a fase de teste, descrita a seguir.

Em termos gerais, todas as quatro fases de treino eram idênticas em termos de organização dos blocos, quantidade de tentativas e critérios de avanço para etapas posteriores. A única diferença estava relacionada às notas fundamentais utilizadas para a formação dos três acordes consonantes e três acordes dissonantes utilizados durante cada fase. No Treino 1, por exemplo, para formar cada um dos três acordes de cada tipo foram utilizadas as notas fundamentais dó3, ré3 e mi3, logo, foram três acordes consonantes – e três dissonantes – distintos entre si e diferentes daqueles das fases de testes; no Treino 2 foram utilizados três acordes consonantes e três acordes dissonantes formados a partir das notas fá3, sol3 e lá3; no Treino 3 foram utilizadas três acordes consonantes e três acordes dissonantes formados a partir das notas si3, réb3 e mib3; finalmente, durante o Treino 4 foram utilizados três acordes consonantes e três dissonantes formados a partir das notas fundamentais solb3, láb3 e sib3. Como apontado antes, ao alterar a nota fundamental do acorde, alteramos todo o acorde, pois, é a partir da nota fundamental que vamos nomear o acorde de modo específico, bem como é a partir da nota fundamental que são estabelecidas as outras notas que o compõem (Levine, 2001; Schmeling, 2011). Desta forma, ao longo de todo o experimento foram apresentados 12 acordes consonantes distintos entre si e 12 acordes dissonantes distintos entre si.

De forma intercalada às fases de treino, foram aplicados testes de generalização. Os referidos testes eram compostos por um bloco de 10 tentativas igualmente divididas entre acordes consonantes e dissonantes. Os acordes consonantes e dissonantes utilizados foram formados a partir das notas réb3, mib3, solb3, láb3 e sib3. Vale ressaltar que os acordes consonantes e dissonantes formados a partir das notas réb3, mib3 também foram utilizadas durante a fase de treino 3, e os acordes consonantes e dissonantes formados a partir das notas solb3, láb3, e sib3 foram utilizados durante a fase de treino 4. Desta forma, nas fases de teste 3 e 4, ocorreu uma sobreposição entre os estímulos utilizados nos treinos e testes. Os possíveis impactos dessa sobreposição foram analisados por meio de ferramentas estatísticas na seção subsequente.

Resultados

As porcentagens de acertos obtidas pelos participantes durante os pré-testes ficaram no nível do acaso. Treze dos 20 participantes obtiveram porcentagens de acertos entre 60% e 65%; cinco deles atingiram entre 50% e 55% de acertos; finalmente, os participantes P5 e P17 atingiram 45% de acertos. Quando considerados em conjunto, o desempenho inicial parece indicar que os participantes não possuíam a habilidade de ouvir um acorde e nomeá-lo conforme proposto pela literatura musical.

Ao considerar que o avanço nos blocos de treinos não dependia exclusivamente da obtenção do critério de acertos, optamos por analisar os resultados desta fase considerando a porcentagem média de acertos. Assim, na Tabela 2, a porção superior apresenta os resultados dos participantes que obtiveram porcentagem média igual ou superior a 70% de acertos e a porção inferior apresenta os resultados daqueles que obtiveram porcentagem média igual ou inferior a 60% de acertos. As células sublinhadas sinalizam os blocos nos quais o critério de acertos foi alcançado.

Tabela 2

Participantes, Fases de Ensino, Porcentagens de Acertos em Cada Bloco de Ensino e Testes

	Treino 1			Teste	Treino 2			Teste	Treino 3			Teste	Treino 4			Teste
Part.	Bl.1	Bl.2	Bl.3	1	Bl.1	Bl.2	Bl.3	2	Bl.1	Bl.2	Bl.3	3	Bl.1	Bl.2	Bl.3	4
P1	83	87	100	100	87	91	--	90	83	100	--	90	79	91	--	100
P3	83	70	95	70	45	66	58	60	66	75	79	90	75	75	70	40
P4	58	66	83	60	95	--	--	80	79	83	87	80	83	91	--	90
P5	70	91	--	50	95	--	--	30	79	79	83	70	62	66	83	60
P6	100	--	--	90	95	--	--	90	83	83	95	100	91	--	--	100
P9	58	45	62	70	87	79	79	70	54	70	62	40	83	83	75	50
P10	70	75	83	70	79	87	79	70	83	83	87	80	83	83	87	80
P12	75	87	66	80	79	75	70	60	66	62	66	80	75	66	62	70
P13	75	75	95	90	83	83	87	70	75	83	75	80	79	95	--	70
P15	79	79	79	70	75	83	95	70	70	75	79	80	83	87	79	90
P16	66	79	83	90	83	83	87	80	95	--	--	90	79	79	83	90
P17	79	95	--	70	91	--	--	60	87	79	91	70	79	100	--	70
P19	50	70	75	70	83	66	79	40	66	54	75	50	83	66	79	40
P20	66	83	87	90	83	79	87	80	100	--	--	90	66	91	--	100
P2	66	70	79	60	66	50	41	70	62	45	66	80	58	45	70	50
P7	54	54	66	50	70	54	62	50	50	75	66	50	41	58	41	40
P8	50	45	66	60	75	58	58	50	54	45	54	20	58	54	45	30
P11	58	58	58	60	58	62	62	60	62	58	66	60	50	58	54	80
P14	50	70	62	60	54	62	41	50	66	66	62	70	41	54	41	90
P18	58	58	70	30	70	50	58	80	50	66	66	60	58	58	54	50

Nota. As siglas “Bl.1, Bl.2 e Bl.3” fazem referência aos três blocos de 24 tentativas de cada fase de treino.

Ao analisarmos a Tabela 2 é possível verificar que os participantes apresentados na porção superior da Tabela foram capazes de aprender, em alguma medida, as relações condicionais ensinadas. Para alguns deles, o aprendizado foi consideravelmente evidente como, por exemplo, P1, P6 e P17, os quais foram capazes de atingir o critério de aprendizagem em todos os passos treinos; os participantes P4, P5, P13 e P20, por sua vez, atingiram os critérios de aprendizagem em dois dos quatro treinos realizados; e os participantes P3, P15 e P16 atingiram mais de 90% de acertos em um dos treinos. Seis dentre estes participantes atingiram 80% de acertos em todas as fases de ensino: P4, P5, P10, P13, P16, P20. Além disto, estes seis participantes demonstram uma evolução gradual no número de acertos ao longo das fases de treino, sendo que, em alguns momentos atingem 95% (P4, P5, P13, P16) e até mesmo 100% de acertos (P20).

Os demais participantes, mesmo não obtendo a quantidade de acertos necessária para atingir o critério de aprendizagem (90% de acertos), apresentaram porcentagens acima dos 70% de acertos na maioria dos blocos, o que corresponde a 16 acertos em um bloco de 24 tentativas. O participante P10, inclusive, obteve porcentagens superiores aos 80% na maioria dos blocos, mesmo não atingindo o critério de aprendizagem em nenhum dos treinos realizados.

Por outro lado, os resultados dos participantes apresentados na porção inferior da Tabela 2 parecem indicar que as relações condicionais não foram aprendidas. Esses participantes apresentaram porcentagens de acertos iguais ou superiores a 75% em momentos específicos, mas tal desempenho não se manteve ao longo dos blocos. Para estes seis participantes, as porcentagens de acertos variaram de forma considerável e ficaram próximas ao nível do acaso na maioria das vezes.

A Tabela 2 também apresenta as porcentagens de acertos obtidas durante os testes realizados ao longo do procedimento. Em alguma medida, os resultados obtidos nos testes foram similares àquilo que aconteceu nos blocos de treino. Por exemplo, os participantes P1 e P6, que alcançaram o critério de aprendizagem em todos os treinos, também alcançaram as maiores médias de acertos nos testes. Além disso, P3, P9 e P19 apresentaram desempenho mediado (i.e., porcentagem média de acertos próximas a 70%) nos blocos de treino e, ao mesmo tempo, obtiveram porcentagens de acertos consideravelmente baixas durante os testes. Finalmente, as três menores médias de acertos ao longo dos testes foram obtidas por P7, P8 e P18, para quem as porcentagens de acertos ficaram próximas ao nível do acaso durante todo o treino.

De maneira inversa, alguns desempenhos apresentados durante os testes foram consideravelmente diferentes do que foi apresentado durante os blocos de treino. O participante P17, por exemplo, atingiu o critério de aprendizagem em todos os treinos, mas não obteve mais que 70% de acertos durante os testes. Os participantes P16 e P20 obtiveram percentual médio de acertos próximo ou igual a 90% de acertos nos testes, ainda que as porcentagens de acertos nos blocos de treino tenham ficado próximas a 80% de acertos.

Tabela 3

Número de Erros durante os Blocos de Treino, de acordo com o tipo do Acorde – Consonante ou Dissonante – e Nota Fundamental a partir da qual o Acorde foi formado.

Treino 1				Treino 2				Treino 3				Treino 4			
Acorde	Erros			Acorde	Erros			Acorde	Erros			Acorde	Erros		
	B1	B2	B3		B1	B2	B3		B1	B2	B3		B1	B2	B3
Dó-C	28	23	25	Fá-C	22	14	20	Si-C	41	32	33	Sol*b*-C	30	24	26
Dó-D	13	18	10	Fá-D	13	20	12	Si-D	17	14	11	Sol*b*-D	17	11	11
Ré-C	24	8	15	Sol-C	22	17	17	Ré*b*-C	13	3	2	Lá*b*-C	19	15	12
Ré-D	43	40	17	Sol-D	12	16	12	Ré*b*-D	24	23	16	Lá*b*-D	25	23	26
Mi-C	20	13	5	Lá-C	8	16	18	Mi*b*-C	3	14	11	Si*b*-C	24	19	12
Mi-D	27	22	20	Lá-D	27	29	29	Mi*b*-D	37	29	31	Si*b*-D	26	26	26

Nota. A letra “C” é abreviação para acorde consonante e a letra “D” para acorde dissonante. A letra “B” é abreviação para bloco.

Ao analisar a quantidade de erros cometidos em cada bloco do Treino 1, de acordo com o tipo do acorde, foi possível observar uma concentração maior de erros nas tentativas de treino que apresentavam como modelo o acorde ré-dissonante. A fim de verificar se esta variação no número de erros foi significativa, foi conduzida uma análise de variância, para dados não paramétricos, do tipo Kruskal-Wallis. Após análise dos resultados, foi constatado que não houve uma diferença significativa na quantidade de erros durante o Treino 1 (H=3,74, Hc=3,74, p=0,1535) que possa estar correlacionado com algum tipo de acorde específico.

Diferentemente do Treino 1, em relação ao Treino 2 foi possível observar uma menor concentração de erros nas tentativas com acordes de sol dissonante. Após análise de variância por meio do teste Kruskal-Wallis, foi encontrado um valor de p um marginalmente significante (*H*=10,78 *Hc*=10,88, *p*=**0,0538**). Por meio da aplicação do Dunn´s Post-Hoc (foi utilizado o método Bonferroni para correção dos valores de *p*), foi encontrado um valor de *p*=0,05944 associado ao acorde de sol dissonante, possível indicativo de que o número de erros associado a este acorde seja diferente daqueles registrados para os outros acordes da fase de Treino 2.

Similar ao Treino 2, também foi observado durante o Treino 3 uma menor concentração de erros nas tentativas com ré bemol consonante. A variância entre os dados obtida por meio do teste Kruskal-Wallis revelou uma diferença significativa (*H*=14,88, *Hc*=14,92, *p*=0,0106). O teste Dunn´s Post-Hoc (com correção Bonferroni dos valores de *p*) indicou um valor de *p*=0,03725 associado ao acorde de ré-bemol consonante, indicando que o número de erros associado a este acorde foi diferente daqueles registrados para os outros acordes da fase de Treino 3.

Durante o Treino 4 também foi possível observar uma quantidade menor de erros nas tentativas com o acorde de sol bemol dissonante. A análise de variância por meio do teste Kruskal-Wallis demonstrou que existe uma diferença significativa (*H*=10,51, *Hc*=10,6, *p*=0,0314) entre as quantidades de erros. O teste Dunn´s Post-Hoc (com correção Bonferroni dos valores de *p*) apontou um valor de *p*=0,05943 relacionado a quantidade de erros durante tentativas com acordes de sol bemol dissonante, um possível indicativo de que o número de erros associado a este acorde foi significativamente diferente daqueles registrados para outros acordes na fase de Treino 4.

Tabela 4

Número de Erros durante os Testes, de acordo com o tipo do Acorde – Consonante e Dissonante – e Nota Fundamental a partir da qual o Acorde foi formado.

Acorde	Testes Erros			
	T1	T2	T3	T4
Ré*b*-C	7	8	3	7
Ré*b*-D	4	5	7	3
Mi*b*-C	4	7	5	6
Mi*b*-D	6	8	8	6
Sol*b*-C	9	5	5	7
Sol*b*-D	6	3	5	5
Lá*b*-C	7	9	7	5
Láb-D	11	10	9	9
Si*b*-C	1	4	5	5
Si*b*-D	6	10	5	11

Nota. A letra “C” é abreviação para consonante e a letra “D” para dissonante.

Por meio da Tabela 4 podemos observar que a distribuição de erros durante os testes variou de forma assistemática. É possível sugerir uma pequena predominância de erros nas tentativas de testes envolvendo os acordes mi bemol dissonante. Mais uma vez, por meio do teste Kruskal-Wallis não foram encontrados resultados significativos (H=11,03, Hc=11,27, p=0,2579) e, diante destes dados, não se pode correlacionar um maior número de erros ao acorde de mi bemol dissonante durante as fases de testes.

Como apontado antes, os acordes consonantes e dissonantes formados a partir das notas réb3 e mib3 também foram utilizadas durante a fase de Treino 3. De forma similar, os acordes consonantes e dissonantes formados a partir das solb3, láb3, e sib3 foram utilizados durante a fase de Treino 4. Nesta perspectiva, a partir do Treino 3 ocorreu uma sobreposição entre os estímulos utilizados nos Treinos 3 e 4 e nos Testes 3 e 4. Para avaliar o impacto desta variação sobre os resultados foi conduzido um teste Kruskal-Wallis a fim de verificar se a variação no número de erros entre os Testes 1, 2, 3 e 4 foi significativa. Os resultados encontrados indicaram que a diferença na quantidade de erros não apresentou significância estatística (H=1,23, Hc=1,25, p=0,07394). Desta forma, temos indícios correlacionais de que não houve uma diminuição significativa do número de erros durante os Testes 3 e 4, se comparados aos Testes 1 e 2.

Discussão

Como proposto inicialmente, o procedimento de ensino utilizado no presente experimento permitiu que todas as fases de treino fossem com acordes consonantes e dissonantes de três notas fundamentais distintas. Tal variação se consistiu em uma tentativa de acentuar as características relevantes e comuns dos acordes (i.e., o intervalo entre as notas que os compõem) e, ao mesmo tempo, evitar o controle exercido por características específicas irrelevantes dos acordes, condições favorecedoras para a ocorrência de generalização (Holth, 2017; Skinner, 1953/2003). A apresentação conjunta de variados exemplares de estímulos desde o início do procedimento de ensino é amplamente utilizada em estudos (e.g., Bortoloti et al., 2019; Kamiyama et al., 2013; Logeswaran & Bhattacharya, 2009) em que os participantes devem ficar sob controle da característica comum a todos eles (e.g., o mesmo estado emocional que é apresentado por um conjunto de faces diferentes) ao invés de características específicas de cada um dos estímulos (e.g., etnia, gênero ou qualquer outra característica específica de um dos modelos fotografados).

A análise dos dados revelou que 14 dentre os 20 participantes do experimento atingiram o critério de 90% de acertos em pelo menos uma das Fase de Treino. Além disto, estes 14 participantes demonstraram um aumento gradual na quantidade de acertos ao longo das fases de treino. Por exemplo, os participantes P4 e P5 demonstraram evolução no número de acertos dentro da mesma de fase de treino e de uma fase de treino para a outra. Esse padrão de evolução também pode ser observado no desempenho de P16 e P20. O participante P16, por exemplo, obteve 66% de acertos no primeiro treino. Esse percentual evoluiu para 87% de acertos no final do Treino 2 e chegou a 95% de acertos logo no início do Treino 3. O participante P20 também obteve 66% de acertos no Treino 1 e atingiu 100% e 91 % de acertos ao final dos Treinos 3 e 4, respectivamente. Estes dados podem ser indícios de que uma aplicação mais prolongada em termos de tempo ou quantidade de sessões poderia resultar em um maior número de participantes atingindo os critérios de aprendizagem estabelecidos. Pesquisas futuras poderiam aplicar procedimentos de ensino similares, contudo, com mais fases de treino, como forma de verificar se aumentar o tempo exposição dos participantes aos estímulos auditivos musicais seria uma condição favorecedora para a aquisição da habilidade musical ensinada no presente experimento.

Ao comparar os resultados do presente experimento com aqueles descritos por Cedro et al. (2019) é preciso considerar que houve uma alteração importante do critério de aprendizagem utilizado. Cedro et al. utilizaram um critério de 75% de acertos em blocos de 20 tentativas, enquanto o critério utilizado no presente estudo era de 90% de acertos em blocos com 24 tentativas. Se utilizássemos o critério de Cedro et al. no presente estudo, 11 dentre 20 participantes teriam atingido os critérios de aprendizagem em todos os blocos de treino. Essa quantidade é levemente superior quando comparado aos resultados do estudo de Cedro et al., no qual sete em 20 participantes atingiram todos os critérios de aprendizagem estabelecidos. Nesse sentido, apesar de não se ter alcançado o nível de efetividade desejado, é possível argumentar que o método de ensino aplicado no presente estudo produziu resultados melhores do que aqueles descritos por Cedro et al.

Mais uma vez, ressaltamos que, por se tratar de pesquisa experimental de caráter exploratório, optamos por não excluir participantes de acordo com critérios pré-estabelecidos de ensino. Desta forma, foi possível observar as porcentagens de cada participante durante todas as fases de ensino (ver Tabela 2). Vale ressaltar que pesquisas anteriores (e.g., Cedro et al., 2019; Reis et al., 2017; Rodrigues et al., 2017) demonstraram como a maioria dos participantes apresentaram porcentagens de acertos ao nível do acaso em tarefas que exigem discriminação de acordes musicais. No presente experimento, por exemplo, apenas três dentre 20 participantes foram capazes de atingir 90% de acertos em todas as fases de treino. Além disto, pesquisas com outros tipos de estímulos auditivos musicais obtiveram dados similares. Por exemplo, em um experimento realizado por Hanna et al. (2016) foram ensinadas relações condicionais entre notações na partitura (estímulo visual) e sequencias de três notas musicais (estímulo auditivo). Durante as fases de testes, em tentativas do tipo auditivo-visual, os resultados variaram entre 65-75% de acertos. No experimento realizado por Madeira et al (2017) foram ensinadas relações condicionais entre notação na partitura e o som de uma nota musical. Durante as fases de testes, os resultados variam entre 45% e 90%. Neste sentido, ao permitir que todos os participantes realizassem todos os passos de treino independentemente dos níveis de acertos obtidos em cada fase de treino, talvez as porcentagens de acertos descritas no presente experimento possam auxiliar futuras pesquisas a identificar critérios de aprendizagem se sejam mais adequados a serem aplicados em tarefas que aparentemente apresentam elevado nível de dificuldade para indivíduos sem histórico de treino formal relacionado a habilidade musicais. Se fosse utilizado um critério de acertos para excluir os participantes, estaríamos inviabilizando de antemão a possibilidade investigar essa importante questão.

O procedimento proposto no presente experimento, assim como aqueles utilizados em experimentos anteriores utilizando o Treino de Múltiplos Exemplares (TME – e.g., Cedro et al., 2019; Reis et al., 2017), está embasado na proposição de que todos os acordes consonantes possuem certas características sonoras comuns. Esse é o motivo pelo qual o estabelecimento de discriminações para um determinado número de acordes consonantes poderia se generalizar para os demais acordes consonantes possíveis. E o mesmo raciocínio se aplica para os acordes dissonantes. O conjunto dos resultados obtidos até o presente momento sugere que essa é uma estratégia possível, porém com eficácia consideravelmente limitada. Em outras palavras, as características sonoras comuns a esses tipos de acordes parecem não exercer o nível de controle suficiente para ocasionar desempenhos característicos de generalização (Cedro et al., 2019). Além disso, esse controle limitado também parece ocasionar dificuldades para o aprendizado das relações condicionais como aquelas ora ensinadas, fato que ocasiona uma quantidade elevada de falhas na obtenção dos critérios de aprendizagem estabelecidos.

Nesse contexto, seria interessante investigar quais outros processos comportamentais, para além do controle pela similaridade sonora entre os acordes, poderia embasar a formação de conceitos envolvendo estímulos musicais, como, por exemplo, consoante e dissonante. Um dos possíveis processos seria a formação de classes de equivalência (Sidman, 1994, 2000). De maneira resumida, o paradigma de equivalência de estímulos argumenta que estímulos podem se tornar equivalentes entre si caso compartilhem uma história comum de reforçamento. Por exemplo, ao treinar habilidades musicais, os aprendizes são constantemente expostos a tarefas em que acordes formados por diferentes notas são nomeados da mesma forma (e.g., consonantes, maiores, menores etc.). Essa relação com um nome comum pode fazer com que sons diferentes tornem-se equivalentes entre si. Assim, a formação do conceito de consonante estaria relacionada não somente à similaridade sonora entre os acordes, mas também, em alguma medida, à formação de uma classe de equivalência decorrente do ensino incidental dessas habilidades de nomeação dos acordes. De fato, uma quantidade considerável de estudos utilizando métodos de ensino baseados no paradigma de equivalência de estímulos para ensinar muitos repertórios comportamentais envolvendo estímulos musicais foi conduzida recentemente (e.g., Griffith, Ramos, Hill, & Miguel, 2018; Hanna et al., 2016; Hill, Griffith, & Miguel, 2020; Madeira et al., 2017). Em pesquisas futuras, para além dos testes de generalização, seria interessante realizar testes de formação de classes de equivalência com os estímulos utilizados. Uma possibilidade seria a de que os participantes com maior porcentagem de acertos nos testes de generalização também seriam aqueles para os quais as classes de equivalência estariam mais bem estabelecidas.

Mesmo considerando as limitações quanto ao procedimento de ensino ora utilizado, também é preciso pontuar que até adultos com diferentes níveis de treino formal em habilidades musicais demonstram variações na quantidade de acertos quando expostos a tarefas de diferenciação entre acordes (Kuusi, 2013). No estudo conduzido por Kuusi foram aplicadas tarefas do tipo oddball, com a apresentação de cinco acordes em sequência. Em cada sequência, quatro acordes maiores e um desviante eram tocados. Os participantes deveriam indicar o acorde desviante ao pressionar um, dentre cinco diferentes botões correspondentes a ordem de apresentação na sequência. Foram três grupos de participantes divididos por meio de um questionário desenvolvido para aferir seu nível de habilidades musicais. Todos eles obtiveram altos índices de acertos no questionário, contudo, os grupos foram divididos em: compositores e teóricos; músicos profissionais; e músicos não profissionais. Compositores e teóricos obtiveram, em média, 77% de acertos na tarefa; músicos profissionais obtiveram, em média, 40% de acertos; e músicos não profissionais obtiveram, também em média, 30% de acertos. Estes dados refletem o quão difícil pode ser uma tarefa de diferenciação de acordes, mesmo para pessoas com treino formal em habilidades musicais.

Interessante notar que o método aplicado por Kuusi (2013) é similar ao que foi aplicado por Virtala e colaboradores (Virtala et al., 2011, 2012, 2013), ou seja, tarefas do tipo oddball em que o participante deve indicar um acorde musical desviante em relação ao um padrão de acordes musicais. Curiosamente, os resultados encontrados por estes estudos parecem ser discrepantes entre si, na medida em que os índices de acertos dos estudos que exigem uma resposta operante (como apertar um botão –

e.g., Kuusi, 2013) não refletem o grau de diferenciação entre acordes é demonstrada por meio do EEG (e.g., Virtala et al., 2013). Pesquisas futuras poderiam investigar se os participantes demonstrariam diferentes resultados quando submetidos a tarefas do tipo oddball e a medidas do EEG com estímulos auditivos (acordes) idênticos, ou seja, seriam coletadas respostas operantes e, também, por meio de componentes eletroencefalográficos. Se houver discrepância entre estes dados, existe a possibilidade de que os processos de percepção detectados pelo EEG não estejam diretamente associados ao aprendizado de tarefas que exigem repostas comportamentais motoras, pelo menos em casos em que as tarefas envolvam estímulos musicais como acordes.

No presente experimento, optou-se por utilizar acordes com timbre de piano tendo em vista que são recorrentes os experimentos com estímulos musicais que os utilizam em procedimentos de pesquisa (e.g., Bakker & Martin, 2014; Hanna et al., 2016; Leung & Dean, 2018; Loudwin & Bannert, 2017; Madeira et al., 2017; Reis et al., 2017). Se soma a isto o fato de que ainda há poucas publicações nas quais essa variável foi estudada de forma sistemática (Byo & Schelegel, 2016; Rodrigues et al., 2017). Por exemplo, o estudo de Rodrigues et al. comparou os desempenhos de participantes que foram expostos a procedimentos de ensino similares cuja única variação foi o timbre do instrumento utilizado para compor os estímulos auditivos, para um grupo os acordes eram produzidos com o timbre de piano e para outro grupo os acordes eram produzidos com o timbre de violão, não tendo sido observadas diferenças significativas entre os desempenhos dos participantes devido a essa variável.

Por fim, o ensino de habilidades de classificação de intervalos e acordes consonantes e dissonantes pode se configurar em habilidade que propicia a classificação de outros acordes comumente utilizados na tradição da música ocidental, a saber os acordes maiores e menores (por também serem acordes consonantes) e os acordes aumentados e diminutos (por também serem acordes dissonantes). Ainda vale ressaltar que os parâmetros utilizados para programar o procedimento do presente estudo são demonstrações de diferentes formas de tarefas para o ensino de habilidades de classificação de estímulos auditivos. Nesta perspectiva, podemos oferecer esta contribuição para pesquisas futuras que pretendam ensinar relações condicionais entre estímulos auditivos exercendo função de modelo e estímulos visuais com função de comparação. Ainda neste sentido, o presente procedimento pode ser aplicado em diferentes pesquisas com estímulos auditivos de variados tipos, além dos musicais.

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ARTIGO 3

Teaching to Classify Musical Excerpts – Major and Minor – Through a Matching to Sample Training[3]

Abstract

The present study evaluated a procedure based on Matching-to-Sample training to establish conditional relations between musical excerpts and printed words. In addition, tests to assess the generalization of new musical excerpts and harmonic progressions were conducted. Twenty college students were taught about the conditional relations between major and minor musical excerpts and the printed words "MAJOR" and "MINOR." Generalization tests were given in between each training phase. Fourteen participants achieved the learning criteria for all training phases. The results revealed that most the participants had between 80% and 100% correct answers in the four-generalization tests with musical excerpts. Otherwise, during the tests with harmonic progressions, most the participants reached results at the chance level. Our findings showed that the MTS-based procedure was suitable for establishing conditional relations between musical excerpts and printed words. Moreover, the test results revealed the generalization to new musical excerpts, but not for harmonic progressions.

Keywords: musical excerpts, harmonic progressions, matching-to-sample, generalization.

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In recent years, in the context of Behavior Analysis, several studies assessed behavioral methods and processes for teaching different musical skills (Cedro et al., 2019; Griffith et al., 2018; Hanna et al., 2016; Hill et al., 2020; Hanna et al., 2017; Madeira et al., 2017; Reis et al., 2017). Some of these studies sought to teach musical skills related to sheet music reading, chord symbols recognition, and/or pressing specific piano keys when faced with scores or chord symbols (Griffith et al., 2018; Hanna et al., 2016; Hanna et al., 2017; Hill et al., 2020). Other studies, in turn, sought to teach musical skills of discrimination and classification of musical auditory stimuli, such as musical notes or chords – play two or more musical notes simultaneously (Cedro et al., 2019; Madeira et al., 2017; Reis et al., 2017). In common, all these studies used matching-to-sample procedures (MTS – Cumming & Berryman, 1961, 1965) for teaching the conditional relations embedded in the tasks.

In this way, an example of research with MTS is the study conducted by Griffith et al. (2018). In Griffith et al., the stimulus set A was the three dictated chord names, namely fa major, sol major, and do major. The stimuli set B was the three representations in the form of symbols for these chords, in which the fa major chord was symbolized by the letter “F”, the sol major chord was symbolized by the letter “G”, and the do major chord was symbolized by the letter “C”. The stimuli set C was the three representations of these same chords in the score. The set D was the vocal responses emitted by the participants, referring to the names of the chords. The E set was the response to the piano keys referring to one of the three chords. During the training phases, the teaching of conditional relations between stimuli from sets A and B (AB training) between stimuli from sets A and C (AC training), and between stimuli from sets A and E (AE training) were conducted. Thus, during a given trial, after the presentation of the sample stimulus A1, and when faced with two or more comparison stimuli, the participant must choose the comparison stimulus which is related to the sample stimulus, in this case, B1. In a later trial, in front of the sample A2 stimulus, when faced with two or more comparison stimuli, the participant must choose the B2. In a third trial, in front of the sample stimulus A3, when faced with two or more comparison stimuli, the participant must choose the stimulus comparison B3. The same process was carried out to establish relations between “AC” and “AE”.

The MTS can also be used to apply tests to verify the emergence of conditional relations between stimuli that were not directly taught. According to the stimulus equivalence paradigm (Sidman & Tailby, 1982; Sidman, 1994), after direct teaching of conditional relations between arbitrary stimuli A and B, and between arbitrary stimuli B and C, these relations could be classified as equivalence relation if it possesses the properties of reflexivity, symmetry, and transitivity. The reflexivity is observed when emerges relations between the same stimuli, for example, conditional relations between A and A, B and B, C and C. We observe the property of symmetry when occurs an emergence of relation with inversion of functions between stimuli, for example, B and A or C and B type relations. The property of transitivity is observed when occurs a relation between stimuli that were not directly paired but paired to a third common stimulus during training, for example, the emergence of the AC conditional relation, after teaching AB and BC relations.

Griffith et al. (2018), during the testing phases, verified the emergence of the BC and CB relations, in other words, relations between the visual stimuli chord name and chord symbol. Also during the testing phases, the emergence of the BD and CD relations was verified, that is, the participant was asked which chord was presented in the score. The experimenters also asked to the participants press the piano keys referring to the presented chords. Participants scored between 89% and 100% on tests of relating and labeling visual stimuli. The participants also presented between 89% and 100% of correct answers in the tests of pressing the piano keys referring to the chords presented in the score.

Similar to other studies (Arntzem et al., 2010; Hill et al., 2020), in Griffith et al. (2018), the teaching of conditional relations between auditory musical stimuli (i.e., chords) and the representation of chords in the score does not lead to generalization. In other words, the C major chord was related to a specific set of visual stimuli, for example, its representation in the score. In turn, the re major chord is related to another specific set of visual stimuli, once again, it representation in the score. In this context, the essential thing is to distinguish chords sounds from each other, because the teaching procedure was based on the establishment of different stimulus classes.

However, some musical skills are largely based on the generalization between different stimuli, for example, labeling auditory musical stimuli as “major” or “minor”. Chords; harmonic progressions (groups of chords); scales – standardized sets of musical notes played sequentially; melodies – semi-randomized sets of musical notes played sequentially; and musical excerpts – a combination of melody and harmonic progression – are all auditory musical stimuli that can be classified as “major” (i.e., major chord, major scale, major harmonic progression, major melody, major musical excerpt). To the same extent, all the before cited auditory musical stimuli also can be classified as “minor” (i.e., minor chord, minor scale, minor harmonic progression, minor melody, minor musical excerpt) (Guest, 2006; Levine, 2011; Mulholland & Hojnacki, 2013; Schmeling, 2011). To determine the type of the chord – major or minor – we need to verify the distance between the first note (fundamental note of the chord – gives it a name) and the second note of the chord. In the case of the scales, we need to verify the distance between the first note (tonic note of the scale – gives it a name) and the third note. We measure this distance using semitones: in the major chords, the distance between the first and second notes is four semitones; in the minor chords, the distance between the first and second notes is three semitones. Similar to the major chord, in the major scale, the distance between the first and the third note is four semitones. Similar to the minor chord, in the minor scale, the distance between the first and third notes is three semitones. The most important point about this, the distance between notes is the same in the major chord and major scale and, the distance between notes is the same in the minor chord and minor scale.

A crucial difference between scales and chord is in the way the notes are played: in the scales, the notes are played sequentially; in the chords, the notes are played simultaneously. In turn, harmonic progressions are groups of chords and, a major harmonic progression is composed of major chords and, a minor harmonic progression is composed of minor chords. A major melody is composed with the same notes of the major scale but these notes are organized in a semi-randomized way, it is true for minor melodies either. Therefore, the major chord shares some sound characteristics with all other major chords and, at some point, share some sound characteristics with the major scale. The same can be said about minor chords, that is, a minor chord shares some sound characteristics with all other minor chords and, at some extent, share some sound characteristics with the minor scales. Logically, a major scale share some sound characteristics with all other major scales and a minor scale share some sound characteristics with all other minor scales either. Maybe, all the auditory musical stimuli (chords, scales, harmonic progressions, melodies, musical excerpts) classified as major share some sound characteristics among them, and, all the musical stimuli classified as minor share some sound characteristics among them. Perhaps, the discrimination of one restricted set of auditory musical stimuli (e.g., chords) can generate generalization of stimuli control between different sets of stimuli (harmonic progression, musical excerpts, melodies, etc.). Following Mulholland and Hojnacki

(2013), the complete extension of the chord is in the relative scale of the chord. As stated by the authors, “In C Major, the full expression of the IMaj7 chord is the Ionian chord scale” (p. xi).

To some extent, some studies (Cedro et al., 2019; Madeira et al., 2017; Reis et al., 2017; Langendonck et al., 2020) have tried to teach musical skills involving the generalization of different auditory musical stimuli. For example, Cedro et al. (2019) used an MTS-based procedure to establish conditional relations between major and minor chords and the printed words MAJOR and MINOR, respectively. Testing phases were interspersed with teaching phases, after teaching phase 1, test phase 1, after phase teaching phase 2, test phase 2, and so on. The chords were of the same types during the training and testing phases – majors and minors –, the difference between these chords were the notes used to compose them. The chords used during the teaching phases were formed from the notes do, re, mi, fa, and sol; otherwise, the chords used during the testing phases were formed from the notes re flat, mi flat, sol flat, and la flat. Among the 20 participants, only five reached the criteria of correct answers in the teaching phases (75% of correct answers per phase), with results between 80% and 100% of correct answers during the generalization tests. These results suggest that was difficult to establish the discrimination of musical chords.

Despite of the results described in Cedro et al. (2019), in the present experiment, we tried to teach participants to label auditory musical stimuli; however, for this, we did not use the chords as auditory musical stimuli. In the literature, the number of studies using musical excerpts in their experimental design seems to be greater than studies using any other musical stimuli (i.e., chords, harmonic progressions, melodies). Eerola and Vuoskoski (2013) conducted a literature review on the relationship between music and the different emotions elicited by it. According to the authors, among 251 experiments, 175 used musical excerpts as auditory stimuli. In addition, 48% of them used musical excerpts extracted from songs by composers such as Bach, Beethoven, Wagner, and Vivaldi – composers of western classical music. Furthermore, due to the elements of each one of these auditory musical stimuli, we can assume that musical excerpts are easiest to distinguish from each other than musical chords. Maybe, can be easiest for the participant to identify the differences between two different musical excerpts, mainly when compared to the differences between two different chords.

In summary, a considerable number of studies provided important evidence on the teaching of different musical skills. Mainly musical skills related to sheet music reading, chord symbols recognition, and pressing specific piano keys when faced with scores or chord symbols (e.g., Acín et al., 2006; Arntzen et al., 2010; de Souza & Micheletto, 2020; Griffith et al., 2018; Hanna et al., 2016; Hanna et al., 2017; Hill et al., 2020; Langton et al., 2020). However, few studies (Cedro et al., 2019; Madeira et al., 2017; Reis et al., 2017) aimed to establish discrimination of auditory musical stimuli such as musical chords. Specifically, just Cedro et al., (2019) tried to teach musical skills supported by a generalization of stimulus control. Moreover, it is also worth noting that auditory discriminations based on the generalization of stimulus control have considerable ecological value, being among the first skills taught to music learners. In other words, to some extent, recognizing and labeling chords, scales, harmonic progressions, and melodic intervals is what we know as aural skills.

Following the exposed reasons, the objective of the present experiment was to conduct training to establish conditional relations between major and minor musical excerpts and the printed words MAJOR and MINOR. It was also an objective to verify whether, during test phases, the participants would be able to label new musical excerpts and harmonic progressions. Due to the similarities between the used musical stimuli, maybe, in the test phases, the participants can be able to label new musical excerpts, in this case, generalization between different musical excerpts. In addition, we also verified whether the discrimination training with musical excerpts was enough for the participant labeling harmonic progressions, demonstrating generalization when faced with stimuli from a new set of auditory musical stimuli. Positive results in the tests with harmonic progressions are indicatives that a training with one set of auditory musical stimuli can lead to generalization between different set of auditory musical stimuli.

Method

Participants

Twenty undergraduate students (15 women) with a mean age of 20.9 years (SD: 5.39 years) participated in the experiment. Before being exposed to the experimental task, they read and signed an informed consent form. All experimental procedures were approved by the Committee of Ethics in Research with Humans, Universidade Federal de Minas Gerais (process number CAAE: 44508615.2.0000.5149).

Setting and Equipment

Data were collected in a 4m x 6m room, provided with good lighting and low noise levels, were used computers with 23" screens, keyboard, and mouse. The auditory stimuli were presented through headphones – bilateral headphones, with high fidelity and stereo sound, capable of reproducing all frequency waves between 10Hz and 23,000Hz, with an impedance of 32Ω, maximum output of 50mW, and sensitivity of 96dB. The pretest, training, and testing blocks were programmed using the Stimulus Control software (Picanço, 2017).

Stimuli

Two sets of musical stimuli were used. The first set of stimuli consisted of 24 excerpts from the Western classical music repertoire extracted from Peretz, Gagnon, and Bouchard (1998). Among these musical excerpts, 12 were compositions in major keys and 12 in minor keys. These excerpts are the same used by Peretz et al. (1998 – see appendix 1 for details) and were presented with a pulse of 84 beats per minute and duration varying between five and seven seconds.

The second set of auditory stimuli was composed of harmonic progressions. The major harmonic progressions were made with three major chords and minor harmonic progressions were made with three minor chords. The harmonic progressions used here are known as "I, IV, V", for a more detailed explanation see Mulholland and Hojnacki (2013) or Levine (2011). The main difference between the harmonic progressions are the chords to compose them; the five major harmonic progressions were compounded with major chords composed from the notes si-flat 3 (Bb3), re-flat 3 (Db3), mi-flat 3 (Eb3), sol-flat 3 (Gb3), and la-flat 3 (Ab3). Similarly, the five minor harmonic progressions were compounded with minor chords composed from the same notes (Bb3, Db3, Eb3, Gb3 and Ab3). To record the harmonic progression, we used Ableton® software (version 9.4.7 – 64 bits) and MIDI technology (Musical Instrument Digital Interface) to play the chords of the harmonic progressions with classical piano timbre. All the harmonic progressions were made with the same rhythmic characteristics (quarter notes in 84 bpm´s) and the same parameters of intensity, volume, duration, and attack, each harmonic progression lasting four seconds. Visual stimuli were the printed words MAJOR and MINOR, written in capital letters, with Arial font, size 100.

Procedure

The trial started with the simultaneous presentation of an auditory sample stimulus and a blue rectangle in the upper central part of the computer screen. The interruption of the presentation of the auditory stimulus occurred when the participant clicked on this rectangle. The emission of this response produced the presentation of two visual comparison stimuli (i.e., printed words) at the lower right and left vertices of the screen, while the presentation of the auditory sample stimulus ended. The presentation positions of the comparison stimuli varied in a semi-random manner. During the teaching phases, responses to the correct comparison stimulus caused the presentation of a green check, and responses to the incorrect comparison stimulus caused the presentation of a red “X”. The presentation of the differential consequences for correct and incorrect answers lasted 1s and was followed by an inter-trial interval (ITI), also lasting 1s, during which the screen remained blank.

Pretest

The Pretest consisted of a block of 20 trials in which the auditory stimuli were divided as follows: five trials presenting major musical excerpts, five presenting minor musical excerpts, five presenting major harmonic progressions, and, five presenting minor harmonic progressions. The presentation of auditory stimuli occurred in a semi-random order, in which the same type of sample was presented only in two consecutive trials. In the test blocks, the differential consequences were suspended for correct and incorrect answers. The visual comparison stimuli were the printed words MAJOR and MINOR. Participants who reached no more than 65% correct answers during the Pretest performed the Training Phases and later Test Phases. Participants who reached more than 65% correct answers in the Pretest were dismissed.

MTS-based Training

There was an application of four teaching phases and four testing phases during the training procedure. In each teaching phase, six musical excerpts, three major musical excerpts and three minor musical excerpts were used. In each test phase were used five major musical excerpts, five minor musical excerpts, five major harmonic progressions, and five minor harmonic progressions. Differential consequences for the for correct and incorrect answers occurred only during the training phases. Training Phase 1 consisted of a block with 12 prompted trials – a green frame indicated the correct answer. No learning criteria were used for this block. After the prompted block, a block with 18 trials without cues was conducted, and three trials for each musical excerpt were presented. Was used a learning criteria of 80% of correct answers for this block. When the participant reached the criterion, he was exposed to Test 1. However, in case he does not reach the criteria, he was exposed to a new prompted block with six trials and proceeded to a new training block with 18 trials. Participants had three opportunities to meet the 80% of correct answers. Nevertheless, the participant proceeded to Test 1 even when he did not reach the criteria after three opportunities. We did this in an attempt to avoid losing participants. Training Phases 2, 3, and 4 are practically identical to Training Phase 1, the only difference is the musical excerpts used in each phase.

All posttests were identical to the Pretest, that is, five trials with major musical excerpts, five trials with minor musical excerpts, five trials with major harmonic progressions, and five trials with minor harmonic progressions, including the same musical excerpts and harmonic progressions used during the pretest and the differential consequences were suspended for correct and incorrect answers.

It is worth mentioning that in Tests 1 and 2, it was possible to assess generalization with the results of all trials because the five musical excerpts used are different from those used in the training. Otherwise, in Test 3, it was possible to assess generalization with the results of six trials, because four musical excerpts – two major and two minor – also were used in Training 3. The Test 4 measured just the results of direct training because the six musical excerpts – three major and three minor – used during Test 4 also were used during Training 4. However, in the case of harmonic progressions, we can assess generalization in the four test phases, because this set of auditory musical stimuli (harmonic progressions) never was presented during the training.

As shown in Table 1, there was an alternation between the training and testing phases throughout the procedure so that, after applying the Pretest, the participants performed the Training Phase 1, followed by Test 1, and so on.

Table 1

Sequence and Details of the Training and Tests Phases

Sequence	Auditory Musical Stimuli	Trials	Criteria
1 – Training	3 major excerpts: A1, A2, A3 3 minor excerpts: B1, B2, B3	12 prompted 18 without cues	80% in one block or three repetitions without criteria
1 – Test	5 major excerpts: A8, A9, A10, A11, A12 5 minor excerpts: B8, B9, B10, B11, B12 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply
2 – Training	3 major excerpts: A4, A5, A6 3 minor excerpts: B4, B5, B6	12 prompted 18 without cues	80% in one block or three repetitions without criteria
2 – Test	5 major excerpts 5 minor excerpts 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply
3 – Training	3 major excerpts: A7, A8, A9 3 minor excerpts: B7, B8, B9	12 prompted 18 without cues	80% in one block or three repetitions without criteria
3 – Test	5 major excerpts 5 minor excerpts 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply
4 – Training	3 major excerpts: A10, A11, A12 3 minor excerpts: B10, B11, B12	12 prompted 18 without cues	80% in one block or three repetitions without criteria
4 – Test	5 major excerpts 5 minor excerpts 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply

Results

Figure 1 demonstrates the participant´s results during the Pretest. The gray bars represent the percentage of correct answers in trials with musical excerpts (M.E) and black bars in trials with harmonic progressions (H.P). In both trial types (M.E and H.P), the participants presented results at the random level. Interestingly, among 20 participants, 13 showed slightly better results with harmonic progressions.

Figure 1.

Percentage of the Correct Answers in Pre-Test

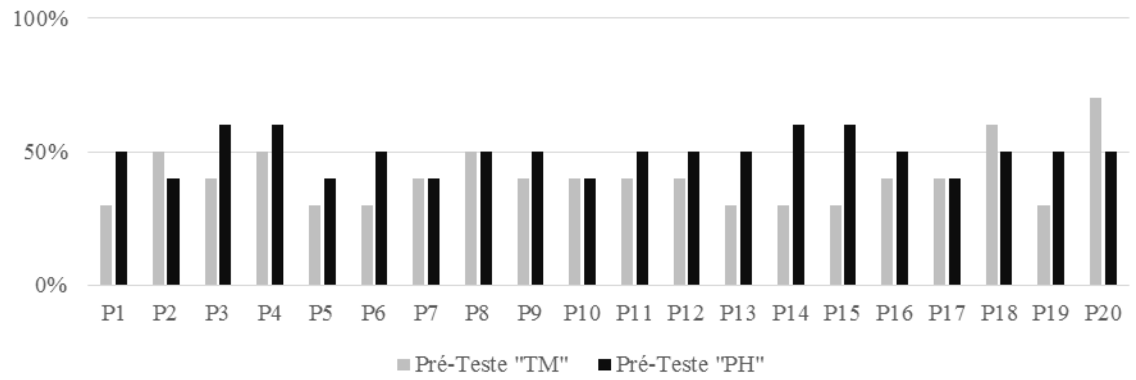

Table 2 shows the participants' performance during the teaching phases. In Training 1, 14 participants reached the learning criteria in the first exposure to the block, and five of them obtained 100% of correct answers. In addition, four participants (i.e., P9, P12, P13, and P20) achieved the learning criteria during the second exposure to the block. Participants P3 and P10 did not reach the criteria even after three exposures but, according to the rules defined for the procedure, they were moved to phase 2. During Training 2, 14 participants reached 80% of correct answers in the first block, among these, four reached 100% of correct answers. Four participants reached 80% of correct answers during the second block (P14, P15, P18, P20), and P18 reached 100% of correct answers. Two participants (P3 and P11) did not reach 80% of correct answers during Training 2. Concerning Training 3, 16 participants reached 80% of correct answers or more in the first block, among these, nine participants reached 100% of correct answers. Two participants reached 80% of correct answers during block 2 (P10 and P14), one participant reached 94% of correct answers during block 3, and one participant did not reach 80% of correct answers during Training 3 (P15). In Training 4, all the participants reached 80% of correct answers or more during the first block. It is worth mentioning that 14 participants reached 100% of correct answers in the first block, five participants (P5, P7, P10, P15, P20) reached 94% of correct answers during the first block, and one participant (P1) reached 89% of correct answers.

Table 2

Percentage of the Correct Answers During Training

	Training 1			Training 2			Training 3			Training 4
Part.	B.1	B.2	B.3	B.1	B.2	B.3	B.1	B.2	B.3	B.1
P1	94%			94%			100%			89%
P2	94%			100%			100%			100%
P3	28%	72%	50%	72%	78%	67%	83%			100%
P4	94%			100%			94%			100%
P5	100%			94%			100%			94%
P6	100%			89%			100%			100%
P7	94%			89%			94%			94%
P8	100%			100%			94%			100%
P9	56%	94%		89%			100%			100%
P10	56%	61%	67%	83%			72%	83%		94%
P11	100%			56%	78%	67%	100%			100%
P12	72%	89%		94%			100%			100%
P13	78%	94%		100%			100%			100%
P14	83%			61%	89%		78%	83%		100%
P15	83%			61%	83%		61%	67%	61%	94%
P16	100%			83%			83%			100%
P17	89%			83%			94%			100%
P18	94%			72%	100%		72%	78%	94%	100%
P19	89%			89%			100%			100%
P20	56%	89%		78%	83%		89%			94%

Note: Part = participant; B.1 = block 1; B.2 = block 2; B. 3 = block 3

The data of the test phases are presented in Table 3. Regarding the musical excerpts, most participants obtained results above 80% of correct answers during Test 1, and more than half of the participants reached 100% of correct answers in Test 1. In general, the majority of participants reached between 90% and 100% correct answers during Test 2. During Test 3, one participant reached 70% correct answers. Again, the majority of participants reached 90% or more the correct answers. Regarding Test 4, 15 participants obtained 100% of correct answers, and five participants obtained 90% of correct answers. Interestingly, during Test 3, the mistakes made by participant 10 were with new musical excerpts, different from those shown in Training 3 and, in this way, the results of this participant do not indicate generalization. Table 3 shows the results of the participants during the pretests and subsequent tests.

Table 3

Percentage of the Correct Answers During Tests

Part	Pretest M.E	Pretest H.P	Test 1 M.E	Test 1 H.P	Test 2 M.E	Test 2 H.P	Test 3 M.E	Test 3 H.P	Test 4 M.E	Test 4 H.P
1	30%	50%	90%	60%	90%	40%	100%	60%	100%	60%
2	50%	40%	90%	80%	100%	70%	100%	80%	100%	70%
3	40%	60%	80%	50%	80%	50%	80%	60%	90%	50%
4	50%	60%	100%	60%	100%	50%	100%	60%	100%	50%
5	30%	40%	100%	80%	100%	70%	100%	80%	100%	90%
6	30%	50%	100%	60%	100%	50%	100%	60%	100%	70%
7	40%	40%	80%	50%	100%	50%	90%	50%	100%	40%
8	50%	50%	100%	60%	100%	80%	100%	80%	100%	90%
9	40%	50%	100%	70%	100%	80%	90%	70%	100%	60%
10	40%	40%	50%	60%	40%	40%	80%	50%	90%	50%
11	40%	50%	100%	50%	100%	60%	100%	50%	100%	70%
12	40%	50%	100%	60%	100%	50%	100%	80%	100%	60%
13	30%	50%	100%	70%	100%	80%	100%	70%	100%	70%
14	30%	60%	30%	30%	80%	40%	80%	50%	90%	50%
15	30%	60%	100%	40%	80%	50%	70%	50%	90%	50%
16	40%	50%	100%	50%	100%	60%	100%	50%	100%	50%
17	40%	40%	100%	50%	90%	50%	100%	50%	90%	60%
18	60%	50%	90%	80%	90%	50%	90%	50%	100%	60%
19	30%	50%	90%	50%	90%	60%	90%	100%	100%	60%
20	70%	50%	90%	60%	80%	50%	90%	50%	100%	50%

Note: Part = participant; M.E = musical excerpt; H.P = Harmonic Progression.

During the Pretest, the majority of participants presented results between 30% and 50% of correct answers. On the other hand, after the application of Training 1, 16 participants presented between 90% and 100% correct answers during Test 1. The Shapiro-Wilkinson test showed that the distribution of the number of answers in the Pretest and Test 1 with musical excerpts was not parametric. In this sense, the Mann-Whitney test showed a statistically relevant difference (z: 4.95; p= 0,0001) between the number of correct answers in the Pretest and the number of correct answers in the Test 1. Accordingly, the skill of label musical excerpts was absent in the participants' repertoire and it was acquired very quickly, the participants demonstrated generalization without the need for extensive training with an extensive variety of stimuli.

To verify whether the difference in the number of correct answers between tests 1, 2, 3, and 4 was statistically significant we used the Kruskal-Wallis test, the test did not show a significant statistical difference (H=2.88; Hc=3 .74; p=0.29). In this sense, we can argue that the use of identical musical excerpts during the training and testing phases, as occurred in the final part of the procedure, did not influence the percentages of correct answers obtained by the participants. It is worth noting that during tests 1 and 2, the majority of participants reached 100% of correct answers in trials with the musical excerpts.

Regarding the trials of tests with harmonic progressions, during Test 1, most participants showed results at the chance level. Only three participants (P2, P5, and P18) showed 80% of correct answers. These participants also reached high results in Test 1 with musical excerpts. During Test 2, once again most participants obtained percentages close to 50% of correct answers. Only three participants (P8, P9, P13) reached 80% of correct answers. Once again, the same participants (P8, P9, P13) also achieved high results in Test 2 with musical excerpts. On Test 3, most participants obtained correct answers at the chance level. One participant (P19) attained 100% of correct answers, this participant also reached 100% during Test 3 with musical excerpts. With Test 4, one more time, most participants reached levels at the chance of correct answers. Just two participants (P5 and P8) reached 90% of correct answers. These participants also attained high results in Test 4 with musical excerpts. As we said before, the participants were not taught to discriminate harmonic progressions. Hence, the positive results in the tests with harmonic progressions are evidence of generalization between auditory musical stimuli from different sets.

Discussion

The objective of the experiment was to verify the possibility of establishing abilities of classification of major and minor musical excerpts through an MTS-based training. To establish these skills, we conducted four training phases. Participants also performed tests that assess the occurrence of generalization of stimulus control for new musical excerpts. Regarding the participants' performance in the training phases, most of them reached percentages above 80% of correct answers in the first teaching step (i.e., Training 1) and maintained this performance throughout the other steps (i.e., Training 2, 3, and 4). Considering that the performance of the participants in the Pretest indicated the absence of this skill, it seems plausible to argue about the effectiveness of the procedure used for teaching the classification of musical excerpts as major or minor. Considering mainly the results obtained in Tests 1 and 2, it is also plausible to argue about the occurrence of generalization of stimulus control. More specifically, we can observe that the classification skill based on “major” and “minor” taught to a restricted set of musical excerpts was generalized to a new set of musical excerpts; these new musical excerpts were also major and minor types.

It is interesting to note that the results obtained in the present experiment were considerably superior to those obtained by Cedro et al. (2019), whose objective was to teach the ability to classify major and minor chords also using an MTS-based training. As demonstrated in a literature review on the relationship between music and the different emotions elicited by it (Eerola & Vuoskoski, 2013), among 251 experiments, 175 used musical excerpts as auditory stimuli and, among these, 48% of them used musical excerpts extracted from songs of the repertoire of western classical music. Maybe, the simple use of musical excerpts explains the better results obtained in the present experiment, when compared to Cedro et al. As we pointed out before, according to the acoustic elements of these stimuli, the musical excerpts are easiest to distinguish from each other than to distinguish the harmonic progressions from each other. The results showed that, during test phases, more participants identify the differences between different musical excerpts, and, just a few participants identify the differences between different harmonic progressions.

Another possible reason for the high results, previous studies have systematically demonstrated the existence of conditional relations between major musical excerpts and emotions of positive valence, as well as between minor musical excerpts and emotions of negative valence (Eerola & Vuoskoski, 2013; Kastner & Crowder, 1990; Peretz et al., 1998). For example, Kastner and Crowder (1990) investigated the affective qualities of musical excerpts in typically developing children aged between 3 and 12 years. Participants listened to different musical excerpts and chose the face that best represented the emotion conveyed by the musical excerpt. The results obtained indicated that children were able to relate major musical excerpts to faces that expressed positive valence emotions and minor musical excerpts to faces that expressed negative valence emotions, even in the absence of any previous training.

Perhaps, the high results in training- and test trials with the musical excerpts are due to the rhythmic characteristics of these stimuli. To some extent, minor musical excerpt tend to be slower, mainly compared to major musical excerpts, which in turn, tend to be fast. Some studies demonstrated that this rhythmic characteristic determines the way people discriminate and classify musical excerpts. For example, in Dalla-Bella et al. (2001), participants of 5 years old or younger classify the faster musical excerpts as major (or happy) and the slower musical excerpt as minor (or sad), independently of whether these excerpts are major or minor. Nave-Blodgett et al. (2021) paired musical excerpts with auditory and visual metronomes that matched or mismatched the beats per second of the musical excerpts. Then, they asking children – between 5 and 10 years old – to rating the beat of the musical excerpts in relation to the beat of the metronomes. The children were able to recognize incongruences between the beat of the metronome and the beat of the musical excerpts, even in the absence of any previous training. As seen in Dalla-Bella et al. (2001) and Nave-Blodgett et al. (2021), even young children can distinguish between musical excerpts based only on the rhythmic characteristics. Perhaps, future research can conduct experiments in which the rhythmic characteristics between musical excerpts are fully controlled, in an attempt to assess only the characteristics associated with “major” and “minor” classification or other aspects of the musical excerpt, such as timbre, attack, dynamics, and/or duration.

In addition to the generalization of stimulus control for new musical excerpts, the present experiment also evaluated the generalization for major and minor harmonic progressions. Regarding these tests, most participants obtained results at the chance level, demonstrating that an MTS-based training with musical excerpts was not enough to establish the skills to discriminate and classify major and minor harmonic progressions. Perhaps, the results during tests with harmonic progressions were due to the less discriminating characteristics of harmonic progressions when compared to musical excerpts, as we pointed out before.

It is worth mentioning that a trial with one harmonic progression is equal to a trial with three chords. The major harmonic progressions used in this experiment were compounds of three major chords, and the minor harmonic progression used were compounds of three minor chords. Therefore, the results with harmonic progressions are similar and comparable to those founded with one chord per trial, as in Cedro et al. (2019). In this way, in both cases, Cedro et al. and the present study, the majority of the participants demonstrated results at the chance level in the test trials with chords, independently whether the trial was with one chord or three chords.

Additionally, the absence of generalization for harmonic progressions seems to indicate the need for longer training, with other musical stimuli, in addition to musical excerpts. It seems pertinent to conduct a teaching procedure to establish the discrimination between major and minor musical excerpts first, followed by the discrimination of major and minor melodies, moving on to the discrimination of major and minor harmonic progressions to finally carry out the discrimination of major and minor chords. Perhaps, a procedure like that could become an agile and accurate way to establish the discrimination of auditory musical stimuli. Future experiments could verify this sequential training to assess its usefulness.

The data set produced so far seems to suggest that musical excerpts are the most suitable stimuli to start a teaching procedure to establish the discrimination of auditory musical stimuli. At least, we can point to two reasons: (i) the majority of participants in the present experiment reached high levels of correct answers during training and tests with musical excerpts; (ii) among the aforementioned auditory stimuli, the musical excerpt is the only one with characteristics of all other auditory musical stimuli. For example, a given major musical excerpt contains a majority of major chords (harmonic progression), parts of major scales (as melodies), all presented semi-randomly (rhythm) and, most importantly, all with the main characteristic which must be discriminated by the participant, in this case, all the stimuli are the major ones. The same is valid for minor musical excerpts. For these reasons, we argue that is more indicated start an auditory discrimination training with musical excerpts rather than any other musical stimulus.

In summary, the results presented in the present experiment demonstrate that an MTS-based procedure was effective for both, teaching the discrimination of major and minor musical excerpts and enabling generalization for new musical excerpts. These are skills with high ecological values, after all, the ability to recognize the excerpts, melodies, harmonies, and chords as “major” or “minor” allows the musician to compose new songs, by grouping chords and notes. In addition, the musicians able to recognize “major” and “minor” can play songs from other musicians more easily and independently, because they will be able to recognize what other musicians played. Thus, skills like that are highly necessary for anyone who intends to compose or perform any kind of music.

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Appendix 1

The excerpts were extracted from the songs listed below. The excerpts were originally extracted by Peretz et al. (1998) and kindly provided by these authors:

Major Musical Excerpts:

Beethoven – Piano Concerto no. 3 (3rd mvt – part 1) – used in Training 1.

Beethoven – Piano Concerto no. 3 (3rd mvt – part 2) – used in the Tests/Training 3.

Beethoven Symphony no. 3 (3rd mvt) – used in the Tests/Training 3.

Mozart – Die Zauberflöte (Act-1#2-Papageno's Aria) – used in Training 1.

Mozart – Eine kleine nachtmusik (1st mvt) – used in the Tests/Training 4.

Mozart – Piano Concerto no. 27 (3rd mvt) – used in the Tests/Training 4.

Ravel – Tombeau de Couperin (Rigaudon) – used in the Training 1.

Saint-Saëns – Carnaval des Animaux (La volière) – used in the Training 2.

Schumann – Kinderszenen (Op 15 no. 9) – used in the Training 2.

Verdi – La Traviatta (Brindisi) – used in the Training 2.

Verdi – Rigoletto (Act 1 no. 4) – used in the Tests/Training 4.

Vivaldi – L'Autunno (1st mvt) – used in the Training 3.

Minor Musical Excerpts

Albinoni – Adagio – used in the Training 1.

Bach – Passionsmusik nach dem evangelisten Mattha¨us – used in the Training 1

Bruch – Kol Nidrei – used in the Tests/Training 3.

Chopin – Nocturne Op 27 no. 1 – used in Training 1.

Chopin – Nocturne Op 48 no. 1 – used in Training 2.

Chopin – Nocturne Op 9 no. 1 – used in the Tests/Training 3.

Debussy – Pre´lude: Des pas sur la Neige – used in the Training 2.

Grieg – Peer Gynt's Suite no. 2 (Solveigs lied) – used in Training 2.

Mahler – Symphony no. 5 (3rd mvt) – used in the Tests/Training 4.

Mozart – Piano Concerto no. 23 (2nd mvt) – used in the Tests/Training 4.

Rodrigo – Concerto de Aranjuez (Adagio) – used in the Training 3.

Schubert – String Quartet no. 14 (2nd mvt) – used in the Tests/Training 4.

ARTIGO 4

Teaching To Classify Musical Melodies – Major And Minor – Through A Matching-To-Sample Training

Abstract

The present study evaluated a procedure based on Matching-to-Sample training to establish conditional relations between melodies and printed words. Moreover, we conducted tests to assess the generalization for new melodies and harmonic progressions. Thirty college students were taught the conditional relations between major and minor melodies and the printed words "MAJOR" and "MINOR." The generalization tests were carried-out after each training phase. The training trials presented melodies and test trials presented new melodies and harmonic progressions. Eighteen participants achieved the learning criteria for all training phases. The results revealed that among these 18 participants, at least nine of them reached between 80% and 100% of correct answers in the generalization tests with melodies. In addition, during the Test 3 with harmonic progressions, 10 participants reached between 80% and 100% of correct answers. Our findings showed that the MTS-based procedure was suitable for establishing conditional relations between melodies and printed words. Moreover, the test results revealed the generalization to new melodies and for harmonic progressions.

Keywords: melodies, harmonic progressions, matching-to-sample, generalization.

In last ten years, supported on methods and procedures developing by Experimental Analysis Behavior, some studies aimed to teach to the participants musical skills of discrimination and classification of musical auditory stimuli (Cedro et al., 2019; Landengton et al., 2020; Reis et al., 2017; Rodrigues et al., 2017). These auditory musical stimuli can be chords, harmonic progressions, melodies, musical excerpts. Roughly speaking, chords are the simultaneously playing of two or more musical notes; a harmonic progression is a set of chords, grouped in accordance with determined rules. A musical scale is an ordained set of musical notes played sequentially; a musical melody is a randomized set of notes derived from a scale and also played sequentially. (Guest, 2006; Levine, 2011; Mulholland & Hojnacki, 2013; Schmeling, 2011).

All these cited auditory musical stimuli can be classified as “major” or “minor”. Hence, we have major chords and minor chords; major scales and minor scales. A harmonic progression compound by a majority of major chords is a major harmonic progression and, a harmonic progression compound by a majority of minor chords is a minor harmonic progression. A set of randomized notes derived from a major scale can be classified as a major melody, at the same extent, a set of randomized notes derived from minor scale can be classified as a minor melody. The classification in these terms is also known as the key of chords, scales, harmonic progressions, melodies (Guest, 2006; Levine, 2011; Mulholland & Hojnacki, 2013; Schmeling, 2011).

The distance between the notes determine the key of chords and scales, we measure this distance by means of the semitones. The major scale is an ordained set of seven musical notes and the distance between the first (tonic note of the scale – gives name to the scale) and third notes (the interval of “major third”) is four semitones and, the distance between the first note and the sixth note (the interval of “major sixth”) is nine semitones. The minor scale also is a set of seven musical notes, and the distance between first and third note (in this case, the interval of “minor third”) is three semitones and, the distance between the first and the sixth note (in this case, the interval of “minor sixth”) is eight semitones. In this case, these intervals are called. Likewise, in the major chord, the distance between first (fundamental note of the chord – gives name to the chord) and second notes are of four semitone – similar to the major scale, this a major third interval. In the minor chord, the distance between first and second notes are three semitones – similar to the minor scale, this a minor third interval (Guest, 2006; Levine, 2011; Mulholland & Hojnacki, 2013; Schmeling, 2011). At this point, we can argue that the major scales and the major chords share some similarities, specifically; the major third interval is present in both. The same is true for the minor scales and the minor chords, the minor third interval is present in both. In fact, musical theorists (Levine, 2011; Mulholland & Hojnacki, 2013) recommend the use of the relative scales to the specific chords. In a simple manner, in the context of the major chords, the recommendation is the using of major scales to create solos and/or melodies, and, in the context of the minor chords, the suggestion is the use of the minor scale to the same proposes. Thus, regardless of the differences between chords and scales, both sets of auditory musical stimuli share some properties by which we can classify them as major or minor or its keys.

Cedro et al. (2019) conducted an experiment to establish conditional relations between major and minor chords and the printed words major and minor, respectively. Twenty participants were involved in the experiment. In the first phase, the participants were exposed to a training with major and minor chords of the note C. In the phase 2, the training was with major and minor chords of C and D notes. During the phase 3, the training was with major and minor chords of the notes C, D, and E; the phase 4 was with major and minor chords of the notes C, D, E, and F. The phase 5 was with major and minor chords of the notes C, D, E, F, and G. After each training phase, was conduct a phase of test with major and minor chord of the notes A, B, D flat, G flat, and A flat. Just five participants attained the learning criteria in the training phases. Actually, 10 participants did not reach the learning criteria in the training 1. These results indicate how hard it can be establishing the discrimination of auditory musical stimuli.

Some studies (Cedro et al., 2019; Reis et al., 2017; Rodrigues et al., 2017) reported results at the level chance in tasks in which the participants must to discriminate and classify musical chords. Perhaps this difficulty is related to the stimuli used and, unlike chords, other auditory musical stimuli are easier to discriminate. Eerola and Vuoskoski (2013) conducted a literature review about the emotions elicited by music. They founded that 175 between the 251 articles used musical excerpt as musical stimuli during the experimental procedures. In addition, almost half of that (48%) used musical excerpts from songs of classical music of the 16th century through 19th centuries.

Dalla-Bella et al. (2001), for example, verified whether participants were able to classify major and minor musical excerpts with images of happy and sad faces, respectively. Adults and two groups of children (< 5 years old; between 6 and 10 years old) were involved as participants. After listen to a musical excerpt, the adults were asked to choose between images of happy and sad faces. In turn, the children were asked to choose schematic happy or sad faces. The results showed that, in 80% of opportunities, the adults and the children (between 6 and 10 years old) choose a major musical excerpt when faced to a happy face and they choose a minor musical excerpt when faced to a sad face.

Thompson and Opfer (2014) conducted an experiment to verify if participants who classified major and minor musical scales according to positive or negative adjectives would obtain positive results in a training to classify these same scales through the words major and minor. First was conducted a affective valence task, in which after listening to a major or minor scale, the participants rated the affective valence of the scales as warm/sunny (sun icon), cool/cloudy (cloud icon), or neutral (sun covered by cloud icon) on an 11-point Likert scale. During the training, after listening to a scale, the participant should classify the scale as major or minor. The participants who rated the major scales more positively during the affective valence tasks – and the minor scales more negatively – are the same ones who showed superior results in the training phases.

Cedro and Huziwara (in preparation) carried-out a procedure to teach college students to classify major and minor musical excerpts. After the participant demonstrated results at the level chance in the pretest, this participant was exposed to training in which they should classify the musical excerpts as major and minor. A posttest – identical to pretest – was conducted after each training-phase. Sixteen of the 20 participants attained more than 80% correct during the four training phases. Moreover, these 16 participants reached between 80% and 100% of correct answers during the two generalization tests with new excerpts. By other hand, the same participants demonstrated results at the level chance during the generalization tests with harmonic progressions. These data are indicative that the structure of the carried-out teaching procedure may be correct, as well as the musical stimuli used – musical excerpts – are more discriminable than chords. However, there was no generalization between stimuli of different types – this is, from musical excerpts to harmonic progressions. In addition to the effect of this experimental procedure, probably, these percentages of correct responses with musical excerpts were due to pre-experimental factors such as faster musical excerpts are recognized as major and slower musical excerpts are recognized as minor (Dalla-Bella et al., 2001; Kerer et al., 2014; Thompson & Opfer, 2014).

When we looking closely at the musical stimuli used, major musical excerpts tend to be faster and minor musical excerpts tend to be slower, even when beats per minute (BPM´s) are equalized between these musical excerpts. It´s worth noting, a musical excerpts is recognized as fast or slow in accordance with a combination between beats per minute and rhythmic figures. The rhythmic figure is a measure to determine how many notes must be played in each beat per minute. (Levine, 2011; Mulholland & Hojnacki, 2013; Schmeling, 2011). In the major musical excerpts, the most common is the combination between an elevated number of beats per minute and rhythmic figures determining many musical notes per beat. On the other hand, in the minor musical excerpts, the most common is the combination of a reduced number of beats per minute and rhythmic figures determining few notes per beat. This characteristic of the stimuli may have influenced the results founded by Cedro and Huziwara (in preparation). In part, due this the participants presented results equal to or close to 100% of correct answers in the first training block and subsequent test with musical excerpts. Nevertheless, in Cedro and Huziwara (in preparation), the participants demonstrated results at the level chance during the generalization tests with harmonic progressions. These data are indicative that the structure of the carried-out teaching procedure may be correct, as well as the musical stimuli used – musical excerpts – are more discriminable than chords. However, there was no generalization between stimuli of different types – i.e., from musical excerpts to harmonic progressions. Moreover, it´s almost impossible determine which characteristics – related to the rhythmic or related to the key – of the musical excerpts controlled the responses of participants, probably, the both characteristics controlled the responses of participants.

The present experiment aimed to teach non-musicians participants classify as major and minor different musical melodies. To this end, participants were taught to choose a printed word (MAJOR or MINOR) after the presentation of different major and minor melodies. During the testing phases, the participants were asked to classify new melodies and, in addition, major and minor harmonic progressions. In this way, we assessed the generalization from melodies to melodies and from melodies to harmonic progressions. Moreover, we assessed the discriminability of the melodies in relation to the musical excerpts and in relation to the musical chords.

It´s worth noting, we tried to avoid that the participants classifies the melodies according to the rhythmic characteristics (BPM´s plus rhythmic figures). To this end, seventeen different rhythmic patterns were developed. We used a unique rhythmic pattern to compound a pair of melodies, one major and one minor. We used the same BPM´s and rhythmic figures in the each pair of melodies, and the only difference between the melodies of the same pair were associated to the major and minor keys. More details of the used melodies are presented in the method section.

Method

Participants

Thirty undergraduate students (21 women) with a mean age of 19,3 years (SD: 1.14 years) participated in the experiment. Before to be exposed to the experimental task, they read and signed an informed consent form. All experimental procedures were approved by the Committee of Ethics in Research with Humans, Universidade Federal de Minas Gerais (process number CAAE: 44508615.2.0000.5149).

Setting and Equipment

Data were collected in a four 2m x 2m rooms, provided with good lighting and semi-noise-proof. Were used fours computers with 23" screens, keyboard, and mouse. The auditory stimuli were presented through headphones – bilateral headphones, with high fidelity and stereo sound, capable of reproducing all frequency waves between 10Hz and 23,000Hz, with impedance of 32Ω, maximum output of 50mW and sensitivity of 96dB. The pretest, training and testing blocks were programmed using the Stimulus Control software (Picanço, 2017).

Stimuli

Two sets of musical stimuli were used. The first set of stimuli consisted of 34 melodies. Among these, 17 were in major key and 17 in minor key. These melodies were made exclusively for this experiment, in order to control all rhythmic characteristics and keeping the difference between melodies related to major key or minor key only. The melodies lasting between five and seven seconds each. The melodies were composed in pairs, in this way, parameters associated with the rhythm and the BPM´s of execution are identical between the pairs of melodies, the only difference between the melodies of a pair are related to the “third” and “sixth” intervals. As we said before, these intervals defines whether a melody is in the major or minor key. Among these melodies, 24 were used in training – 12 melodies in major key and 12 melodies in minor key and, 10 melodies were used in tests – five in major key and five in minor key.

The second set of auditory stimuli was composed of harmonic progressions. The major harmonic progressions were compound by three major chords and minor harmonic progressions were compound by three minor chords. The harmonic progressions used here are known as “I, IV, V, I” (to more detailed explanation see Levine, 2011; Mulholland & Hojnacki, 2013). To play and record the harmonic progressions, we used Ableton® software (version 9.4.7 – 64 bits) and MIDI technology (Musical Instrument Digital Interface). All the chords of the harmonic progressions were recorded with classical piano timbre. All the harmonic progressions had the same rhythmic characteristics (quarter notes in 84 bpm´s) and the same parameters of intensity, volume, attack and duration (the harmonic progressions lasting four seconds). Visual stimuli were the printed words MAJOR and MINOR, written in capital letters, with arial font, size 100.

Procedure

The trial started with the simultaneous presentation of an auditory sample stimulus (i.e., melodies or harmonic progression) and a blue rectangle in the upper central part of the computer screen. The interruption of the presentation of the auditory stimulus occurred when the participant clicked on this rectangle. The emission of this response produced the presentation of two visual comparison stimuli (i.e., printed words) at the lower right and left vertices of the screen, while the presentation of the auditory sample stimulus ended. The presentation positions of the comparison stimuli varied in a semi-random manner. During the teaching phases, responses to the correct comparison stimulus caused the presentation of a green check and responses to the incorrect comparison stimulus caused the presentation of a red “X”. The presentation of the differential consequences for corrects and incorrect answers lasted 1s and was followed by an inter-trial interval (ITI), also lasting 1s, during which the screen remained blank.

Pretest

The Pretest consisted of a block of 20 trials in which the auditory stimuli were divided as follows: five trials presenting major melodies, five presenting minor melodies, five presenting major harmonic progressions and, finally, five presenting minor harmonic progressions. The presentation of auditory stimuli occurred in a semi-random order, in which the same type of sample was presented only in two consecutive trials. In the tests blocks the differential consequences for corrects and incorrect answers were suspended. The visual comparison stimuli were the printed words MAJOR and MINOR. Participants who reached no more than 60% correct answers during the Pretest performed the Training Phases and later Test Phases. Participants who reached more than 60% correct answers were dismissed.

MTS-based Training

There was an application of four teaching phases and four testing phases during the training procedure. In each teaching phase, six melodies were used, three in major key and three in minor key. In each test phase were used five major melodies, five minor melodies, five major harmonic progressions and five minor harmonic progressions. Differential consequences for the responses of the participants occurred only during the training. The Training Phase 1 consisted of a block with 12 prompted trials – a green frame indicated the correct answer. None learning criteria was used for this block. After the prompted block, was conducted a block with 12 trials without cues, were presented three trials for each melodies. Was stipulated a criteria of 80% of correct answers for this block. When the participant reached the criterion, he was exposed to Test 1. However, in cases the participant does not reach the criteria, he was exposed to new prompted block with six trials, and proceed to a new training block with 12 trials. Participants could repeat each training block a maximum of three times to achieve the learning criteria. Afterwards, when participants does not meet the learning criteria after three repetitions, they did the last generalization test and were dismissed from the remaining training. Training Phases 2, 3 and 4 are practically identical to Training Phase 1, the only difference are the melodies used in each phase. For each training phase, a unique set of six melodies was used – three major and three minor.

All posttests were identical to the pretest, five trials with major melodies, five trials with minor melodies, five trials with major harmonic progressions and five trials with minor harmonic progressions. In fact, were used the same melodies and harmonic progressions used during the pretest.

It is worth mentioning, in all the conducted tests was possible to assess generalization with the results of all trials, because the 10 melodies used are different from 24 melodies used in the training. The same for harmonic progressions, we can assess generalization in the four conducted tests, because these set of auditory musical stimuli (harmonic progressions) never was presented during the training.

As shown in Table 1, there was an alternation between the training and testing phases throughout the procedure so that, after applying the Pretest, the participants performed the Training Phase 1, followed by Test 1 and so on.

Table 1

Sequence and Details of the Training Phases and Tests

Sequence	Auditory Musical Stimuli	Trials	Criteria
1 – Training	3 major melodies 3 minor melodies	12 prompted 18 without cues	80% in one block
1 – Test	5 major melodies 5 minor melodies 5 major harmonic progressions 5 minor harmonic progressions	20 without cues or consequences	Do not apply
2 – Training	3 major melodies 3 minor melodies	12 prompted 18 without cues	80% in one block
2 – Test	5 major melodies 5 minor melodies 5 major harmonic progressions 5 minor harmonic progressions	20 without cues or consequences	Do not apply
3 – Training	3 major melodies 3 minor melodies	12 prompted 18 without cues	80% in one block
3 – Test	5 major melodies 5 minor melodies 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply
4 – Training	3 major melodies 3 minor melodies	12 prompted 18 without cues	80% in one block
4 – Test	5 major melodies 5 minor melodies 5 major harmonic progression 5 minor harmonic progressions	20 without cues or consequences	Do not apply

Results

Table 2 shows the participants performance during the teaching phases. In Training 1, 13 participants reached the learning criteria in the first exposure to the block. In addition, seven participants achieved the learning criteria during the second exposure to the block. Two participants reached criterion of correct answers during the third exposure to the block, and three participants reached it after the fourth exposure to the block. Participants from P26 to P30 did not reach 80% of correct answers even after four exposures and, according to the established criteria, these participants followed to Test 4 and, afterwards, their participation was terminated.

During Training 2, 14 participants reached the learning criteria in the first block. Five participants reached the criterion of correct answers during the second exposure to the block. Two participants reached the learning criteria during the third block. Four participants did not reach 80% of correct answers during the Training 2. These four participants followed to Test 4 and, after that, their participation was terminated.

In relation to Training 3, 14 participants reached 80% of correct answers or more in the first block. One participant reached the learning criteria during the block 2, two participants reached the criterion of correct answers during block 3, and one participant reached the criterion of the correct answers during the block 4. Three participants did not reach the criterion of 80% of correct answers after the fourth exposure of the teaching block of phase 3 and, therefore, these participants were referred to Test 4 and, subsequently, their participation was terminated.

On Training 4, 14 participants reached the criterion of correct answers during the first block. Two participants reached the learning criteria after the second exposure and two reached it after the fourth exposure. In this way, from an initial 30 participants, 18 participants were able to meet all the learning criteria.

Table 2

Percentage Of The Correct Answers During Training

Part	Training 1				Training 2				Training 3				Training 4			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
P1	100%				100%				100%				100%			
P2	100%				83%				100%				100%			
P3	100%				100%				75%				83%			
P4	83%				75%				75%				75%			
P5	75%				75%				75%				83%			
P6	67%	42%	83%		92%				100%				100%			
P7	58%	83%			92%				92%				83%			
P8	83%				67%	58%	75%		92%				92%			
P9	67%	83%			92%				83%				83%			
P10	92%				75%				67%	50%	75%		75%			
P11	50%	33%	42%	83%	83%				83%				83%			
P12	75%				75%				50%	58%	58%	83%	75%			
P13	42%	58%	67%	75%	75%				75%				92%			
P14	58%	92%			100%				92%				67%	58%	67%	83%
P15	92%				75%				67%	58%	83%		58%	75%		
P16	75%				67%	75%			58%	92%			75%			
P17	58%	75%			67%	83%			75%				67%	67%	33%	75%
P18	50%	67%	67%	92%	50%	58%	75%		83%				58%	75%		
P19	50%	92%			67%	92%			58%	67%	67%	50%				
P20	50%	83%			58%	92%			58%	58%	58%	42%				
P21	67%	58%	75%		33%	75%			42%	50%	50%	50%				
P22	83%				67%	42%	42%	58								
P23	75%				67%	58%	33%	50								
P24	75%				50%	42%	50%	58								
P25	58%	75%			67%	67%	67%	50								
P26	50%	58%	58%	67%												
P27	58%	50%	58%	58%												
P28	50%	67%	25%	67%												
P29	58%	50%	58%	58%												
P30	58%	42%	58%	50%												

Note: Part = participant; B.1 = block 1; B.2 = block 2; B. 3 = block 3

Table 3 shows the participants performance during the test phases. During the Pretest, the participants presented results at the chance level in trials with melodies and in trials with harmonic progressions. Regarding the generalization test with melodies, nine of the 25 participants reached between 90% and 100% of correct answers during Test 1, the other participants reached between 60% and 70% of correct answers. During the Test 2, six of the 21 participants reached between 90% and 100% of correct answers, three participants reached 80% of correct answers, and the other participants reached results varying 50% and 70% of correct answers. During the Test 3, four of the 18 participants reached 100% of correct answers, two reached 90% of correct answers, and three reached 80% of correct answers. The other participants achieved results between 50% and 70% of correct answers. According to the established criteria used in this procedure, all participants were exposed to Generalization Test 4. On the results of the participants that reached the criteria during the four training phases, two reached 100% of correct answers, five reached 90% of correct answers, three reached 80 of correct answers and, eight participants achieved results between 50% and 70% of correct answers. On the results of participants that not reached the criteria during the training phases, one reached 80% of correct answers, the other participants achieved results between 40% and 70% of correct answers.

Regarding the generalization test with harmonic progressions, two of the 21 participants reached 100% of correct answers, one reaches 90% of correct answers, and six participants reached 80% of correct answers in Test 1. The other participants present results between 40% and 70% of correct answers. On the Test 2, only one of the 21 participants reached 100% of correct answers, three reached 90% of correct answers, two reached 80% of correct answers and, the others ranged between 30 and 70% of correct answers. On the Test 3, two of the 18 participants obtained 100% of correct answers, four reached 90% of correct answers, four participants obtained 80% of correct answers, six participants varying 30% and 70% of correct answers. According to the established criteria used in this procedure, all participants were exposed to Generalization Test 4. On the results of the participants that reached the criteria during the four training phases, two reached 100% of correct answers, two reached 90% of correct answers, three reached 80 of correct answers and, the others participants achieved results between 40% and 70% of correct answers. On the results of participants that not reached the criteria during the training phases, one reached 80% of correct answers, the other participants achieved results between 40% and 70% of correct answers.

All participants were exposed to Pretest with melodies and Test 4 with melodies. This allows us verifying whether there was a relevant difference between the percentage of correct answers obtained by the participants in a moment before training and in a moment after training. First, on the results of the participants that reached the criteria during the four training phases, through the Mann-Whitney test was possible to observe a statistically relevant difference between the percentages of correct answers obtained by the participants during the Pre-Test and Test 4 with melodies (z=4.26, p=0.0001). In this sense, the number of correct answers during Test 4 was higher than the number of correct answers during the Pretest. Secondly, on the results of participants that not reached the criteria during the training phases, through the Mann-Whitney test was not possible to observe a statistically relevant difference between the percentages of correct answers obtained by the participants during the Pre-Test and

Test 4 with melodies (*z*=0.39, *p*=0.68). According to this, the number of correct answers during Test 4 was similar than the number of correct answers during the Pretest.

Similarly, the Mann-Whitney was used to verify the difference between the percentages of correct answers obtained by the participants during the Pretest and Test 4 with harmonic progressions. Once again, on the results of the participants that reached the criteria during the four training phases, the referred test showed a statistically relevant difference between the percentages of correct answers obtained by the participants during the Pretest in relation to Test 4 with harmonic progressions (*z*=3.88, *p*=0.0002). According to this, the number of correct answers during Test 4 was higher than the number of correct answers during the Pretest. On the results of participants that not reached the criteria during the training phases, through the Mann-Whitney test was not possible to observe a statistically relevant difference between the percentages of correct answers obtained by the participants during the Pre-Test and Test 4 with melodies (*z*=1.62, *p*=0.10). In this sense, the number of correct answers during Test 4 was similar than the number of correct answers during the Pretest.

On the results of participants that not reached the criteria during the training phases, a Mann-Whitney test showed a statistically significant difference between the percentages of correct answers during the Pretest in relation to Test 3 with melodies (*z*=4.66, *p*=0.0001). Thus, the number of correct answers during Test 3 was higher than the number of correct answers during the Pretest. A Mann-Whitney test also showed a statistically relevant difference between the percentages of correct answers obtained by the participants during the Pre-Test with harmonic progressions in compared to Test 3 with harmonic progressions (*z*=3.34, *p*=0.0003). Therefore, the number of correct answers during Test 3 was higher than the number of correct answers during the Pretest.

Table 3

Percentage of the Correct Answers During Tests

Part	PreTests		Test 1		Test 2		Test 3		Test 4	
	Mels	Progs	Mels	Progs	Mels	Progs	Mels	Progs	Mels	Progs
P1	60%	50%	100%	100%	100%	100%	100%	100%	100%	80%
P2	50%	30%	100%	80%	90%	70%	100%	90%	90%	80%
P3	30%	30%	100%	100%	90%	70%	80%	90%	100%	100%
P4	60%	60%	70%	50%	80%	50%	70%	40%	60%	60%
P5	60%	50%	90%	50%	70%	50%	60%	80%	80%	70%
P6	50%	50%	100%	90%	90%	80%	100%	80%	90%	70%
P7	50%	30%	70%	80%	70%	90%	100%	90%	80%	100%
P8	50%	50%	40%	50%	100%	70%	80%	80%	80%	90%
P9	40%	60%	90%	80%	70%	60%	90%	100%	90%	90%
P10	60%	40%	60%	30%	50%	70%	60%	70%	60%	80%
P11	60%	60%	60%	70%	80%	40%	70%	40%	90%	50%
P12	30%	30%	90%	60%	50%	20%	70%	40%	60%	70%
P13	40%	50%	60%	40%	90%	90%	70%	70%	60%	70%
P14	30%	50%	60%	80%	80%	80%	90%	30%	60%	50%
P15	20%	50%	90%	50%	70%	70%	70%	90%	70%	70%
P16	30%	60%	50%	50%	50%	30%	50%	80%	40%	50%
P17	60%	40%	70%	60%	60%	40%	70%	70%	90%	60%
P18	60%	50%	60%	60%	70%	60%	80%	60%	70%	40%
P19	60%	50%	90%	80%	60%	90%			70%	60%
P20	50%	50%	70%	70%	70%	70%			80%	80%
P21	50%	30%	70%	40%	50%	50%			20%	40%
P22	30%	40%	60%	40%					50%	30%
P23	30%	60%	50%	80%					40%	60%
P24	60%	50%	50%	60%					50%	60%
P25	50%	60%	70%	60%					60%	70%
P26	50%	40%							50%	50%
P27	40%	60%							30%	60%
P28	50%	40%							50%	50%
P29	50%	20%							40%	50%
P30	50%	20%							70%	40%

Note: Part = participant; Mels. = melodies; Progs. = Harmonic Progressions

Discussion

The present experiment assessed the possibility of teaching skills that rely on auditory discrimination of musical stimuli – melodies. Twenty-five of the 30 participants reached the learning criteria in at least two phases of training. In addition, 18 participants reached the learning criteria in all training phases. Data from Tests 3 and 4 indicated that participants were able to classify as major and minor melodies different from those presented in the training phases. Such results in the test phases are evidence that there was generalization between musical auditory stimuli with from the same category. In addition, data from Tests 3 indicated that the 10 of the 18 participants reached between 80% and 100% of the correct answers in the tasks to classify major and minor harmonic progressions. Data from Tests 4 also indicated that the eight of the 18 participants reached between 80% and 100% of the correct answers in the tasks to classify major and minor harmonic progressions.

Once again, we emphasize, the participants were not taught to discriminate and classify harmonic progressions at any time. Therefore, during the test phases with harmonic progressions, the results superior to the learning criteria can be considered indicative of generalization between stimuli of different categories (from melodies to progressions), but which share properties in common (major or minor keys). We consider that this type of generalization between stimuli is less likely to occur, given the numerous differences between melodies and harmonic progressions. In the present experiment, the tests of generalization with melodies were closer to what was taught during training. On the other hand, when compared to the tests with melodies, the tests with harmonic progressions were further away from what was taught during training.

Cedro et al. (2019) conducted a study to teach non-musician participants to classify major and minor chords. The results obtained during the present experiment were superior when compared to Cedro et al. In accordance with the acoustic elements of these stimuli, we can argue that musical melodies are more easily distinguished from each other when compared to chords. In melodies, the notes are played sequentially, otherwise, in chords the notes are played simultaneously. In order to exemplify this difference, imagine that musical notes are colors, just as we have seven basic musical notes, we have seven basic colors. In this perspective, the melody is a sequence of notes, and the presentation of a melody would be equivalent to presenting the participant with a sequence of colors, one color presented at a time. On the other hand, the chord is a simultaneous playing of musical notes and, the presentation of a musical chord would be equivalent to the simultaneous presentation of three or four distinct and overlapping colors. Perhaps, due to these differences between the stimuli, it may be easier for the participant to identify sound differences when comparing two melodies than when comparing two chords. This may explain the better results obtained in the present experiment, when compared to the results of Cedro et al.

In Cedro and Huziwara (in preparation), 16 of the 20 participants reached all the learning criteria. In present experiment, 18 of 30 participants were able to meet all the learning criteria. Due these data, perhaps, musical excerpts are more discriminable than musical melodies. As pointed-out before, the rhythm characteristics of the musical excerpts maybe influence the results in Cedro and Huziwara. In the present experiment, we tried to avoid the influence of rhythmic characteristics. Maybe, the absence of differences related to the rhythmic characteristics is the reason of the inferior results in the training phases, when compared to Cedro and Huziwara. By other hand, the results of tests with harmonic progressions are better than founded in Cedro and Huziwara, who conducted a training with musical excerpts. The data of the present experiment indicated that a training with one type of stimulus (i.e., melodies) was enough to the participant discriminate and labeling a stimulus of another type (i.e., harmonic progression) with similar properties (of major or minor key). Moreover, the results of conducted tests are better than the results of previous experiments (Cedro et al., 2019; Reis et al., 2017; Rodrigues et al., 2017) that aimed to directly teaching the discrimination of musical chords of the same type that was used in the harmonic progressions in the present experiment. As said, discriminating and labeling chords seems to be a more arduous task than discriminating and labeling melodies. This reasoning is also applicable to harmonic progressions discrimination; after all, as stated before, a harmonic progression is a set of chords. Possibly, for a set of similar chords (e.g., four major chords presented in sequence), the harmonic progression allows the participant to access more stimuli of the same type (e.g., major chords) during one trial. After all, a trial with harmonic progression presents more than one chord at a time, unlike a trial with a single chord of a given type – for example, major or minor chords.

The blocks of prompted trials used during the present experiment may also have contributed to obtaining better results, when compared to the results in Cedro et al.

(2019). In the teaching phase 1, blocks of prompted trials were organized in a way that the “major melody 1” always preceded the “minor melody 1”; the “major melody 2” always preceded the “minor melody 2”; the “major melody 3” always preceded “the minor melody 3” and so on. This trial organization was adopted for all blocks of prompted trials during all teaching phases. This arrangement was used to allow the participant to discriminate only the different aspects between the melodies, that is, the “third” and “sixth” intervals referring to each key, major or minor. This arrangement of trials was also intended to allow the participant to discriminate the identical properties between the melodies, for example, rhythmic figures, beats per minute, attack of the notes, duration of the melody, timbre of the instrument, volume, dynamics of execution, among others. In Cedro et al., in the blocks of prompted trials, the chord presentation happens randomly. Future research can replicate the present experiment using blocks of prompted trials in which the presentation of melodies is randomized, this may broaden the discussion on the use of the prompted trials in teaching procedures with musical auditory stimuli.

On the teaching of auditory discriminations that allow the generalization of stimulus control, the set of data obtained suggests that melodies may be the most suitable stimuli to precede the teaching with harmonic progressions. Data on generalization to harmonic progressions indicated that prior training to discriminate melodies maybe as prerequisite for participants to succeed in training with harmonic progressions. Broadly speaking, it seems pertinent to conduct a teaching procedure that first establishes the discrimination of major and minor melodies, to then conduct a training to establish the discrimination of harmonic progressions to, finally, conduct a training to establish the discrimination of musical chords.

In summary, the results presented in the present experiment demonstrate that a procedure based on Matching-to-Sample (Cumming & Berryman, 1961; Cumming & Berryman, 1965) was effective both for teaching the discrimination of major and minor musical melodies and for the occurrence of control generalization to new melodies. Moreover, the teaching procedure allowed the occurrence of generalization of control for auditory musical stimuli not presented during the training phases, in this case, harmonic progressions of the major and minor keys. Classifying auditory musical stimuli according to their key is a skill of high ecological value. The musician able to recognizing the key of musical excerpts, melodies, harmonies and chords can easiest create their own songs, more than that, he became able to group chords, notes, melodies, harmonic progressions according to parameters associated with the sound of each stimulus. In addition, the recognition of the key of different musical auditory stimuli allows the musician to perform songs by other composers in an agile, pleasant and inexpensive way, because he will be able to recognize the sounds of the musical stimuli present in the music. Thus, discriminate and classify auditory musical stimuli is crucial for musicians in general, from those who intend to compose their own music to those who intend to perform other musicians' music.

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Considerações Finais

Esta tese teve por objetivo propor e investigar procedimentos para o ensino de habilidades musicais que dependem de discriminação auditiva. Além disto, também tentamos propor procedimentos de ensino que promovessem a generalização entre estímulos auditivos musicais de diferentes tipos. Para tanto, primeiro foi necessário conhecer e analisar mais a fundo os estudos que se prestaram à objetivos similares em oportunidades anteriores. Para tanto, por meio de revisão da literatura na área, observamos que atualmente as pesquisas sobre o ensino de habilidades musicais estão mais focadas no ensino de relações condicionais que dependem de discriminação visual, inclusive, tendo em vista a quantidade e variedade de estímulos visuais utilizados (Acin et al., 2006; Arntzem et al., 2010; Griffith et al., 2018; Hill et al., 2020; Langendonck, Asnis, & Elias, 2020) quando comparado a relações condicionais de discriminações auditivas. Além disso, a revisão da literatura também apontou que os participantes atingem entre 80% e 100% de acertos em tentativas que apresentam apenas estímulos visuais (i.e., do tipo visual-visual; Hanna et al., 2016; Hanna et al, 2017), mas que desempenhos semelhantes não são descritos em tentativas que apresentam relações auditivo-visuais ou visual-auditivas. De forma mais detalhada, a maioria desses participantes apresenta resultados ao nível do acaso em tentativas do tipo auditivo-visual (Cedro et al., 2019; Hanna et al., 2016; Hanna et al, 2017; Reis et al., 2019; Rodrigues et al., 2017). De acordo com estes dados, parece-nos que habilidades musicais que dependem de discriminação de estímulos auditivos são mais custosas de serem estabelecidas se comparadas as habilidades que dependem de discriminação visual.

Vale ressaltar, as pesquisas sobre ensino de música por meio de métodos da Análise do Comportamento realizadas durantes as décadas de 1960 e 1970 (Edmonson III, 1972; Greer, Dorow, & Hanser, 1973; Greer, Randall, & Timberlake, 1971; Madsen, 1966; Madsen, Wolfe, & Madsen, 1969; Porter, 1977) pareciam mais interessadas no estabelecimento de habilidades de discriminação de estímulos auditivos musicais como escalas, melodias e acordes. Nesta perspectiva, uma retomada dos procedimentos para o ensino de habilidades deste tipo pode enriquecer os estudos da área. Primeiro, por demonstrar que procedimentos de ensino concebidos no âmbito da Análise do Comportamento possibilitam o ensino de habilidades musicais diversas de forma ágil, amena e acessível. Segundo, por enriquecer a literatura no sentido de propor, testar e ampliar métodos para o estabelecimento de habilidades musicais como o reconhecimento e rotulação de estímulos auditivos musicais. Ambos os pontos expõem como métodos concebidos no âmbito da Análise do Comportamento podem ser utilizados para o estabelecimento de uma infinidade de habilidades, dentre estas, habilidades musicais que dependem tanto de discriminação auditiva quanto visual.

O nosso primeiro experimento se embasou na proposição de que os acordes consonantes possuem certas características sonoras que são comuns a todos os acordes consonantes, independentemente da nota fundamental utilizada para compô-los. Esse é o motivo pelo qual o estabelecimento de discriminações com acordes consonantes cujas notas fundamentais são dó3, ré3 e mi3 poderia ser generalizado para as demais notas que compõem a escala cromática. O mesmo raciocínio se aplica para os acordes dissonantes. O conjunto dos resultados obtidos até o presente momento sugere que essa é uma estratégia possível, porém com eficácia consideravelmente limitada. Em outras palavras, as características sonoras comuns a esses tipos de acordes parecem não exercer o nível de controle suficiente para ocasionar desempenhos característicos de generalização (Cedro et al., 2019).

Vale destacar, o ensino de habilidades de classificação de intervalos e acordes consonantes e dissonantes pode se configurar em habilidade que propicia a classificação de outros acordes comumente utilizados na tradição da música ocidental, a saber os acordes maiores e menores (por também serem acordes consonantes) e os acordes aumentados e diminutos (por também serem acordes dissonantes). Ainda vale ressaltar que os parâmetros utilizados para programar o procedimento do experimento com acordes são demonstrações de diferentes formas para organização de procedimentos para o ensino de habilidades de classificação de estímulos auditivos. Nesta perspectiva, podemos oferecer esta contribuição para pesquisas futuras que pretendam ensinar relações condicionais entre estímulos auditivos exercendo função de modelo e estímulos visuais com função de comparação. Ainda neste sentido, o presente procedimento pode ser aplicado em diferentes pesquisas com estímulos musicais auditivos de variados tipos.

Interessante notar, os resultados obtidos na coleta de dados com trechos musicais foram consideravelmente superiores aos obtidos por outros estudos cujo objetivo foi ensinar participantes a classificar estímulos auditivos musicais por meio de palavras impressas (Cedro et al., 2019; Hanna et al., 2016; Hanna et al, 2017; Reis et al., 2019; Rodrigues et al., 2017). Uma revisão da literatura (Eerola & Vuoskoski,

2013) demonstrou que dentre 251 pesquisas, 175 utilizaram trechos musicais como estímulos auditivos durante procedimentos para classificação de estímulos auditivos musicais. A maioria dos participantes destes estudos foram capazes de relacionar uma palavra de valência positiva (ou imagem de valência positiva) a trechos musicais maiores, bem como foram capazes de relacionar palavras de valência negativa (ou imagens de valência negativa) à trechos musicais menores, sem necessidade de treino para tanto. Associado a isso, podemos supor que, quando falamos de uma população composta por não músicos, a exposição cotidiana a trechos musicais deve ser mais frequente quando comparado a exposição a acordes musicais tocados de forma isolada. Além disso, de acordo com os elementos acústicos que compõem cada um desses estímulos, podemos supor que trechos musicais são mais facilmente discriminados uns dos outros do que acordes, de forma que, pode ser mais fácil identificar diferenças acústicas ao comparar dois trechos musicais distintos do que ao comparar dois acordes distintos. Em conjunto, estes fatores podem explicar os melhores resultados obtidos com trechos musicais. Ainda somado a isto, como dito antes, características rítmicas dos trechos musicais utilizados podem ter contribuído para os resultados encontrados. Entretanto, interessante notar, apesar de uma maioria (16 dentre 20) de participantes atingirem todos os critérios de ensino durante os treinos com trechos musicais, apenas uma minoria (dois dentre 20) apresentou 80% de acertos ou mais durante os testes com progressões harmônicas. Neste sentido, o treino com trechos musicais não promoveu generalização do controle de estímulos entre estímulos musicais auditivos de tipos diferentes.

Por fim, foi verificado se melodias seriam mais discrimináveis do que acordes musicais e, também, se seriam tão discrimináveis quantos trechos musicais. Além disso, buscamos verificar se um treino com melodias seria suficiente para os participantes também classificarem novas melodias e progressões harmônicas durante as fases de testes. Resultados positivos durante os testes com progressões harmônicas seriam indicativos de generalização do controle de estímulos entre estímulos auditivos de diferentes tipos. Foi feito um esforço para controlar a influência exercida pelas características rítmicas. Para tanto, padronizamos as características rítmicas das melodias utilizadas durante as fases de treinos e testes. O procedimento baseado em emparelhamento ao modelo foi eficaz tanto para o ensino da discriminação de melodias musicais maiores e menores quanto para a ocorrência da generalização do controle para novas melodias.

De maneira geral, os dados obtidos apontam que estímulos auditivos como trechos musicais e melodias podem ser mais discrimináveis do que acordes musicais, tendo em vista os desempenhos dos participantes em cada experimento. Além disto, apesar de mais participantes demonstraram entre 80% e 100% de acertos em treinos com trechos musicais, os treinos com melodias propiciaram generalização entre estímulos auditivos distintos, de tal forma que os participantes também foram capazes de classificar progressões harmônicas. As melodias não parecem ser tão discrimináveis quanto os trechos musicais, tendo em vista o desempenho dos participantes durantes as fases de treino dos respectivos experimentos. Contudo, em relação aos trechos musicais, como dito antes, provavelmente as características rítmicas dos trechos musicais os tornam mais discrimináveis quando comparados às melodias utilizadas. Por outro lado, diferentemente do procedimento com trechos musicais, o procedimento de ensino com melodias propiciou a ocorrência de generalização do controle de estímulos para estímulos musicais auditivos que não foram apresentados durante as fases de treino, no caso, progressões harmônicas.

No que diz respeito ao ensino de discriminações auditivas que possibilitam a generalização do controle de estímulos, o conjunto de dados obtidos parece sugerir que um treino discriminativo com melodias é o mais indicado para anteceder o treino discriminativo com progressões harmônicas. Os dados sobre a generalização para progressões harmônicas indicam que um treino anterior para discriminar melodias pode ser um pré-requisito para que participantes obtenham sucesso em um treino para discriminar progressões harmônicas.

Como dito ao longo desta Tese, a discriminação e nomeação de estímulos auditivos musicais – trechos, melodias, progressões harmônicas e acordes – de acordo com sua tonalidade (maior ou menor) é uma habilidade de alto valor ecológico. Ao analisar por uma perspectiva mais ampla, a partir do conjunto de dados obtidos por meio do experimento com trechos musicais, parece-nos pertinente supor que o ensino de habilidades musicais deste tipo se inicie pelo estabelecimento da discriminação de trechos musicais maiores e menores para, posteriormente, ocorrer o estabelecimento da discriminação de melodias maiores e menores. Ainda nesta perspectiva, conforme os dados encontrados na coleta com melodias, parece-nos pertinente supor que um treino para o estabelecimento da discriminação de melodias maiores e menores deve preceder um treino para o estabelecimento da discriminação de progressões harmônicas maiores e menores. Por fim, de acordo com os dados obtidos durante a coleta com acordes, também nos parece pertinente sugerir que um treino para estabelecimento da discriminação de progressões harmônicas deve preceder um treino para o estabelecimento da discriminação de acordes. Esta ordem para aplicação dos treinos de discriminação auditiva pode subsidiar programas de ensino que pretendam estabelecer habilidades musicais diversas, principalmente, programas que pretendam estabelecer habilidades musicais que dependem da discriminação de estímulos auditivos musicais.

Por fim, a discriminação de estímulos auditivos musicais permite ao musicista criar peças musicais e, mais do que isso, ele se torna capaz de agrupar os acordes, as notas, as melodias, as progressões de acordo com parâmetros associados ao som de cada um destes estímulos. Além disto, o reconhecimento da tonalidade de estímulos auditivos musicais diversos possibilita ao músico executar músicas de outros compositores de forma ágil, amena e pouco custosa, afinal, ele será capaz de reconhecer os sons dos estímulos musicais presentes na música. Assim, habilidades auditivas deste tipo são necessárias para musicistas em geral, desde aqueles que pretendem compor suas próprias músicas até aqueles que pretendem executar músicas de outros musicistas.

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