Listen to the music!

The effect of background music on the recall of Dutch spoken sentences in people with and without musical training

Elsa Opheij
s1025719
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Bachelor's thesis Linguistics
Faculty of Arts
Radboud University Nijmegen

Supervisor: dr. Susanne Brouwer
Second reader: dr. Marianne Starren

Preface

Before you lies the thesis "Listen to the music![1] The effect of background music on the recall of Dutch spoken sentences in people with and without musical training", which I have written during the months April to July of 2021.

Music never ceases to inspire me. I enjoy listening to music of all kinds of genres, but I also love making music myself. After many years of musical training for playing the flute, I started to play a bit of guitar, ukulele, and piano. For this reason, I wanted to partly focus my thesis on the impact music and musical training can have.

When following the course Introduction to Psycholinguistics during my second bachelor year, taught by my supervisor, the field of psycholinguistics first sparked my interest. I was amazed by the fascinating results of studies conducted to get a better idea of how language and thought are connected. In the continuation of my studies, I began to focus more and more on this area of research.

I would love to thank dr. Susanne Brouwer, my supervisor, for sparking my interest in the field of psycholinguistics in the first place, but most importantly for her indispensable advice and flexibility, for sharing her knowledge, and for helping me in any way possible during my thesis period. The dataset of Cooper, Brouwer, and Bradlow (2015) has saved me a lot of puzzling, as did the two scripts for Praat (Boersma, 2001) and the sentence stimuli provided by Susanne. I had a wonderful time discussing the best plan of approach for my research and it was fun to have someone correct *my* grammar for once. I am very thankful for you accepting my request to be my thesis supervisor.

I also want to thank dr. Marianne Starren for fulfilling the role of second reader for my thesis, after having only just finished being my internship supervisor for months.

Next, I would really like to thank my partner Simon Pingen for sharing his knowledge of music from a music therapist point of view, for his help in producing the music fragments I used for my thesis, and for his love and support throughout the past couple of months.

Without the respondents that have taken the time to fill out my questionnaire, I would never have been able to find such interesting results. A very big thank you to everyone who has helped me to write my thesis in this way.

Lastly, I would like to show my gratitude to all my dear friends and family members for asking how I was doing, for being interested in my research whenever I was talking about it, for always trying to find an answer to my many questions and for generally being there for me. My parents and sister deserve a particular note of thanks for supporting me by showing genuine interest and asking critical questions, by helping me make decisions, and by functioning as my spelling checkers and Excel helpdesk.

I have truly enjoyed writing my thesis these past few months, and I hope you enjoy reading about my research.

Elsa Opheij

Nijmegen, July 16, 2021

[1] "Listen to the Music", a song by The Doobie Brothers (The Doobie Brothers, 1972).

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Summary

Previous research has found that spoken words and background noise are stored collectively in working memory, as congruency in background noise had a facilitating effect on recall performance (Cooper et al., 2015). The aim of the current study was to examine the effect of background music on memory in people with and without musical training. 45 native Dutch participants were tested on a continuous recognition memory paradigm in which Dutch spoken sentences were presented together with background music, for which the congruency (congruent or incongruent background music) and lag value (lag 4, 8, or 16) was manipulated.

The results showed that accuracy was influenced by both the lag and the congruency in background music for both presentations of a spoken sentence. Performance was higher for the congruent condition (same background music) than for the incongruent condition (different background music), suggesting that speech and background music are collectively stored in working memory. In addition, a lower lag value resulted in a higher accuracy on the task. Finally, performance was not influenced by musical training, although this lack of an effect could have been due to methodological limitations. Taken together, these results demonstrate that background music had a facilitating effect on recall performance, suggesting that spoken sentences and background music are stored collectively in working memory.

1. Introduction

When wandering through shops, having dinner at a restaurant or having drinks at a party, it is not uncommon to hear music playing in the background. Music is frequently experienced in people's everyday lives, and even companies have started to use specially produced 'jingles' as an effective marketing tool besides visual promotion material. Particularly when in conversation in social settings, one might not even notice the presence of background music. Overall, people are perfectly capable of having a conversation in background music. One can choose to focus attention on a specific sound input, for instance a particular voice, and selectively listen to only this source of sound, so music is not necessarily forming an obstacle in communication. Being able to understand speech in the presence of speech input from a different source is known as the 'Cocktail party effect' (Cherry, 1953).

Instead of filtering out this music from the input signal, music can also be used in a positive way. Background music has, for example, been proven to aid in study productivity, comprehension and cognitive functions such as memory. The latter is of particular interest in the current study.

The aim of this research was to study the effect of background music on recall memory in people with and without musical training. The relevance of the current study is that investigating whether background music can indeed promote memory would allow for a broader application of background music to boost memory performance.

1.1 Background music

The role of background music on communication can be positive as well as negative. For example, Götell, Brown, and Ekman (2002) stated that in the absence of background music, caregivers of people with severe dementia were mostly explaining and narrating, and difficulty was experienced in understanding each other. When in presence of background music, however, the patient and caregiver better understood one another and the instructing and narrating behaviour of the caregiver decreased. In this case, music thus aided comprehension in conversation.

In contrast, multiple studies have shown a negative effect of background music on speech intelligibility (e.g., Scharenborg & Larson, 2018a; Scharenborg & Larson, 2018b). Scharenborg and Larson (2018b) have studied how specific properties of music impact speech processing. Dutch participants listened to Dutch words accompanied by background music (with a low or high level of complexity). Music with a higher level of complexity appeared to have a negative effect on word recognition ability, and thus interferes with comprehension of speech.

Next to the studies on the effect of music on communication or speech intelligibility, several other studies have investigated the impact of background music on studying in general. These studies have also found positive and negative effects. More specifically, study productivity (e.g., Jäncke & Sandmann, 2010; Lehmann & Seufert, 2017; Shek & Schubert, 2009) and reading comprehension in background music (e.g., Hilliard & Tolin, 1979; Thompson, Schellenberg, & Letnic, 2012; Hu, Li, & Kong, 2019) have been frequently investigated. A positive effect of music on study productivity and reading comprehension is in line with the mood-arousal hypothesis, which states that a person's mood, arousal, and cognitive performance can be affected by listening to enjoyable music (e.g., Thompson, Schellenberg, & Husain, 2001; Hallam, Price, & Katsarou, 2002; Lesiuk, 2005). Hallam et al. (2002) found an effect of mood and arousal on performance. They studied performance of participants on an arithmetic and on a memory task in presence of calming music, unpleasant and arousing music, or no music. The results showed that when presented with calming music, accuracy for both tasks was higher than for the no-music condition. Unpleasant music led to lower performance on the memory task. These results indicated that arousal and mood played a role in the effect of music on the performance on both tasks, as a difference in the perceived mood and arousal resulted in a different outcome.

On the other hand, some studies have proposed that music is distracting a person from their task and thus limits their cognitive resources to fulfil this task and therefore results in decreased performance, which is in line with the cognitive load theory (e.g., Anderson & Fuller, 2010; Pool, Koolstra, & van der Voort, 2003; see also Brouwer et al., in press).

Besides the mood-arousal-hypothesis, the Mozart effect (Rauscher, Shaw, and Ky, 1993) indicates that learning is aided by background music. Rauscher and colleagues found a better performance on spatial tasks for participants that had listened to part of a Mozart sonata than participants who had not listened to music. Replication of these results has, however, been found to be difficult (e.g., Steele, Bass, & Crook, 1999; Pietschnig, Voracek, & Formann, 2010). Thompson et al. (2001) stated that the Mozart effect can be seen as an artefact of mood and arousal, as this effect disappeared when scores of mood and arousal were equalised for all participant groups (Mozart, Albinoni, or no music condition). Participants scored higher on a test of spatial abilities when having listened to a Mozart sonata than in the no music condition, but no positive effect of exposure to music was found when participants listened to a musical fragment by Albinoni. Participants in the Mozart condition scored higher on positive mood and arousal and lower on negative ratings than participants in the Albinoni condition. The authors thus argued that the Mozart effect can be explained by the mood and arousal levels of the participants.

A number of studies have specifically investigated the effects of background music on verbal memory (e.g., Smith, 1985; Balch, Bowman, & Mohler, 1992; Anderson et al., 2000; Kang & Williamson, 2014). This is of particular interest for the current study as its aim is to investigate whether the presence of background music can positively affect recall of spoken words. First of all, Anderson et al. (2000) reported on the effect of using background music to enhance spelling word retention by elementary students. Data after the intervention displayed that using background music had enhanced students' spelling word retention. By listening to music, the students were able to concentrate, relax and revisualise spelling words, which improved their spelling word retention skills.

Secondly, Smith (1985) studied the effect of congruency in background music on memory. Participants performed a two-phased task of recalling a learned list of words after 48 hours. When learning the list of words, participants heard either one of two background music options (Mozart piano concerto or jazz selection) or no music as a control condition. After 48 hours, the participants were asked to recall the list of words. The acoustic background was either constant or different between both the learning and recall phase. As predicted, the results of this experiment suggested that background music leads to context-dependent memory. When the participant heard background music during the learning session and this music was consistent with the background music during the recall phase, the participant performed better at recalling of the list of words compared to when the music was removed or changed. When the participant performed the learning phase in the quiet condition, reinstatement of this background sound did not facilitate recall, and neither did introduction of a new acoustic background. When the learning session took place with background music, recall performance was not worse when changing the music compared to removing the music. Thus, music had a positive effect on recall rather than a negative effect due to distraction from the task by a changing background sound.

Thirdly, Balch et al. (1992) have studied context-dependent memory in immediate and delayed word recall, focussing on presenting words in a musical context (classical music, jazz music) or without music present. The results showed no evidence for a sufficient facilitation effect caused by the same musical cue, though evidence for a significant context dependency was found for immediate recall. This means that presenting the same musical cue during recall did not result in the participants remembering more words than when no music was provided at all, but the participants did remember significantly more words with a congruent musical cue than with an incongruent musical cue.

Concerning the level of familiarity with the background music, De Groot and Smedinga (2014) found that being familiar with the background music had a short-term effect on vocabulary learning. Participants learned vocabulary in a foreign language with vocal music in a familiar or unfamiliar language, or without any music. When tested immediately after the training, participants scored higher on the familiar language music condition than on the unfamiliar language music condition (see also Hilliard & Tolin, 1979; Chew et al., 2016). This effect was, however, no longer visible one week after training.

Unlike De Groot and Smedinga (2014), both Smith (1985) and Balch et al. (1992) have used only instrumental music (i.e., lyrics are absent). It is reasonable to choose this method, as it has been suggested that background music with lyrics limits the cognitive semantic capacity. Lyrics in songs can be seen as meaningful language, which has an inhibitory effect on the processing of other semantic tasks (e.g., Shih, Huang, & Chiang, 2012). Lyrics are an example of informational masking (e.g., Brouwer et al., 2012; Scharenborg & Larson, 2018). A distinction between two kinds of masking was made by Pollack (1975): informational masking and energetic masking (see also Kidd et al., 2008; Brouwer, 2017). The latter concerns the audibility of speech, and information is lost because of spectral and temporal overlap between the signal and the noise. For informational masking, in contrast, both signal and noise can be audible, but it is more difficult to distinguish between both sound inputs because of for instance linguistic or attentional factors.

One of the causes of informational masking occurring is that too little cognitive resources are available for processing the target speech as the cognitive capacity is partly used for processing the masker (e.g., Mattys et al., 2012; Shinn-Cunningham, 2008). In this light, Brouwer et al. (2012) found that speech intelligibility was lower when target speech occurred with meaningful background babble than when occurring with anomalous background babble, suggesting that meaningful background speech makes a bigger appeal to the cognitive capacities than arbitrary speech. This higher speech intelligibility in an arbitrary speech condition was, however, not always found (e.g., Calandruccio, Dhar, & Bradlow, 2010; Tun, O'Kane, & Wingfield, 2002).

In sum, though results can be ambiguous, background music can have an effect on intelligibility and comprehension (Scharenborg & Larson, 2018a; Scharenborg & Larson, 2018b), on study productivity (Jäncke & Sandmann, 2010; Lehmann & Seufert, 2017; Shek & Schubert, 2009), on reading comprehension (Hilliard & Tolin, 1979; Thompson et al., 2012; Hu et al., 2019), and on memory (Smith, 1985; Balch et al., 1992; Anderson et al., 2000; Kang & Williamson, 2014). Familiarity with the music fragments possibly influenced results (De Groot & Smedinga, 2014; Hilliard & Tolin, 1979; Chew et al., 2016).

1.2 Background noise

Multiple studies have targeted another type of background acoustics – that is, background noise, like filtered white-noise and pure-tone samples (Cooper et al., 2015), and asked the question whether the memory representations of language input and background noise are integrated. Input of language consists of two types of information. First, linguistic information is encoded by spoken language, which includes the phonological, morphological, syntactic, and semantic information that is provided.

Secondly, speaker-specific properties, pertaining to the identity of the speaker, are known as indexical information. This can be seen as the medium through which the linguistic information is conveyed (Levi & Pisoni, 2020). Abercrombie (1967, in Levi & Pisoni, 2020) differentiated between three types of indexical properties: 1) properties indicating group membership (e.g., regional dialect and social aspects), 2) individual properties (e.g., age, gender, and size of speech organs), and 3) properties of personal states that are prone to change (e.g., emotions, speaking rate, and fatigue). The indexical information plays a major role in the realisation of speech, as this information is subject to many varieties within as well as between speakers (Borrie et al., 2013). Listeners can distinguish between linguistic and indexical information when presented with a speech signal in which the two are combined.

McLennan and Luce (2005) have shown that details about a speaker are retained in memory, which leads to indexical effects. They found that memories of indexical information resulted in an improved accuracy or response time for items repeated in the same voice in contrast to items repeated in a different voice. Hence, congruency in indexical properties facilitated memory, which suggests that linguistic and indexical information are stored collectively in verbal memory.

Background music can be seen as another type of indexical property. Pufahl and Samuel (2014) presented participants with words, accompanied by environmental sounds, and participants were asked to indicate for each item whether the word was animate or inanimate. When the words were later presented again, identification was restricted if the voice or the sound had changed. Results showed that an incongruent voice or environmental sound led to a lowered performance in comparison to the congruent condition. This suggested that background information can be stored in memory and that it can have a facilitating effect on successive speech perception. The mental lexicon does not make a distinction between linguistic and indexical information. Instead, representations of words and other sounds (the latter being a form of indexical property) are collectively stored in this memory system.

Note that Pufahl and Samuel (2014) mentioned a critical difference between explicit and implicit recognition tests to measure indexical effects. They stated that explicit tasks produce smaller indexical effects than implicit memory tasks, which has caused inconsistent results across different studies. Implicit tests are more susceptible to indexical effects. Hence, they have been proven to be more reliable.

An explicit memory task has been conducted by Cooper et al., (2015), as participants were explicitly asked to make indications about their memory. They have examined whether keeping the combination of a spoken word and background noise equal had a facilitating effect on the participants' recall of whether the word was already presented once before. Monolingual American English participants were divided in two groups: one participant group was presented with overlapping speech (a disyllabic word) and background noise (either a pure tone or white noise) and the other participant group was presented with speech-background noise combinations that did not overlap.

Both groups carried out a *continuous recognition memory paradigm.* For every item, the participants were asked to indicate which of the following three options was applicable: 'old-same' (indicating that the spoken word was heard before with the same background noise (pure tone versus white noise), 'old-different' (meaning that the word was heard before, but with a different background noise) or 'new' (which means that the word was not heard before in this task). This task would indicate whether speech and background noise were integrated in the memory representation, and if so, if this had an effect on recalling whether or not a word had already been presented.

The results indicated that the effect of background noise on the recognition memory of the spoken word depended on the way in which the combination of speech and background noise was presented. When both sound inputs overlapped, inconsistency of the background noise across two presentations of the spoken word led to a decreased recognition compared to a consistent background noise. Only when speech and background noise overlapped, there was a visible effect of an inconsistent background noise. This indicated that speech and background noise are collectively saved to the working memory. In this condition, the recognition of a word that was presented before was facilitated by consistency of the background noise in both presentations of the word. The results of this experiment suggested integral processing of speech and background noise when both sound inputs are spectrally overlapping. This raises the question whether this also holds for background music. In particular, the question addressed in the current study is if background music would have a similar facilitating effect on memory recall.

1.3 Musical experience

A relevant factor to consider in the present study is the potential effect of musical experience (also indicated with the term 'musical training') on participants' cognitive functions. Most of the previous work, though not all, has shown positive effects of musical training. Swaminathan et al. (2015), for example, have investigated the effect of musical training on the ability to understand speech in noise. The results pointed out an enhanced speech-in-noise perception for musicians compared to non-musicians.

This enhanced speech-in-noise perception for musically trained participants was also found by Kraus and Chandrasekaran (2010). They stated that musical training leads to structural changes in the brain, amongst others in the auditory system. Because of these changes, musicians are well prepared for listening tasks that go beyond the boundaries of musical processing. Thus, the effects of musicality are passed on to domains other than just music, which deal with speech, language, emotion and auditory processing. Music is a source to increase the brain's ability to process auditory information, which could cause an effect on the results in the current study.

Moreover, an effect of musical training on neural representations of speech-in-noise was also found by Parbery-Clark, Skoe, and Kraus (2009). They examined speech perception in noise by a highly musically trained and not musically trained participant group and found that musical training limited negative effects of competing background noise on the neural processing of sound.

Finally, George & Coch (2011) found that musical training is correlated with improved working memory. Musicians performed better on tasks of visual, phonological and executive memory than non-musicians. Additionally, musicians were able to update their auditory and visual working memory faster than non-musicians were.

However, there are also studies which have demonstrated no (e.g., Yeend et al., 2017; Escobar, Mussoi, & Silberer, 2020) or negative effects (e.g., Patson & Tippett, 2011) of musical training on cognitive functions. Patson and Tippett (2011) stated that no effect of background music on language comprehension was found for non-musically trained participants, while musically trained participants did show a negative effect of music on comprehension.

1.4 The present study

The studies mentioned above have shown that background music, sometimes in combination with musical training, can have an effect on auditory processing, working memory, and recall memory. The aim of the current experiment is to examine how spoken words combined with music are stored in memory. To investigate this, native Dutch participants will be tested on a continuous recognition memory paradigm (cf. Cooper et al., 2015) and will be asked about their music experience in a questionnaire. The research question is twofold: *(1) To what extent does background music have an effect on the ability of native Dutch speakers to recall Dutch sentences, and (2) does musical training contribute to this potential effect?*

The continuous recognition memory paradigm employed in the current study contrasts with Cooper et al.'s (2015) set-up in using background music instead of background noise. It is expected that the facilitating effect of background noise on recall of spoken words also holds for background music. In other words, congruency in background music is expected to facilitate recall memory, so spoken words and background music are predicted to be stored collectively (Cooper et al., 2015). Furthermore, Cooper et al. (2015) found a significant effect of the lag on performance on the continuous recognition memory paradigm. This effect was reflected in the results, using *d*-prime scores, as a decrease in accuracy for items that were presented with a different background noise 4 or 8, but not 16 items earlier, which was consistent with findings indicating that *d*-prime values decreased as a function of lag (e.g., Bradlow, Nygaard, & Pisoni, 1999). For this reason, an effect of the lag is also expected in the current study. Furthermore, it is hypothesised that the interaction between congruency and lag is of significant influence on the accuracy, in the way that a lower number of intervening items results in a stronger influence of congruency on performance than a higher lag value. In addition, it is expected that an increase in musical training results in an advantage for the musicians compared to the non-musicians, in the way of an enhanced speech-in-noise perception (Swaminathan et al., 2015; Kraus and Chandrasekaran, 2010) and limitation of negative effects of background noise on the neural processing of sound (Parbery-Clark et al., 2009).

2. Method

2.1 Participants

46 native Dutch speakers participated in this study. One participant reported having had technical difficulties during the task and was excluded from further analysis. Therefore, data from 45 participants were analysed (32 female, 11 male, 2 other, M_{age} = 21.4 years old, *SD* = 1.45). All participants reported to having no hearing problems or deficits. Most participants (*N* = 43) indicated to be highly educated.

31 of 45 participants (21 female, 8 male, 2 other, M_{age} = 21.4 years old, *SD* = 1.63) indicated in a questionnaire to have had musical training, either for playing a musical instrument (*N* = 21), for singing (*N* = 3) or both (*N* = 7). The remaining 14 participants (11 female, 3 male, M_{age} = 21.2 years old, *SD* = 1.53) reported to have not received any musical training. This categorical distinction in musical training will also be used in the analyses.

2.2 Stimuli

Target sentences

The stimulus materials consisted of 127 unique Dutch target sentences, selected from 16 lists (lists 2-6, 10-19, and 21) of the revised Bamford-Kowal-Bench (BKB-R) Standard Sentence Test (Bamford & Wilson, 1979; Bench, Kowal, & Bamford, 1979). A native Dutch speaker translated the sentences and two other native Dutch speakers checked the translations (Brouwer et al., 2012).

From each list, sentences were selected that met the following two criteria: (1) the sentence should employ a subject-object-verb (SVO) word order with a definite article *'de'* or *'het'* preceding the subject noun, and (2) it should contain three keywords (e.g., The CHILD GRABBED the TOY (*"Het KIND PAKTE het SPEELGOED"*), The GIRL HELD a MIRROR (*"Het MEISJE HIELD een SPIEGEL vast"*), The PARK is NEAR the ROAD (*"Het PARK is VLAKBIJ de WEG"*)). Keywords are shown in capital letters. The number of keywords per sentence was indicated in the original stimulus set.

Background music

The stimulus materials consisted of a total of 127 Dutch spoken sentences combined with either one of two music fragments. Two pretests were carried out to determine which music fragments were most suitable to be used. For both pretests, four music fragments were used that were produced with Logic Pro X (2004), a professional music production application. Two music fragments were produced in a major key (music fragment 1 and 2) and two in a minor key (music fragment 3 and 4). Others factors, like tempo and intensity, being the same, music in a major key is generally perceived as relatively happy or bright, whereas music in a minor key is perceived as relatively sad or dark (Bowling et al., 2010).

Pretest 1. The aim of pretest 1 was to examine which two music fragments were perceived as most different from each other, to confirm that participants actually heard the difference between these two fragments, which would be used in the continuous recognition memory paradigm. Participants (*N* = 7, 7 female native Dutch speakers, M_{age} = 21.6 years old, *SD* = 1.27) were asked to indicate, on a scale from 1 (very different) to 7 (not different), how different two music fragments sounded. The presentation order was counterbalanced, meaning that every possible combination of two music fragments was presented in both possible orders (fragments 1-2, 2-1, 1-3, 3-1, 1-4, etc.).

To study which two music fragments were perceived as most different from each other, a 6 by 2 Repeated Measures ANOVA was conducted, with within-subjects factors Combination (music fragments 1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4, and 3 and 4) and Order (two options per Combination, e.g., 1-2 and 2-1). Mauchly's test of sphericity indicated that sphericity could be assumed for the factor Combination and the interaction between Combination and Order. Mean scores of the perceived difference between two music fragments are demonstrated in Table 1.

Table 1

Descriptives (mean and SDs) of the perceived score of difference between two music fragments per Combination per Order.

Combination	Order	Mean score of perceived difference	Standard deviation
Fragments 1 and 2	1-2	4.57	1.62
	2-1	3.71	1.38
Fragments 1 and 3	1-3	1.29	.49
	3-1	1.14	.38
Fragments 1 and 4	1-4	3.14	1.22
	4-1	2.86	.69
Fragments 2 and 3	2-3	2.14	.69
	3-2	1.86	1.46
Fragments 2 and 4	2-4	3.14	1.22
	4-2	3.29	.95
Fragments 3 and 4	3-4	3.43	1.51
	4-3	3.71	2.06

The results demonstrated a significant main effect of Combination ($F(5, 30) = 10.40$, $p < .001$, $\eta^2_p = .63$), indicating that different combinations of two music fragments were perceived differently. More specifically, music fragment 1 and 3 were perceived as significantly more different from each other than the combinations 1 and 2 ($F(1, 6) = 30.75$, $p = .001$, $\eta^2_p = .84$), 1 and 4 ($F(1, 6) = 27.17$, $p = .002$, $\eta^2_p = .82$), 2 and 4 ($F(1, 6) = 168.00$, $p < .001$, $\eta^2_p = .97$), and 3 and 4 ($F(1, 6) = 20.55$, $p = .004$, $\eta^2_p = .77$), and approaching significance in comparison with the combination of music fragment 2 and 3 ($F(1, 6) = 5.26$, $p = .062$, $\eta^2_p = .47$).

Furthermore, the results did not show a main effect of Order ($F(1, 6) = 2.21$, $p = .188$, $\eta^2_p = .27$), neither was the interaction between Combination and Order ($F(5, 30) = .59$, $p = .704$, $\eta^2_p = .09$) found to have a significant effect on scores of perceived difference.

The results of pretest 1 showed that music fragment 1 (in major key) and 3 (in minor key) were most different from each other, scoring (fairly) significantly lower on perceived difference than all other combinations of two music fragments. Based on these findings, fragment 1 and 3 were selected to be included in the continuous recognition memory paradigm.

Pretest 2. The aim of pretest 2 was to examine participants' feelings towards the four music fragments in order to find out whether feelings towards the two selected music fragments (based on results of pretest 1) were different. Participants ($N = 9$, 7 female and 2 male native Dutch speakers, $M_{age} = 21.2$ years old, $SD = 1.20$) were asked to indicate their feelings towards these two music fragments on a scale from 1 (not applicable) to 7 (very much applicable). The results demonstrated that statements concerning positive emotions (e.g., happy, optimistic) were rated higher than statements concerning negative emotions (e.g., sad, angry) for both music fragment 1 (respectively $M = 5.53$ for positive and $M = 1.22$ for negative emotions) and music fragment 3 (respectively $M = 4.00$ and $M = 2.33$). The mean score for positive emotions was significantly higher for music fragment 1 than for music fragment 3, $t(3) = 8.59$, $p = .003$, and the mean score for negative emotions was significantly lower for music fragment 1 than for music fragment 3, $t(3) = -3.65$, $p = .035$.

All stimuli were set to a sampling frequency of 22050 Hz using Praat (Boersma, 2001), a computer programme for analysing, synthesising, and manipulating speech. Besides, both the music fragments and the sentence fragments were set to 65 dB, resulting in a SNR (Signal-to-Noise Ratio) of 0 dB, and normalisation of spectral aspects[2] was applied in Praat (Boersma, 2001). The sentence and music fragments were combined into one sound fragment using Audacity® (Audacity Team, 2020). Each item was set to last precisely 2.0 seconds.

2.3 Procedure

Participants completed the experiment online via a Qualtrics questionnaire (Qualtrics, Provo, UT) on their own electronic device and were asked to use headphones or earphones. The same two lists as in Cooper et al. (2015) were used and two additional lists were created to control for order effects. The background music fragments, and thus the conditions, were counterbalanced across lists. Each list consisted of 228 items of Dutch spoken sentences combined with either music fragment, of which 192 were experimental items, 16 were memory load items, and 20 were filler items (see Appendix A for list 1 as example). Before randomly presenting one of the four lists, 8 practice items were presented to let the participants habituate to the task and to check their audio settings.

One of four lists was randomly assigned to each participant. A list started with 8 practice items to let the listener familiarise with the task and to enable participants to adjust their audio settings to a comfortable listening level. The practice items were followed by 16 memory load items, which were included to avert potential order effects, as performance on items occurring early in the list would presumably be higher than performance on later occurring items due to the fact that the working memory had not been loaded yet in the beginning. 20 filler items were randomly distributed over the list together with the 192 experimental items.

For each trial, participants were asked to indicate which of three options was applicable: 'old-same' (heard the sentence before with the same music fragment; congruent), 'old-different' (heard the sentence before with a different music fragment; incongruent) or 'new' (not heard the sentence before during the task). Each experimental stimulus (but not the filler items) was repeated 4, 8, or 16 items later. For this lag, the first and last presentation of the item counted as respectively the first and the last intervening item. Each lag occurred equally frequent, and 32 new and 32 old (16 'old-same' and 16 'old-different') items were presented per lag. For the 'old-same' condition, two occurrences of a sentence with music fragment 1 were equally likely as two presentations with music fragment 2, and vice versa.

Afterwards, a short questionnaire assessed whether participants had received musical training. If a participant indicated to have had musical training either for playing an instrument or for singing, a couple of additional questions followed to gather information on the age of onset of musical training and the degree to which the participant was still playing the instrument

[2] For this purpose, a long-term average speech spectrum (LTAS) script was employed (created by Chun Liang Chan, see also Brouwer et al., in press). This script was roughly based on the Praat script created by Veenker, van Delft, and Quené ("ltasnoise.praat", see Quené & van Delft, 2010). The LTAS script takes a directory of stimulus files and sets the intensity to match the average intensity of these sound files. The LTAS object is then also saved in the output directory.

or singing on a weekly basis. The total duration of the experimental session was approximately 20 minutes.

2.4 Design and Analysis

The percentage of correct responses (accuracy, 0-100) on the continuous recognition memory paradigm was the dependent variable. The design included three independent variables: the congruency of the background music between two presentations of a sentence (Congruency: congruent vs. incongruent, within-subjects), the lag between items including the same spoken sentence (Lag: 4 vs. 8 vs. 16, within-subjects), and the amount of musical training participants have received (Musical training: musical training vs. no musical training, between-subjects).

Practice, memory load, and filler item were not included in the analyses. A 2 (Condition: congruent or incongruent) by 3 (Lag: 4, 8, or 16) Repeated Measures ANOVA was conducted on the accuracy on the continuous recognition memory paradigm. In addition, it was examined whether musical training had an effect on participants' performance. For this purpose, A 2 by 2 by 3 mixed ANOVA was conducted, with Lag and Condition as within-subjects factors and musical training included as a between-subjects factor. Assumptions of sphericity, normality of difference scores, equal variances, and insignificance of Box's M had to be met to be able to perform this analysis.

3. Results

Mean accuracy (% correct responses) and standard deviations of the participants on each condition and for each lag are presented in Table 2. It can be observed that participants performed better on the old-same than on the old-different condition. Furthermore, participants' accuracy was higher on items with a lower lag value.

Table 2

Descriptives of the accuracy (mean and SDs) per condition per lag

Condition	Lag	Accuracy (% correct)	Standard deviation
Old-same	Lag 4	70.42	20.44
	Lag 8	70.69	19.30
	Lag 16	66.53	18.36
Old-different	Lag 4	56.81	23.92
	Lag 8	51.53	19.04
	Lag 16	45.00	27.33

Conversion of the accuracy to z-scores has shown that there were no significant outliers. Mauchly's test of sphericity indicated that sphericity could be assumed for both the factor Lag and the interaction between the Lag and Condition variable. Results of the Shapiro-Wilk test of normality pointed out a significant difference from normality of standardised residuals of the old-different condition for lag 8 ($W(45) = .95$, $p = .033$) and lag 16 ($W(45) = .94$, $p = .019$). Note that the assumption of normality is of less importance for sample sizes larger than 30, as such data sets meet the Central Limit theorem and therefore tend to be normally distributed (Field, 2013, p. 245). A parametric test was thus preferred over a non-parametric one.

A 2 by 3 Repeated Measures ANOVA with within-subject factors Condition (old-same or old-different) and Lag (lag 4, 8, or 16) was conducted on the dependent variable Accuracy.

The results demonstrated a significant main effect of Condition ($F(1, 44) = 31.82$, $p < .001$, $\eta^2_p = .42$), indicating that accuracy for the old-same condition ($M = 69.07$, $SD = 16.86$) were significantly higher than accuracy for the old-different condition ($M = 51.02$, $SD = 20.90$).

Furthermore, the results showed a main effect of Lag ($F(2, 88) = 10.03$, $p < .001$, $\eta^2_p = .19$). Post hoc pairwise comparisons with a Bonferroni correction indicated that accuracy for lag 4 ($p = .001$) and for lag 8 ($p = .015$) were significantly higher than accuracy for lag 16. Accuracy for lag 4 did, however, not differ significantly from accuracy for lag 8 ($p = .406$).

Finally, the interaction between Condition and Lag was not significant ($F(2, 86) = 1.69$, $p = .191$, $\eta^2_p = .04$). Figure 1 illustrates the mean accuracy for each condition and each lag.

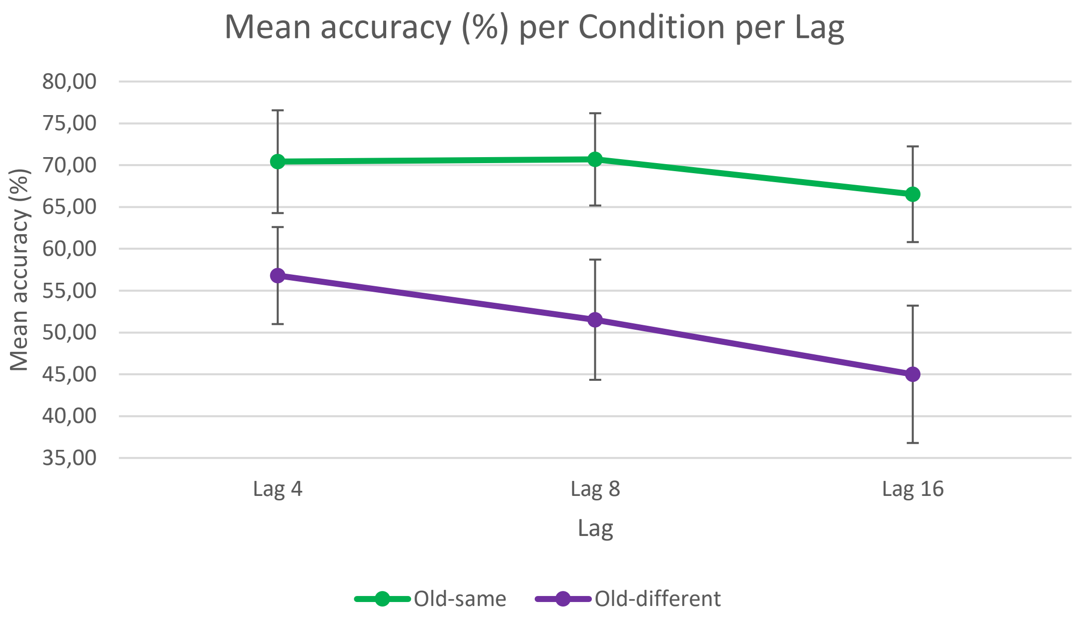

Figure 1. Mean accuracy (% correct responses) per Condition (old-same and old-different) per Lag value (lag 4, 8, and 16), Error bars: 95% CI.

The influence of musical training on the accuracy on the continuous recognition memory paradigm was studied by conducting a 2 by 2 by 3 Mixed ANOVA, with Musical training (musical training for playing an instrument or for singing versus no musical training) as between-subjects factor, Condition (old-same or old-different) and Lag (lag 4, 8, or 16) as within-subjects factors, and the dependent variable Accuracy. Table 3 displays the mean accuracy and standard deviations of each combination of the participant groups, lags, and conditions.

Table 3

Descriptives of the accuracy per musical training group per condition per lag.

Participant group	Condition	Lag	Mean score (%)	Standard deviation
Musical training	Old-same	Lag 4	71.88	18.96
		Lag 8	70.70	16.09
		Lag 16	70.70	12.23
	Old-different	Lag 4	54.30	21.25
		Lag 8	54.30	26.59
		Lag 16	40.23	28.59
No musical training	Old-same	Lag 4	69.64	23.11
		Lag 8	63.84	24.29
		Lag 16	59.82	26.71
	Old-different	Lag 4	62.50	16.81
		Lag 8	51.79	21,15
		Lag 16	48.21	22.39

Conversion of the accuracy to z-scores has shown that there were no significant outliers. Mauchly's test of sphericity indicated that sphericity could be assumed for both the factor Lag and the interaction between the Lag and Condition variable. Results of the Shapiro-Wilk test of normality pointed out no significant differences from normality of standardised residuals. Furthermore, Box's M was not significant and Levene's test revealed no statistically significant deviations from equal variances.

No main effect of musical training was found ($F(1, 44) = .20$, $p = .654$, $\eta^2_p = .01$), which indicated that musical training did not have a significant effect on the accuracy. Additionally, no significant interaction effects of musical training with either Condition ($F(1, 44) = 2.93$, $p = .094$, $\eta^2_p = .06$) or Lag ($F(2, 88) = 2.53$, $p = .086$, $\eta^2_p = .05$) or both were found ($F(2, 88) = .33$, $p = .719$, $\eta^2_p = .01$), illustrating that the impact of musical training did not depend on the value of the lag, the condition or both.

4. Discussion and Conclusion

The main aim of the present study was to examine the effect of congruency in background music on the recall of spoken sentences. Besides the congruency between two presentations of a sentence in background music, the lag between these two presentations (either lag 4, 8, or 16) was included as an independent variable. To answer this, two research questions were formulated: *(1) To what extent does background music have an effect on the ability of native Dutch speakers to recall Dutch sentences, and (2) does musical training contribute to this potential effect?*

Participants filled out an online questionnaire, which consisted of two parts. For the first part of the questionnaire, native Dutch participants completed a continuous recognition memory paradigm (cf. Cooper et al., 2015), in which they were asked to indicate for each item (consisting of a combination of a spoken sentence and a music fragment) whether they had heard the sentence before with the same music fragment ('old-same'), whether they had heard the sentence before with a different music fragment ('old-different') or whether they had not heard the sentence before during the task. The second part asked questions about the amount of musical training participants had received. With this information, the effect of musical training on the performance on the continuous recognition memory paradigm could also be examined.

The results on the continuous recognition memory paradigm showed three main findings. First of all, it was found that the congruency of the background music did have an effect on the ability to recall whether sentences had been presented before. More specifically, the accuracy was significantly higher for the congruent condition ('old-same'), when both presentations of a sentence were presented together with the same background music, compared to the incongruent condition ('old-different'), when two presentations of a sentence were accompanied by different background music. This was in line with previous research showing a similar effect of congruency in background noise (Cooper et al., 2015).

Secondly, the results demonstrated that a lower lag value resulted in a higher accuracy on the task, as predicted based on the results found by Cooper et al. (2015). In particular, the accuracy was significantly higher for lag 4 and lag 8 than for lag 16. In addition, lag 4 did not result in a higher accuracy than lag 8.

The results on the continuous recognition memory paradigm were partly in line with the formulated hypotheses. The two main effects, as expected, had a significant effect on the results, but the interaction between the two factors was, unexpectedly, not significant. The facilitating effect of background noise on recall of spoken words (as demonstrated by Cooper et al., 2015) was hypothesised to also hold for background music and spoken sentences. In other words, spoken sentences and background music were predicted to be stored collectively in the working memory. This appeared to be true, as congruent background music facilitated the recall of whether sentences had been presented before. Performance on recalling sentences was possibly even higher than for recalling words because sentences carry more semantic information than words do. The lower performance found for items with a higher lag value was also expected (e.g., Bradlow et al., 1999; Cooper et al., 2015). The interaction between condition and lag was found not to be of significant influence on accuracy scores on the continuous recognition memory paradigm. This interaction was hypothesised to be of significant influence on the accuracy. More specifically, a lower lag value was expected to result in a stronger effect of congruency in background music on accuracy than a higher lag value. This interaction did not have a significant effect on performance, inferring that the joint effect of the condition and lag was not higher than the individual main effects of these two factors. No significant interaction effect was found, because the effect of either one of these variables was not significantly dependent on the value of the other.

These results indicate that music and spoken sentences were stored together in working memory and no segregation of this memory takes place between two presentations of a stimulus sentence. This contributes to a more broad understanding of the effects of background music and speech perception under presentation with competing input sources on memory. These findings suggest that background music can have a positive influence on accuracy and the ability to boost memory performance can be more broadly used in everyday life.

Two hypotheses on the effect of background music on memory performance were mentioned. First of all, the mood-arousal hypothesis states that a person's mood, arousal, and cognitive performance is improved by the presence of enjoyable music (e.g., Thompson, Schellenberg, & Husain, 2001; Hallam, Price, & Katsarou, 2002; Lesiuk, 2005). Results of pretest 2 showed that both music fragments were rated higher on statements concerning positive emotions (e.g., happy, optimistic) than on statements concerning negative emotions (e.g., sad, angry), suggesting that both fragments were experienced as rather enjoyable.

Secondly, the cognitive load theory (e.g., Anderson & Fuller, 2010; Pool, Koolstra, & van der Voort, 2003) includes music being a distraction and thus limiting the cognitive resources available to complete the task. According to this theory, a higher cognitive load, for example due to the presence of music, results in lower performance on the task.

Considering the fact that music had a positive effect on performance on the memory task employed in the present study, it can be concluded that the results support the mood-arousal hypothesis. The positive effects of music on participants' mood, arousal, and most importantly, their cognitive abilities outweighed the potential negative impact of music on cognitive performance due to the distraction music can pose, limiting cognitive resources (see also Brouwer et al., in press).

Another main finding of the current study was that musical training was not found to have an impact on the performance on the continuous recognition memory paradigm. In other words, there was no effect of musical training on accuracy, implicating that the ability to store the combination of speech and background music was not better for musically training participants than for non-musically trained participants. The facilitating effect of background music was thus not improved for participants who had had musical training, suggesting that the higher (and more divers) amount of contact with music was not of influence on performance on the continuous recognition memory paradigm. This was not consistent with previous research. Swaminathan et al. (2015) found that participants with musical training had a better speech-in-noise perception than participants without musical training. In other words, the musicians had an enhanced speech-in-noise perception compared to non-musicians. Furthermore, Kraus and Chandrasekaran (2010) mentioned that the effects of musicality are passed on to other domains such as speech, language, and auditory processing. The authors argued that music can be seen as a source to increase the brain's ability to process auditory information, which would positively influence the results found for musical participants. The results of the current experiment did not show this expected higher performance for musically trained participants over non-musically trained participants.

Two possible limitations of the current study should be acknowledged to explain the lack of an effect of musical training. First of all, the reliability of the data might be influenced by the way in which musical training has been measured in the current study. In a questionnaire, two questions were asked concerning the participants' musical training. In particular, the age of onset of musical training and the duration of musical training up until the current moment were addressed. These questions yielded limited information on the actual level of their musical training. Participants that, for instance, had a couple of piano lessons at the age of six, but who had never touched a musical instrument afterwards, were also counted as participants with musical training. This could have interfered with the results, thus being a confounding factor. Preferably, there would have been a more true distinction between the two participant groups.

It would be interesting for future research to include only participants with a certain level of musical training and participants with no musical training at all, and whether this more sound categorisation brings about a significant difference between performance of the musical training and non-musical training group.

Another option is to measure musicality more objectively, as playing an instrument or singing only partly defines musicality (e.g., Turker & Reiterer, 2021). Although measuring musical ability has not been investigated often, Müllensiefen et al. (2014) have, for instance, used the Goldsmiths Musical Sophistication Index (Gold-MSI) to assess musical skills and behaviours on multiple dimensions. Nevertheless, these self-reported skills and behaviours were associated with actual performance on two listening tasks. This measuring instrument could be used in future research to examine the effect of musicality on the ability to recall whether sentences were presented before.

Secondly, the unbalanced groups are a point of discussion. The musical training group consisted of 31 members, whereas the participant group with no musical training included only 14 members. Shaw and Mitchell-Olds (1993) stated that unequal sample sizes result in more information available on the effect of one group in comparison to another, thus not realising independency of the independent variables. For this reason, the lack of balance impairs the ability to distinguish what the effects are.

A more general limitation is the nature of the task. Pufahl and Samuel (2014) mentioned a critical difference between explicit and implicit recognition memory tests to measure indexical effects. Implicit tests are more susceptible to indexical effects, thus allowing for a more reliable measurement of memory. For this reason, an implicit test would be preferred over an explicit test. In the current study, an explicit test is employed. Participants' conscious memory for a stimulus is explicitly measured when asked to indicate whether items are old or new in a continuous recognition memory test, and participants were asked whether the background music was equal or different across two presentations of an item, hence the explicit nature of measuring memory for indexical features. A memory task with a more implicit nature would result in a more true measurement of memory for indexical effects.

Another, more general limitation of the present study is the potential effect of the differences in feelings experienced when listening to the two music fragments. Pretest 2 showed that feelings towards music fragment 1 (in major key) were more positive than feelings towards music fragment 3 (in minor key), as could be expected based on the difference in key (major vs. minor). Given the finding that the two music fragments were experienced differently in terms of positive and negative feelings towards the music, this could have interfered with what was aimed to be measured by the continuous recognition memory paradigm. Positive and negative connotations with respectively music fragment 1 and 3 could have aided memory, linking the feelings experienced as a result of the music with the sentence presented. For this reason, it would be preferred to repeat the current research with two music fragments that share the feelings experienced when listening to these fragments.

A second, more broad limitation is that general working memory capacity of the participants has not been taken into account in this study, as it was beyond the scope of this study. However, previous research has shown a disadvantage for participants with lower working memory capacity for recognising speech in noise (Gordon-Salant & Cole, 2016) and a better recognition memory of sentences in noise for participants with a better verbal working memory (Koeritzer et al., 2018), suggesting that working memory capacity plays a central role in the continuous recognition memory paradigm. That is, the higher the working memory capacity, the better performance. It could be the case that significant differences in the participants' working memory capacity would have been found (e.g., George & Coch, 2011), which could have led to different results. In the future, a task to measure memory capacity, for instance a (backwards) digit span task, could be employed to reveal whether working memory capacity influences the results. Such a factor should then be included in the analysis as a covariate.

Another interesting line for future research could be replicating the current experiment with other participant groups and/or with different music stimuli. For example, it would also be interesting to study speakers of different languages to find out if significant differences can be found between groups of speakers. Differences in perception of lexical tone across languages, for instance, could be of influence on the ability to recall whether an item was presented before. Burnham et al. (1996) compared speakers of tonal languages (Thai and Cantonese) and speakers of a non-tonal language (English). The participants were presented with pairs of Thai tones to study their perceptual discrimination in three different linguistic contexts: normal speech, low-pass filtered speech, and musical sounds (violin). The results indicated that English speakers performed better at discriminating contrasting tones in the context of musical sounds than for the low-pass filtered speech, for which the performance was again better than for the normal speech condition. This indicated that the perception of pitch is decreased when pitch is irrelevant for the linguistic context. The speakers of the tonal languages Thai and Cantonese perceived pitch variations equally well for each context, suggesting that an increase of psychoacoustic abilities was not involved in the development of tone perception. The absence of tone in English led to different results than were found for the tonal language group. Differences between languages could be found due to factors like lexical tone and would provide more knowledge on this area.

Next, studying the recall memory of bilingual speakers could provide information on differences in performance on a continuous recognition memory paradigm between multiple languages spoken. Besides, this could reveal whether speaking more than one language influences performance in one language, so whether native speakers of one language perform differently than bilingual speakers in that same language.

With respect to a change of stimuli, three suggestions for future research are given. First of all, using music with lyrics would provide more evidence for the cognitive load theory playing a part in recalling sentences that were presented with background music. Shih et al. (2012) have reported that lyrics in music can be seen as meaningful language. Therefore, besides energetic masking, informational masking takes place when presenting words or sentences and background music with lyrics (Brouwer et al., 2012; see also Pollack, 1975; Kidd et al., 2008; Brouwer, 2017; Scharenborg & Larson, 2018). This is expected to have an inhibitory effect on the processing of other semantic tasks, as this leads to a higher cognitive load (Brouwer et al., in press; Anderson & Fuller, 2010; Pool, Koolstra, & van der Voort, 2003), which would be reflected in the results as a lower performance for background music with lyrics than for background music without lyrics.

Secondly, familiarity with the background music could be altered. Being familiar with background music was found to lead to higher scores than unfamiliar music on a vocabulary learning test (De Groot & Smedinga, 2014), on multiple reading comprehension tasks (Hilliard & Tolin, 1979), and on a word memory task (Chew et al., 2016). To rule out any effect of familiarity with music in the current study, unfamiliar music (newly created music fragments) was used. Including familiar music in future research could confirm whether the positive effect of familiarity with background music is also true for recall memory of spoken sentences and whether the positive effect of congruency in familiar background music on memory is also present and possibly even more considerable.

Thirdly, instead of the sentences included in the current study, Dutch spoken words could be used (cf. Cooper et al., 2015), to study the effect of background music on recall memory for words. This could lead to different results than were found in this study. As words are shorter units of language, they are likely to carry less information than sentences, resulting in a lower cognitive load. Following the cognitive load theory, a decrease in cognitive resources needed results in increased performance.

In conclusion, the results showed that background music had a positive effect on the ability of native Dutch speakers to recall whether Dutch spoken sentences were presented before. As expected, performance on the continuous recognition memory paradigm was influenced by both the congruency in background music for two presentations of a spoken sentence and by the lag, as a lower lag value resulted in higher accuracy on the task. The effect of musical training was, unexpectedly, not of significant influence on the performance, indicating that participants with musical training did not score higher than participants that had not had musical training. The lack of an effect of musical training could have been influenced by possible methodological limitations. A more objective classification of participants' musical training would possibly provide different results. The finding that congruency in background music facilitated recall adds to the current knowledge of background music on memory, as this suggested that spoken sentences and background music are stored collectively in working memory. Although future research would have to provide additional information on the effect music can have on memory, these results allow for a broader application of background music to boost memory performance.

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Appendix A. Stimulus set

Four stimuli lists were created, based on the two lists by Cooper et al. (2015). List 1 is presented below, which is made up of 9 practice items (p1 - p8), 16 memory load items (m1 - p16), 20 filler items (indicated by filler 1 - filler 20) and 192 experimental items. Experimental items with lag 4 are marked blue, items with lag 8 are marked yellow, and items with lag 16 are marked red. For each item, the name of the music fragment indicating the BKB-list and item number (Brouwer et al., 2012; Bamford & Wilson, 1979; Bench, Kowal, & Bamford, 1979), the correct response ('new' or 'old'), the condition ('new', 'same', or 'diff'), and the lag value ('4', '8', or '16', or 'new' for new items) are included.

Trial	Sentence	Music fragment	Response	Condition	Lag
p1	De familie houdt van vis.	AD24r1901_min	new	new	new
p2	De baby bevindt zich op het kleed.	AD24r1903_maj	new	new	new
p3	De wasmachine ging kapot.	AD24r1904_min	new	new	new
p4	De concierge veegde de vloer.	AD24r1906_maj	new	new	new
p5	De baby bevindt zich op het kleed.	AD24r1903_maj	old	same	4
p6	De wasmachine ging kapot.	AD24r1904_maj	old	diff	4
p7	Het badwater was warm.	AD24r1908_min	new	new	new
p8	De familie houdt van vis.	AD24r1901_min	old	same	8
break					
m1	Het meisje hield een spiegel vast.	m1_AD24r1914_maj	new	new	new
m2	De kop staat op een schotel.	m2_AD24r1915_maj	new	new	new
m3	De koeien zijn in het weiland.	m3_AD24r1916_min	new	new	new
m4	De pepermolen was leeg.	m4_AD24r2101_maj	new	new	new
m5	De hond dronk uit een schaal.	m5_AD24r2102_min	new	new	new
m6	De koeien zijn in het weiland.	m6_AD24r1916_min	old	same	4
m7	De kat ving een muis.	m7_AD24r2105_min	new	new	new
m8	De hond dronk uit een schaal.	m8_AD24r2102_maj	old	diff	4
m9	De kop staat op een schotel.	m9_AD24r1915_min	old	diff	8
m10	De koe staat op het gras.	m10_AD24r2109_min	new	new	new
m11	De pepermolen was leeg.	m11_AD24r2101_maj	old	same	8
m12	De koffiekoppen staan op de tafel.	m12_AD24r2110_maj	new	new	new
m13	De koe staat op het gras.	m13_AD24r2109_maj	old	diff	4
m14	De kat ving een muis.	m14_AD24r2105_min	old	same	8
m15	De koffiekoppen staan op de tafel.	m15_AD24r2110_min	old	diff	4
m16	Het meisje hield een spiegel vast.	m16_AD24r1914_maj	old	same	16
1	De ladder staat vlakbij de deur.	AD24r0201_maj1	new	new	new
2	De oude handschoenen zijn vies.	AD24r0204_min1	new	new	new
3	De magere hond had honger.	AD24r0206_maj1	new	new	new
4	De ladder staat vlakbij de deur.	AD24r0201_maj1	old	same	4
5	De jongen kende het spel.	AD24r0207_maj1	new	new	new
6	De politie achtervolgde de auto.	AD24r0210_min1	new	new	new
7	De dame maakt een stuk speelgoed.	AD24r0212_maj1	new	new	new
8	De kleine baby slaapt.	AD24r0214_min1	new	new	new
9	1	filler1			filler
10	De magere hond had honger.	AD24r0206_min1	old	diff	8
11	De kleine baby slaapt.	AD24r0214_min1	old	same	4
12	De school is vandaag vroeg uit.	AD24r0216_min1	new	new	new

13	De politie achtervolgde de auto.	AD24r0210_maj1	old	diff	8
14	De dame maakt een stuk speelgoed.	AD24r0212_min1	old	diff	8
15	De school is vandaag vroeg uit.	AD24r0216_maj1	old	diff	4
16	De glazen schaal brak.	AD24r0301_min1	new	new	new
17	De oude handschoenen zijn vies.	AD24r0204_min1	old	same	16
18	De hond speelde met een stok.	AD24r0302_min1	new	new	new
19	De theepot is erg heet.	AD24r0303_maj1	new	new	new
20	De jongen kende het spel.	AD24r0207_maj1	old	same	16
21	De hond speelde met een stok.	AD24r0302_maj1	old	diff	4
22	De boer heeft een stier.	AD24r0304_maj1	new	new	new
23	De glazen schaal brak.	AD24r0301_min1	old	same	8
24	De dame droeg een jas.	AD24r0306_maj1	new	new	new
25	De kinderen lopen naar huis.	AD24r0307_min1	new	new	new
26	De theepot is erg heet.	AD24r0303_min1	old	diff	8
27	De man maakte zijn schoenen schoon.	AD24r0310_min1	new	new	new
28	2	filler2			filler
29	De jongen rent weg.	AD24r0312_maj1	new	new	new
30	De kamer wordt koud.	AD24r0315_min1	new	new	new
31	Het meisje schopte tegen de tafel.	AD24r0316_maj1	new	new	new
32	De jongen rent weg.	AD24r0312_maj1	old	same	4
33	De kamer wordt koud.	AD24r0315_min1	old	same	4
34	De man maakte zijn schoenen schoon.	AD24r0310_min1	old	same	8
35	De vrouw hielp haar man.	AD24r0401_min1	new	new	new
36	De machine maakte veel lawaai.	AD24r0402_maj1	new	new	new
37	De boer heeft een stier.	AD24r0304_maj1	old	same	16
38	Het meisje schopte tegen de tafel.	AD24r0316_maj1	old	same	8
39	De dame droeg een jas.	AD24r0306_min1	old	diff	16
40	De kinderen lopen naar huis.	AD24r0307_min1	old	same	16
41	De oude man is bezorgd.	AD24r0403_maj1	new	new	new
42	Het huis had een mooie tuin.	AD24r0405_maj1	new	new	new
43	De glazen pot zat vol.	AD24r0411_min1	new	new	new
44	De oude man is bezorgd.	AD24r0403_min1	old	diff	4
45	Het meisje verloor haar pop.	AD24r0413_min1	new	new	new
46	De glazen pot zat vol.	AD24r0411_min1	old	same	4
47	3	filler3			filler
48	4	filler4			filler
49	Het huis had een mooie tuin.	AD24r0405_maj1	old	same	8
50	De vrouw hielp haar man.	AD24r0401_maj1	old	diff	16
51	De machine maakte veel lawaai.	AD24r0402_min1	old	diff	16
52	Het meisje verloor haar pop.	AD24r0413_maj1	old	diff	8
53	De kok maakt een taart.	AD24r0414_min1	new	new	new
54	Het kind pakte het speelgoed.	AD24r0415_maj1	new	new	new
55	De modder plakte aan zijn schoen.	AD24r0416_maj1	new	new	new
56	De badhanddoek was nat.	AD24r0501_min1	new	new	new
57	5	filler5			filler
58	De lucifers liggen op de plank.	AD24r0502_maj1	new	new	new
59	De trein had een ernstig ongeluk.	AD24r0504_maj1	new	new	new
60	De kok maakt een taart.	AD24r0414_min1	old	same	8

61	De gootsteen in de keuken is leeg.	AD24r0505_maj1	new	new	new
62	De trein had een ernstig ongeluk.	AD24r0504_maj1	old	same	4
63	Het park is vlakbij de weg.	AD24r0508_maj1	new	new	new
64	De kok sneed enkele uien.	AD24r0509_maj1	new	new	new
65	De lucifers liggen op de plank.	AD24r0502_min1	old	diff	8
66	Het park is vlakbij de weg.	AD24r0508_min1	old	diff	4
67	De kok sneed enkele uien.	AD24r0509_maj1	old	same	4
68	De gootsteen in de keuken is leeg.	AD24r0505_maj1	old	same	8
69	Het kind pakte het speelgoed.	AD24r0415_min1	old	diff	16
70	De modder plakte aan zijn schoen.	AD24r0416_maj1	old	same	16
71	De badhanddoek was nat.	AD24r0501_maj1	old	diff	16
72	Het kleine meisje schreeuwt.	AD24r0515_min1	new	new	new
73	De verf druppelde op de grond.	AD24r0601_min1	new	new	new
74	De zon smolt de sneeuw.	AD24r0607_min1	new	new	new
75	De vader komt naar huis.	AD24r0608_min1	new	new	new
76	De verf druppelde op de grond.	AD24r0601_maj1	old	diff	4
77	De bezem stond in de hoek.	AD24r0615_min1	new	new	new
78	De vrouw maakte haar huis schoon.	AD24r0616_min1	new	new	new
79	6	filler6			filler
80	De concierge gebruikte een bezem.	AD24r1002_maj1	new	new	new
81	De zon smolt de sneeuw.	AD24r0607_min1	old	same	8
82	De vader komt naar huis.	AD24r0608_maj1	old	diff	8
83	De concierge gebruikte een bezem.	AD24r1002_maj1	old	same	4
84	De goede jongen helpt.	AD24r1004_min1	new	new	new
85	De vrouw maakte haar huis schoon.	AD24r0616_maj1	old	diff	8
86	De keukenklok stond verkeerd.	AD24r1006_maj1	new	new	new
87	Het kleine meisje schreeuwt.	AD24r0515_min1	old	same	16
88	7	filler7			filler
89	De postbode bracht een brief.	AD24r1009_maj1	new	new	new
90	8	filler8			filler
91	De melk stond bij de voordeur.	AD24r1012_min1	new	new	new
92	De bezem stond in de hoek.	AD24r0615_maj1	old	diff	16
93	De keukenklok stond verkeerd.	AD24r1006_min1	old	diff	8
94	De melk stond bij de voordeur.	AD24r1012_maj1	old	diff	4
95	De overhemden hangen in de kast.	AD24r1013_maj1	new	new	new
96	De postbode bracht een brief.	AD24r1009_maj1	old	same	8
97	De grond was erg hard.	AD24r1014_min1	new	new	new
98	De kip legde enkele eieren.	AD24r1016_min1	new	new	new
99	De goede jongen helpt.	AD24r1004_maj1	old	diff	16
100	De snoepwinkel was leeg.	AD24r1101_min1	new	new	new
101	De honden gingen wandelen.	AD24r1102_maj1	new	new	new
102	De dame bleef voor de lunch.	AD24r1104_maj1	new	new	new
103	De bestuurder wachtte op de hoek.	AD24r1105_maj1	new	new	new
104	De honden gingen wandelen.	AD24r1102_min1	old	diff	4
105	De agent weet de weg.	AD24r1107_min1	new	new	new
106	De bestuurder wachtte op de hoek.	AD24r1105_maj1	old	same	4
107	De snoepwinkel was leeg.	AD24r1101_min1	old	same	8
108	De agent weet de weg.	AD24r1107_maj1	old	diff	4

109	De dame bleef voor de lunch.	AD24r1104_min1	old	diff	8
110	De overhemden hangen in de kast.	AD24r1013_maj1	old	same	16
111	Het kleine meisje was gelukkig.	AD24r1108_min1	new	new	new
112	De grond was erg hard.	AD24r1014_min1	old	same	16
113	De kip legde enkele eieren.	AD24r1016_min1	old	same	16
114	De koe gaf wat melk.	AD24r1111_maj1	new	new	new
115	9	filler9			filler
116	De twee boeren praten.	AD24r1113_maj1	new	new	new
117	De koe gaf wat melk.	AD24r1111_min1	old	diff	4
118	Het kleine meisje was gelukkig.	AD24r1108_maj1	old	diff	8
119	Het eten is duur.	AD24r1201_min1	new	new	new
120	Het meisje wast haar haar.	AD24r1202_maj1	new	new	new
121	De voortuin was mooi.	AD24r1203_maj1	new	new	new
122	De kranen zijn boven de gootsteen.	AD24r1205_maj1	new	new	new
123	De vrachtwagen met brood komt.	AD24r1208_min1	new	new	new
124	10	filler10			filler
125	De voetbalwedstrijd is voorbij.	AD24r1210_maj1	new	new	new
126	De vrachtwagen met brood komt.	AD24r1208_maj1	old	diff	4
127	De kinderen hielpen de melkboer.	AD24r1212_min1	new	new	new
128	De voortuin was mooi.	AD24r1203_maj1	old	same	8
129	11	filler11			filler
130	De kinderen hielpen de melkboer.	AD24r1212_maj1	old	diff	4
131	De twee boeren praten.	AD24r1113_min1	old	diff	16
132	De voetbalwedstrijd is voorbij.	AD24r1210_maj1	old	same	8
133	De foto kwam uit een boek	AD24r1213_min1	new	new	new
134	Het eten is duur.	AD24r1201_maj1	old	diff	16
135	Het meisje wast haar haar.	AD24r1202_maj1	old	same	16
136	De foto kwam uit een boek	AD24r1213_min1	old	same	4
137	De kranen zijn boven de gootsteen.	AD24r1205_maj1	old	same	16
138	De chocolade pudding was klaar.	AD24r1214_min1	new	new	new
139	De jongen had een speelgoeddraak.	AD24r1215_maj1	new	new	new
140	12	filler12			filler
141	Het fruit zat in een doos.	AD24r1301_maj1	new	new	new
142	13	filler13			filler
143	De echtgenoot bracht enkele bloemen.	AD24r1302_min1	new	new	new
144	Het fruit zat in een doos.	AD24r1301_min1	old	diff	4
145	De chocolade pudding was klaar.	AD24r1214_maj1	old	diff	8
146	Hij maakt de auto schoon.	AD24r1307_min1	new	new	new
147	De grote hond was gevaarlijk.	AD24r1310_min1	new	new	new
148	De aardbeienjam was zoet.	AD24r1311_min1	new	new	new
149	De kinderen eten allemaal.	AD24r1313_maj1	new	new	new
150	De echtgenoot bracht enkele bloemen.	AD24r1302_min1	old	same	8
151	De jongen heeft zwart haar.	AD24r1314_maj1	new	new	new
152	De moeder hoorde de baby.	AD24r1315_min1	new	new	new
153	De vrachtwagen beklom de heuvel.	AD24r1316_maj1	new	new	new
154	De jongen had een speelgoeddraak.	AD24r1215_min1	old	diff	16
155	De moeder hoorde de baby.	AD24r1315_min1	old	same	4
156	De vrachtwagen beklom de heuvel.	AD24r1316_maj1	old	same	4

157	14	filler14			filler
158	De jongen heeft zwart haar.	AD24r1314_maj1	old	same	8
159	De boze man schreeuwde.	AD24r1401_min1	new	new	new
160	De hond slaapt in een mand.	AD24r1402_maj1	new	new	new
161	Hij maakt de auto schoon.	AD24r1307_maj1	old	diff	16
162	De grote hond was gevaarlijk.	AD24r1310_min1	old	same	16
163	De aardbeienjam was zoet.	AD24r1311_maj1	old	diff	16
164	De kinderen eten allemaal.	AD24r1313_min1	old	diff	16
165	Het keukenraam was schoon.	AD24r1408_maj1	new	new	new
166	De boze man schreeuwde.	AD24r1401_min1	old	same	8
167	Het meisje speelde met de baby.	AD24r1409_min1	new	new	new
168	15	filler15			filler
169	De kinderen wasten de borden.	AD24r1412_min1	new	new	new
170	Het meisje speelde met de baby.	AD24r1409_min1	old	same	4
171	De postbode komt vroeg.	AD24r1413_maj1	new	new	new
172	Het keukenraam was schoon.	AD24r1408_min1	old	diff	8
173	Het bord wees de weg.	AD24r1414_maj1	new	new	new
174	Het gras wordt lang.	AD24r1415_maj1	new	new	new
175	De hond slaapt in een mand.	AD24r1402_min1	old	diff	16
176	Het bord wees de weg.	AD24r1414_min1	old	diff	4
177	16	filler16			filler
178	De lucifer viel op de vloer.	AD24r1416_min1	new	new	new
179	Het vuur was erg heet.	AD24r1502_maj1	new	new	new
180	De winkel sloot tijdens de lunch.	AD24r1504_maj1	new	new	new
181	De bestuurder startte de motor.	AD24r1505_min1	new	new	new
182	Het vuur was erg heet.	AD24r1502_maj1	old	same	4
183	17	filler17			filler
184	De kinderen wasten de borden.	AD24r1412_min1	old	same	16
185	De lucifer viel op de vloer.	AD24r1416_min1	old	same	8
186	De postbode komt vroeg.	AD24r1413_min1	old	diff	16
187	De jongen haastte zich naar school.	AD24r1506_maj1	new	new	new
188	De bestuurder startte de motor.	AD24r1505_maj1	old	diff	8
189	Het gras wordt lang.	AD24r1415_maj1	old	same	16
190	De kleine baby was mooi.	AD24r1511_min1	new	new	new
191	De dochter dekte de tafel.	AD24r1512_min1	new	new	new
192	De trein stopt op het station.	AD24r1515_maj1	new	new	new
193	De puppy speelt met een bal.	AD24r1516_min1	new	new	new
194	De jongen haastte zich naar school.	AD24r1506_min1	old	diff	8
195	De winkel sloot tijdens de lunch.	AD24r1504_maj1	old	same	16
196	De puppy speelt met een bal.	AD24r1516_maj1	old	diff	4
197	18	filler18			filler
198	De kinderen zwaaiden naar de trein.	AD24r1601_maj1	new	new	new
199	De trein stopt op het station.	AD24r1515_maj1	old	same	8
200	19	filler19			filler
201	De kinderen zwaaiden naar de trein.	AD24r1601_maj1	old	same	4
202	20	filler20			filler
203	De regenjas is erg nat.	AD24r1604_min1	new	new	new
204	De dame kocht wat boter.	AD24r1605_min1	new	new	new

205	De kleine baby was mooi.	AD24r1511_maj1	old	diff	16
206	De dochter dekte de tafel.	AD24r1512_min1	old	same	16
207	De dame kocht wat boter.	AD24r1605_min1	old	same	4
208	De agent vond een hond.	AD24r1608_maj1	new	new	new
209	De bestuurder raakte de weg kwijt.	AD24r1610_maj1	new	new	new
210	De regenjas is erg nat.	AD24r1604_maj1	old	diff	8
211	De agent vond een hond.	AD24r1608_min1	old	diff	4
212	De bestuurder raakte de weg kwijt.	AD24r1610_min1	old	diff	4