Recognition Memory for Musical Pitch and Rhythm is Resistant to Interference

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Declaration

I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary educational institution.

Tabitha Wood

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Characters – 58,498

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Abstract

Recognition performance for most stimuli decreases as the amount of interference between exposure and recognition increases. However, for a few select stimuli—music, poetry and line drawings—recognition performance shows little to no disruption by interference. The novel Regenerative Multiple Representations (RMR) conjecture proposes that for these select stimuli, our experience influences how they are perceived and encoded into memory. In the case of music, conformity to the compositional rules of the music that a listener is accustomed to, influences whether or not they perceive a stimulus as musical. If a stimulus is perceived as musical, the memory of this stimulus will consist of multiple memory representations which provides resistance to the cumulative disruptive effects of interference. The present study aims to get closer to the precise mechanisms that drive this resilience. In order to do this, we used melodies that conform to fewer compositional rules of Western music compared to musical stimuli that previously showed resilience; yet more rules compared to stimuli that previously showed no resilience. Recognition performance for 90 participants was measured across three experiments, with Experiments 2 and 3 isolating the pitch and rhythm information, respectively. Results from all three experiments showed resistance to the effects of interference with up to 106 intervening items. These findings suggest that the strength of enculturation on memory for melodies is so powerful that even the small amount of recognisable musical information (in the stimuli used in the present study), was enough to trigger the processes described by the RMR conjecture.

Recognition Memory for Musical Pitch and Rhythm is Resistant to Interference

Memory is a complex and essential aspect of human experience. Recognition memory—deciding whether an object has been encountered before—has fascinated cognitive psychologists for decades. The current consensus is that recognition memory consists of two separate mechanisms: recollection and familiarity (Rugg & Yonelinas, 2003; Yonelinas, 2002). Recollection, refers to high confidence recognition of stimuli based on their specific features, e.g. when and where it was previously encountered (Yonelinas, 1994). Familiarity, on the other hand, refers to low confidence recognition based on remembering previous encounters, but being unable to recall specific details (Yonelinas, 1994). For example, running in to someone that you know you have met before, but being unable to recall when, where or the person's name. For the present study, memory recognition based on familiarity is sufficient as we are more interested in the mechanisms of forgetting (i.e. interference) rather than the extent of the participant's recognition (Yonelinas, 2001).

Decay and interference refer to two mechanisms of forgetting (Sadeh, Ozubko, Winocur, & Moscovitch, 2014). Decay denotes forgetting as a result of time passing, whereas interference, the focus of the present paper, infers forgetting as a result of additional stimuli encountered during presentation and retrieval of a given target object (Herff, 2017; Sadeh et al., 2014). A continuous recognition paradigm—the task used in the present study—is an explicit memory task that is not only used for testing memory recognition but also the effects of interference (Shepard & Teghtsoonian, 1961). The continuous recognition paradigm involves presenting a set of stimuli to participants, multiple times, in a continuous stream. This allows the researcher to manipulate interference levels by changing the number of intervening items (interveners) between the first and subsequent presentations of a given item (Shepard & Teghtsoonian, 1961). For example, Olson (1969) used a continuous recognition paradigm to investigate the effects of interference on memory for trigrams (random 3 character combinations). The experiment consisted of a set of 334 trigrams, namely 20 target trigrams repeated 1 to 9 times, and 314 distractor trigrams (interveners) resulting in between 0-70 interveners between any initial and subsequent presentations of a target trigram. The present study is different, however, as the entire set of melodies are target items. The structure of the continuous recognition paradigm used in the present study is discussed further in the Analysis subsection of the General Method section.

The continuous recognition paradigm is different to other explicit tests of memory recognition in which the stimuli are usually presented in blocks (i.e., a block of stimuli to learn and a test block in which stimuli from the learning block need to be identified) (Schaal, Javadi, Halpern, Pollok, & Banissy, 2015). However, the continuous recognition paradigm is more relatable to the continuous recognition of everyday life as there is no distinct learning and test phase (Herff, 2017; Schwartz, 2016). For example, everyday life consists of a constant stream of multiple incoming stimuli through all sensory systems, that act as interference on each other. Furthermore, it is not always apparent when any incoming information will need to be recalled.

Recognition performance for the majority of stimuli decreases due to the cumulative disruptive effect of interveners (Olson, 1969; Sadeh et al., 2014). For example, a disruptive effect of interveners is found in; verbally presented words with 1 - 32 interveners (Buchsbaum, Padmanabhan, & Berman, 2011); visually presented words with 0 – 64 interveners (Poon & Fozard, 1980); photographs of household objects with up to 12 interveners (Yeung, Ryan, Cowell, & Barense, 2013); short letter-number combinations presented visually and verbally with 0 – 32 interveners (Le Breck & Baron, 1987); positive and negatively valanced faces with 10 – 15 interveners (Treese, Johansson, & Lindgren, 2010); sentences with 4 - 8 interveners (Tillmann & Dowling, 2007) and visual rhythm - expressed through flashing lights with 6 – 8 interveners (Collier & Logan, 2000). However, the disruptive effect of interveners on recognition is not found, when using a few select stimuli.

Firstly, melodies that consist of compositional rules that match the musical rules developed and accepted in the participant's culture (Herff & Czernochowski, 2019; Herff, Olsen, & Dean, 2018) are especially resistant to interference, even with up to 197 interveners (Herff, Olsen, & Dean, 2018). Compositional rules can be thought of as a type of grammar in musical language. Just like grammatical rules for language allow for a shared understanding, the expectations that compositional rules create helps people understand and enjoy music (Vuvan, 2012). For example, there are many compositional rules specific to Western music such as tonality (all pitches being in a musical key) and predictable rhythm. However, when melodies that do not conform to the musical rules from a participant's culture are used, the disruptive effect of interveners surfaces (Herff, Olsen, Dean, & Prince, 2018).

Secondly, line drawings show no significant reduction in recognition performance as a result of interveners whereas photographs do (Berman, Friedman, & Cramer, 1991). Thirdly, memory for poetry shows resistance to forgetting as a result of interference (Tillmann & Dowling, 2007). The regenerative multiple representations (RMR) conjecture (Herff, Olsen, & Dean, 2018) is a novel theory that has been proposed to explain why some stimuli demonstrate resilience to interference.

The RMR Conjecture

The RMR conjecture (Herff, Olsen, & Dean, 2018) proposes that recognition performance for certain stimuli involves processes—across four inter-connected layers—that result in a resistance to forgetting: Experience, perception, memory formation and retrieval. Layer one describes how our life experience directs our attention to the most salient features of a stimulus. Layer two explains how experience influences perception which merges individual features with the complete object. Usually only the perception of the integrated whole is of perceptual relevance (Castellano, Bharucha, & Krumhansl, 1984) and forms the basis of a memory representation. However, for some stimuli both the underlying features as well as the coherent whole are of relevance. Layer three explains, how memory representations are formed for both the complete melody and its underlying components. These memory representations overlap and may necessarily contain redundant information. The fourth and final layer postulates that when we need to retrieve such a stimulus, the overlapping multiple representations are able to regenerate each other providing protective mechanisms against forgetting (Herff, Olsen, & Dean, 2018).

The RMR Conjecture and Music

Music contains an array of information and features that can be manipulated, making it an ideal stimulus for exploring the usefulness of the RMR conjecture. Two such features are pitch and rhythm. Both contain many specific compositional rules for Western music, both are integral to music perception and both are commonly used in the study of musical memory (Prince, 2009). The term pitch refers to the subjective perception of frequency (Prince, 2009) and the term rhythm refers to a pattern of durations (timing) within a melody (Fraisse, 1982; Grahn, 2012; Prince, 2011). The rules in Western music dictate that pitch information can be surface level (e.g. the name of a single pitch and the subset of pitches that belong with it: described as all pitches being in a musical key) and part of the underlying structure (e.g. the relationship between pitches) (Krumhansl, 2000; Lerdahl & Jackendoff, 1983; Prince, 2011; Schellenberg, 1996). Likewise, there are rules for Western music that dictate rhythm information (e.g the spaces between notes must follow a regular timing pattern) (Fraisse, 1982; Krumhansl, 2000; Prince, 2009). In summary, for a stimulus to be deemed musical by a Western listener it must follow Western compositional rules, in pitch and rhythm among others.

The RMR conjecture proposes that for the style of music that matches the participants experience, melodies are perceived as multiple components as well as an entire melody. This simultaneous perception is what leads to multiple representations that aid retrieval. The greater the number of representations the more resilient a memory is (Herff, Olsen, & Dean, 2018) . Importantly, this is only the case as long as the compositional rules of the melodies match the musical rules of the listeners culture. Indeed, when listeners are faced with melodies that contain rules they are unaccustomed to, memory shows cumulative disruptive interference (Herff, Olsen, Dean, et al., 2018). In the following we will review literature relevant to the different layers of the RMR conjecture in the context of music. This review will be followed by a closer examination of studies that directly tested hypotheses generated by the RMR conjecture.

Layer One - Experience

As previously mentioned, music is a central component of human behaviour and cognition, evidenced by the fact that it is an important part of every known culture (Schellenberg, 1996; Stevens, 2015). Many aspects of music have differed across culture and time, however, the present study focused on Western music. As previously described, Western music follows many specific compositional rules (Krumhansl, 2000; Lerdahl & Jackendoff, 1983; Prince, 2011; Schellenberg, 1996) that remain consistent across musical events resulting in a predictable experience for listeners. Additionally, music is a pervasive influence in Western culture: appearing on TV, radio, cinema, and at most important memorable occasions such as birthdays, weddings and funerals. This leads to extensive passive exposure of for listeners growing up in a Western culture (Stevens, 2012).

An individual's experience with Western music leads to knowledge that informs processes of selective attention (Kahneman, 1973; Milne, 2013). We are able to conserve resources by having our attention focused on the most important features of a musical event

(Deutsch & Deutsch, 1963; Kahneman, 1973). During their development Western listeners learn that pitch and rhythm are important features to attend to for the comprehension and enjoyment of music (Jones, 1990; Peretz & Coltheart, 2003; Prince, 2009). Furthermore, Western musical rules dictate when, where and how the pitch and rhythm features will occur, which creates melodic expectations (Dowling, Lung, & Herrbold, 1987; Rohrmeier & Koelsch, 2012). Melodic expectations are cognitive frameworks that are engaged when the listener encounters a stimulus as musical (Dowling et al., 1987; Margulis, 2005).

Melodic expectations and selective attention are considered top-down processes as they involve the use of cognitive templates that are created through knowledge and experience (Deutsch & Deutsch, 1963; Jones, 1990). Bottom-up processes refer to more unconscious processing of stimuli that use innate systems to filter incoming stimuli (Narmour, 1989). However, it has been suggested that even bottom-up processing can be adapted or refined by extensive experience with predictable stimuli (Narmour, 1991). In summary, experience with Western music creates melodic expectations for Western listeners that directs their attention to the pitch and rhythm features of a melody.

Layer Two – Perception

Perception is made up of stimulus input combined with cognitive processing (Kahneman, 1973) triggered by experience (Schroger, Marzecova, & SanMiguel, 2015). Cognitive processes use the incoming input to predict precision and usefulness of the stimulus (Schroger et al., 2015). Predictions are based on the theory of Bayesian inference: prior experience shapes our interpretation, continually updating our internal processes, in order to make more accurate predictions (Knill & Richards, 1996). When the incoming stimulus information matches our prediction, we then successfully perceive the event. In the case of music, a complete melody consisting of important features (Koelsch, Vuust, & Friston, 2019; Schroger et al., 2015). For Western encultured listeners, this perception process is more difficult for Non-Western music as experience informing top down processes, becomes irrelevant (Schroger et al., 2015).

For an example of how our experience can change the complexity of our perception, consider our perception of a simple kitchen cupboard. The majority of people will perceive it as a regular cupboard: a cube with a door that is used to store food or crockery. To a cabinet maker whose expertise is in building cupboards, the perception of a cupboard consists of the whole cupboard but, importantly, also involves many features that their experience has taught them is important: the alignment of the door, the quality of the materials and the multiple aesthetic properties of the cupboard as a whole, among others. Just as the cabinet maker's experience informs their perception, an individual's experience of music in their culture informs which aspects of music are necessary to notice.

To summarise, the RMR conjecture predicts that by using cognitive processes that are generated by our experiences, listeners perceive melodies consisting simultaneously of multiple features and a unified whole rather than unrelated individual components.

Layer Three – Memory Formation

The simultaneous perception of the underlying features of a melody as well as a complete whole results in overlapping memory representations (Müllensiefen & Halpern, 2014; Sadeh et al., 2014). Recency-in-memory effects—superior recognition performance for the most recently presented stimulus—have been used to demonstrate that memory of the melody consists of overlapping multiple representations (Dowling, 1973; Herff, Olsen, & Dean, 2018). The RMR conjecture predicts that a recency-in-memory effect would only appear if the memory formation of a melody included a unified whole melody. Otherwise the most recently presented stimulus would be the last individual note of the melody rather than the entire melody. To explore this further Herff, Olsen, and Dean (2018) investigated the effect of recency on Non-Western melodies. They found that the lack of Western compositional rules in the melodies disrupted the ability of participants to create a representation of a complete melody, as no recency-in-memory effect was found (Herff, Olsen, & Dean, 2018).

Continuing with the previous example of the expert cabinet maker, imagine all the materials required to build a cupboard are arranged together on a table. To most people it would appear to be a random arrangement of building materials, however, a cabinet maker can see how the materials will come together to form a cupboard. Similarly, those unfamiliar with how Western music comes together will still hear the individual notes but will be unable to combine them to perceive a unified melody, leaving them without multiple overlapping memory representations for that melody to provide resistance to interference.

Final Layer - Retrieval

A participant's ability to retrieve a melody, depends upon how it was encoded. Individual memory representations of the separate features of a melody without the overlapping representation of the melody as a unified whole, leaves the representations open to effects of interference (Herff, Olsen, & Dean, 2018; Kroll, Knight, Metcalfe, Wolf, & Tulving, 1996; Sadeh et al., 2014; Sadeh, Ozubko, Winocur, & Moscovitch, 2016). This is because if one representation falls below the threshold of retrieval, there is no link to the remaining representations so they are unable to regenerate the lost aspect in order for the participant to recognise the melody (Herff, Olsen, & Dean, 2018). The RMR conjecture predicts that multiple representations are able to regenerate each other as long as they are linked together by belonging to a combined melody.

The retrieval process is further supported by melodic expectations that can help identify what belongs in the gaps that are left by the missing representation (Rohrmeier & Koelsch, 2012). For example, for the experienced cabinet maker, the loss of a memory representation for the type of handles used for a particular cabinet would not prevent the cabinet maker from recognising the whole cabinet. Furthermore, the memory representations from the other features and the cabinet as a whole would trigger retrieval of the memory of the type of handles used.

In summary, the RMR conjecture provides a meaningful way of understanding music's resilience to interference. Experience with Western music creates a perception of a complete melody that determines the overlapping nature of memory representations of the individual features of the melody as well as the unified whole. The overlapping multiple representations in turn afford regeneration of lost representations providing resistance to the effects of interference. Below investigations of three hypotheses generated by the RMR conjecture will be discussed.

RMR Conjecture Investigations

Western Melodies

The first RMR investigation by Herff, Olsen, and Dean (2018), used the continuous recognition paradigm across four different experiments. They hypothesised that interveners should not have a disruptive effect on recognition performance for melodies that followed Western compositional rules (Western Melodies). In Experiment 1, Herff, Olsen and Dean (2018) found no cumulative disruptive effect of interveners (1- 6 interveners) for Western melodies. In Experiment 2 the same melodies were used, and the range of interveners increased (4-13 interveners) but still no significant disruptive effect was found. To establish the extent of resistance to interference for Western melodies, Herff, Olsen and Dean (2018), added a third experiment. Experiment 3 used melodies that still followed Western compositional rules but were transposed in terms of musical key (surface level pitch information). To understand transposition, consider the nursery rhyme 'Row, row, row, your boat'. It starts in a specific musical key however, the ability of the singer to actually produce that key in song does not alter our perception of the tune. The nursery rhyme is transposed to which ever key the singer is able to achieve but which song they are singing remains abundantly clear.

In this third experiment, Herff, Olsen, and Dean (2018) used novel melodies based on European folk songs that were transposed in terms of pitch. Although, recognition performance in this third experiment was worse than in Experiments 1 and 2, there was still no significant effect of interveners (1- 197 interveners). This shows that underlying structural pitch information (the relationships between pitches, which was the only pitch information left after the transposition) is enough to provide resistance to the disruptive effects of interveners, but surface level pitch information provides better recognition performance.

The previous three experiments by Herff, Olsen and Dean (2018) used an explicit memory task, the continuous recognition paradigm. Experiment 4 was added to determine if the same effects would be found in an implicit memory task using the same melodies as Experiment 3. This experiment still showed no effect of cumulative disruptive interference even in an implicit memory (unconscious memory recognition) task of perceived familiarity (Herff, Olsen, Dean, et al., 2018).

Overall, these four experiments (Herff, Olsen, & Dean, 2018) concluded that Western melodies showed no effect of interveners, even with up to 197 interveners and when starting in an unusual key (Herff, Olsen, & Dean, 2018) in implicit and explicit memory tasks.

Non-Western Melodies

The second hypothesis generated by the RMR conjecture proposes that while memory for melodies that follow Western rules should show resistance to interference, but melodies that violate these rules should not. This is because the way memory representations are encoded is dependent on experience. Herff, Olsen, Dean, et al. (2018) tested this prediction using the continuous recognition paradigm.

Experiments 1 and 2 used slightly Non-Western melodies (did not comply with some western compositional rules) with up to 13 interveners. The melodies used in these first two experiments diverged enough from Western music to disrupt the recency effect, but they were not different enough to show a disruptive effect of interveners on memory recognition. Therefore, Experiment 3 used melodies that diverged completely from Western music. The melodies did not conform to any Western compositional rules and as such were maximally different from Western listeners' expectations of a musical stimulus. Additionally, pure artificially generated tones were used instead of piano tones. In this last experiment a clear disruptive effect of interveners was found.

Taken together, these results show that recognition performance—for melodies that do not conform to any western compositional rules—was reduced as a result of interveners (Herff, Olsen, Dean, et al., 2018). Furthermore, melodies that are more similar to Western melodies are able to resist the effect of interveners. However, the lack of recency effect indicates that these similar melodies were not encoded as a whole melody.

Non-Western Melodies: Pitch and Rhythm Information

The third RMR hypothesis investigated the influence of different features of music on interference effects. Herff, Olsen, Prince, and Dean (2018) were interested in the influence of pitch and rhythm information in sequences that did not comply with any Western musical rules, similar to those used in Experiment 3 in Herff, Olsen, Dean, et al. (2018). Experiment 1's melodies served as a base line for Experiments 2 and 3, as in Experiment 1 both rhythm and pitch information were available. Experiment 2's melodies held the rhythm constant so only the pitch dimension provided information. Experiment 3's melodies held the pitch constant so that only the rhythm dimension provided information. Each melody was presented three times to each participant, again using the continuous recognition paradigm. As predicted by the RMR conjecture in each of the three experiments there was a disruptive effect of interveners due to the melodies not matching the musical enculturation of the participants.

However, further research is required to understand which part of a melody provides its musicality, which in turn—due to the processes described by the RMR conjecture—creates resilience to the effect of interveners on recognition performance. One approach towards answering this question is by systematically adjusting the degree to which melodies conform to Western music and observing when interference occurs, and when it does not. As described below, the present study provides one step in the direction of testing interference in recognition memory for melodies that are similar to Western music.

Aim of the Present Study

The present study replicates the previously mention study by Herff, Olsen, Prince, et al. (2018), changing the melodies slightly so that they only conform to one Western compositional rule in pitch and one in rhythm to clarify the role that experience plays in memory for melodies. In line with the RMR conjecture (Herff, Olsen, & Dean, 2018) it is predicted that there should be no cumulative disruption as a result of interveners in Experiments 1 and 2, due to the melodies following the Western rule of pitches all being in a musical key. In Experiment 3, it is predicted that even though rhythm is not as salient as pitch, having one rhythm rule that still follows Western rules should be enough to trigger the processes that result in resistance to cumulative disruptive interference. Furthermore, recognition performance for Experiment 1, should be better than Experiments 2 and 3, as it contains information in two dimensions (pitch and rhythm) resulting in the formation of more overlapping memory representations.

General Method

Overview

Across three experiments, using a continuous recognition paradigm, the effect of interveners on recognition performance for melodies was investigated. In Experiment 1, the melodies contained information from both the pitch and rhythm dimensions. In Experiment 2 the rhythm information was held constant, and in Experiment 3 the pitch information was held constant.

Experimental Design

All three experiments had the same experimental design: a between subject's design. The researcher and the participants were blind as to which experiment the participants were allocated to. This was possible as the procedure was identical for each experiment with only the set of melodies used differentiating the experiments. The set of melodies—the experimental condition—the participant heard, was determined by the software program used to run the experiment.

Stimuli

The melodies created for the three present experiments were adapted from Prince, Stevens, Jones, and Tillmann (2018).The adapted melodies were novel melodies (unheard by the participant prior to the experiment) that resembled Western music: Pitches were from one musical key (a Western pitch compositional rule), and the durations followed a regular rhythmic framework (a Western rhythm compositional rule). However, these were the only aspects of the melodies that conformed to Western tradition. The melodies were constructed using a subset of notes taken from an alphabet of pure tones (See Table 1. for individual details of the subset of notes). Each melody contained a sequence of 5 or 6 notes from the subset in Table 1. The same melodies were used for each experiment, however, for Experiments 2 and 3, the rhythm (Experiment 2) and pitch (Experiment 3) information were held constant (see Figure 1 for an example). The average duration of the melodies was slightly different in Experiments 1 and 3 due to the varying note durations combined with sequence variations.

Table 1.

Notes Used to Create Melodies

Duration (ms)	**Pitch (Hz)**	**Pitch (name)**
60	261.63	C4
120	293.66	D4
240	329.63	E4
480	349.23	F4
960	392.00	G4

The melodies were created using sequences based on varying combinations of the five notes in this table. Each row contains the information for a single note (pattern of durations in a sequence = rhythm). For a full list of sequence codes that were used for the melodies in all three current experiments, see Appendix A. Note this is not an actual sequence, just the specific information of the subset of notes. ms = milliseconds; Hz = Hertz.

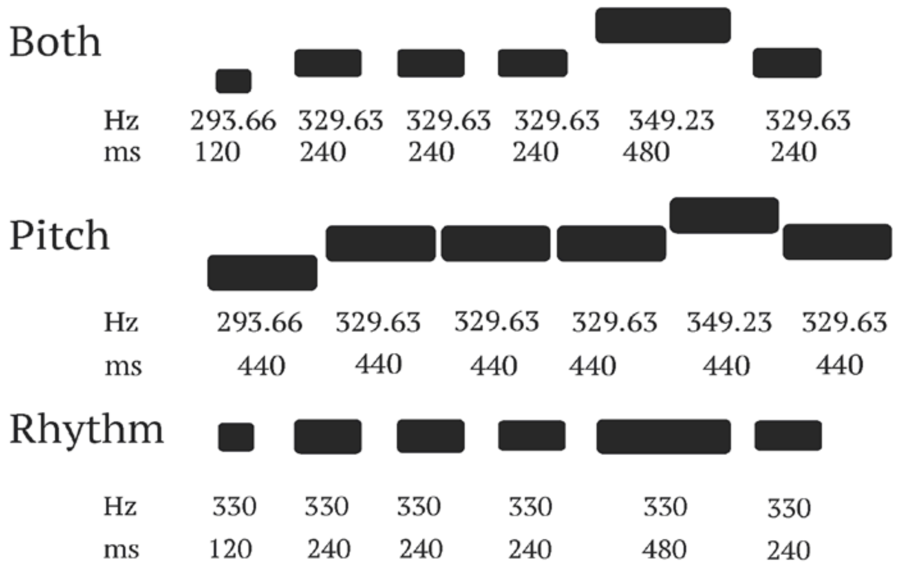

Figure 1. A visual example of the same melody sequence across all three experiments. In Experiment 1 (Both); both the pitch and rhythm information vary, in Experiment 2 (Pitch); the rhythm information is held constant at 440ms and in Experiment 3 (Rhythm); the pitch is held constant at 330Hz. Placement height of bars denotes pitch and width of bars denotes duration (pattern of durations = rhythm). Hz = hertz, ms = milliseconds. Adapted from "Learning of Pitch and Time Structure in an Artificial Grammar Setting," by J.B. Prince, C.J. Stevens, M.R. Jones, and B. Tillmann, 2018, *Journal of Experimental Psychology: Learning, Memory and Cognition*, *44*, p. 11. Copyright 2019 by the American Psychological Association.

Apparatus

A PC running Windows 7 was used to run custom scripts in the MATLAB programming environment (v. r2009a), (MathWorks, 1993) using the psych-toolbox plug in (Brainard, 1997). The headphones (Sennheiser, HD 280 pro) were adjusted to participant's size and loudness preferences. A questionnaire was used to collect demographic information and assess musical background of participants (see Appendix B). All three experiments had human research ethical approval (see Appendix C; ethics approval number: 2019/041)

Procedure

The experiments began by asking the participant to read the information letter (see Appendix D) and sign the consent form (see Appendix E). The participant was then asked to sit in a small quiet room in front of a computer. They were informed that they would be presented with a series of melodies and were to use the computer keyboard to indicate, after each one, if they had heard it previously during the experiment (*Old*), or whether they had not heard it before (*New*). After answering any participant questions, the experimenter left the room and closed the door to minimise distractions. A continuous recognition paradigm was used. When the participant had completed all 111 trials, they completed a questionnaire about their demographics and musical background. Once they had completed the questionnaire the participant was debriefed as to the purpose of the experiment and given the opportunity to ask any questions. The whole process took approximately 30 minutes for each participant.

The continuous recognition paradigm.

The same continuous recognition paradigm that was used in Herff, Olsen, Prince, et al. (2018) was used here in all three experiments. There were 37 different melodies that were presented to the participant, one after the other, until all 37 melodies had been presented three times. This meant that in total the participant heard 111 melodies. As the melodies were randomly interleaved with each other, there could be anywhere from 0 -106 different melodies (interveners) in between any two presentations of the same melody.

Analysis

Chance performance.

To assess whether participants were able to perform the memory task overall, a series of t-tests compared the proportion of *Old* responses between first and second melody presentation. These tests were performed both participant and melody wise. Shapiro-Wilks tests were run to check assumption of normality for the t-tests. All data were normally distributed except for presentation 2 in the rhythm only dataset. This was anticipated, which is why a GLME model was chosen for the main analysis. For the sake of the T-tests the histogram for the second presentation rhythm data was viewed and for the purposes of chance performance calculations the data were sufficiently normal. The results of the t-tests are presented in the form of scatterplots and reported as *t*-scores and *p*-values at the start of the results of each experiment to illustrate that overall, the participants performed above chance.

The Model.

Linear mixed effects models were deployed in order to get a comprehensive analysis based on the data, given the experimental design. This approach can provide support for or against the null and alternate hypotheses, whilst controlling for the random effect structure introduced by the experimental design (Kruschke, 2013; Nathoo & Masson, 2016; Wagenmakers, 2007). As the recognition data is binary—and does not fit the assumptions required for a linear mixed model (Kachman, 2000)—a generalised linear mixed effects model (GLME) was used. This affords the flexibility to create a model that fits the data more accurately rather than transforming the data to make it fit the model (Kachman, 2000).

The analysis aims to determine the *Probability of Recognition Performance* (DV) with the fixed factors of *Interveners*, and *Presentation* (IV's), whilst controlling for the random effects of *Participant* and *Melody.* As described later, the models were also provided with an extra fixed factor to control for dynamic response biases. Producing and reporting predicted probabilities through a GLME model allows for a more complete picture—compared to simply reporting pure recognition scores—as it takes into consideration what the participant got right as well as what they got wrong (Kachman, 2000). For a review of the advantages of mixed effects models and Bayesian analyses over the traditional null hypothesis significance testing please see Wagenmakers (2007) or Nathoo and Masson (2016)

Response Biases.

False alarms (incorrect *Old* responses on the first presentation of a melody) were used to train the model to predict the probability of producing a false alarm based on trial numbers. These predicted probabilities formed the *False Alarm Rate* fixed factor for the GLME model.

The inclusion of this *False Alarm Rate* allows for the control of not only response bias but the dynamic nature of response bias that is often observed in recognition paradigms (Herff, Olsen, & Dean, 2018). For example, a participant may begin the experiment with a bias towards choosing *New* for the majority of melodies but as the trials progress their bias may shift to selecting *Old* for most melodies (Berch, 1976; Snodgrass & Corwin, 1988). First presentation data is used to derive the *False Alarm Rates* predictor, therefore, the GLME model only analyses data from the second and third presentation. Furthermore, GLME models are robust enough to detect an effect in sample sizes considered small (<20) (Gilmour, Anderson, & Rae, 1985) so it is more than powerful enough to detect an effect in our sample size of 30.

Model Comparison.

To account for overfitting (having too many unrelated parameters in the model), model comparisons were performed. These were done using the Bayesian Inference Criterion (BIC) method (Kass & Raftery, 1995; Wagenmakers, 2007). The BIC punishes models for additional parameters and makes it possible to test whether the additional variance explained by a predictor is simply due to an increase in model complexity. When comparing two models, the model with the lower BIC is preferred. A ΔBIC of six or greater provides strong evidence that the model with the lower BIC is the best model to describe the observed data (Herff, Olsen, & Dean, 2018). The BIC method has shown consistent results with sample sizes of 30 participants (Nathoo & Masson, 2016).

The analysis was conducted using the lme4 package (Bates, Mächler, Bolker, & Walker, 2015) in the r-studio interface (RStudio, 2019). The overall results of the GLME model for each experiment are reported in terms of a regression coefficient and a *p*-value which are then supported by the model comparison reported in terms of BIC values. The GLME results are also presented as interaction plots.

Although this analysis style is atypical for mainstream psychological research reports, this analysis style was chosen to remain consistent with the previous investigations of the RMR conjecture (Herff, Olsen, & Dean, 2018; Herff, Olsen, Dean, et al., 2018; Herff, Olsen, Prince, et al., 2018). For other examples of cognitive psychology research using this type of analysis successfully, outside of RMR investigations, please see (Chater, Tenenbaum, & Yuille, 2006; Norris, McQueen, & Cutler, 2016).

Experiment 1 – Both Pitch and Rhythm

For the Western musically trained and the general Western listener alike, patterns of pitch and rhythm information are easily extracted from melodies that are even mildly similar to the Western rules of music (Prince, 2011). Furthermore, recognition performance has shown to be superior when the pitch and rhythm information is combined (Hebert & Peretz, 1997; Schaal, Banissy, & Lange, 2015). According to previous studies (Herff, Olsen, Dean, et al., 2018; Herff, Olsen, Prince, et al., 2018; Prince, 2009) and the RMR conjecture, recognition performance for melodies with combined pitch and rhythm information is resistant to the detrimental effects of interference if the rules of the melodies are similar to those of the music in the participant's culture.

In Experiment 1 it is expected that as there is more information available for the participants to encode, there will be more representations available to help with retrieval, providing resistance to interveners. Furthermore, these melodies should be perceived and encoded as whole melodies due to having pitch and rhythm information - in terms of key and timing patterns - that conform to the rules of Western music, even though all other aspects are still atypical to the Western tradition.

Method

Participants.

Participants were undergraduate students (*N* = 30) from Murdoch University in Perth, Western Australia. The sample size was chosen based on Herff, Olsen, Prince, et al. (2018) who found a significant effect of interveners with the same experimental paradigm and sample size. The participants were aged 18-51 years (*M* = 23.33, *SD* = 8.28, *No. of females* = 24), reported normal hearing and minimal musical background (*M* = 1.62 years of training). All had grown up listening to Western music and were reimbursed with 1-hour research portal credit or a coffee voucher ($4 Australian).

Stimulus.

The pitch and rhythm information in the melodies for Experiment 1 were not held constant thus providing additional information in both dimensions. The average melody duration was 2.94s.

Results and Discussion

Both, an analysis on the participant-wise (*N*=30), as well as melody-wise data (37 melodies), showed that participants were able to perform the task above chance ($t(29) = 8.43$, $p < .001$) (see Figure 2). As shown by the interaction plot in Figure 3, a GLME model with the fixed factors of *Interveners*, *Presentation* and *False Alarm Rate,* showed no significant effect of *Interveners* on the *Probability of Recognition Performance* (*coef* = 0.0004, *p* = 0.934). This was supported by the model comparison showing that when the parameter of *Interveners* is removed from the model the BIC value decreases (from 2408.5 to 2397.2). The ΔBIC supports the finding that *Interveners* do not have a significant impact on memory recognition as the model without *Interveners* is a better fit for the observed data in Experiment 1.

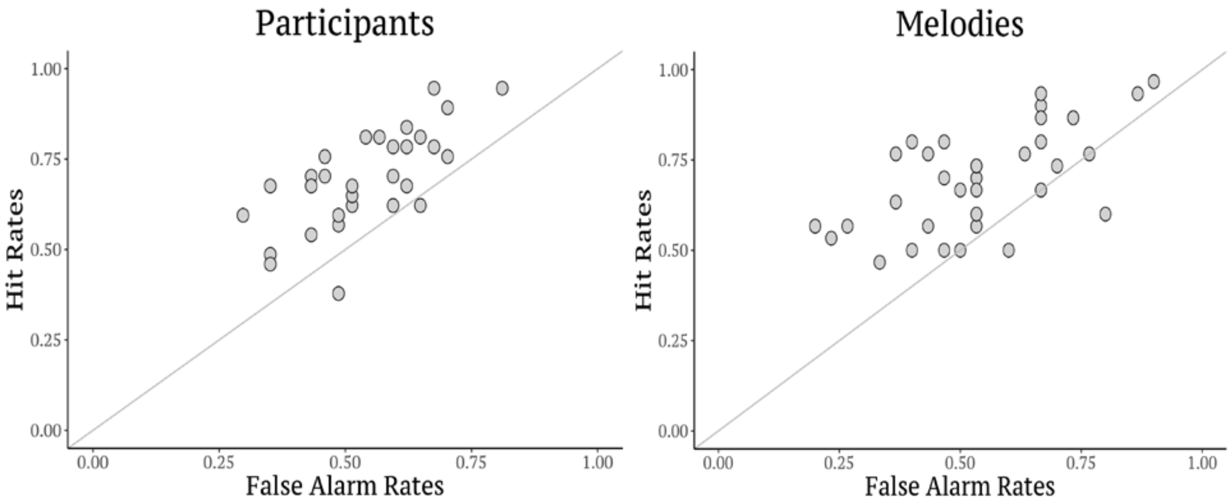

Figure 2. Scatterplots showing *Recognition Performance* for *Participants* and *Melodies* based on the pair of *Hit* and *False Alarm Rates* for each participant and each melody using data from presentations one and two. Diagonal line denotes chance level. The majority of data points above the chance line indicates that participants performed above chance, both when looking at the data participant and melody-wise.

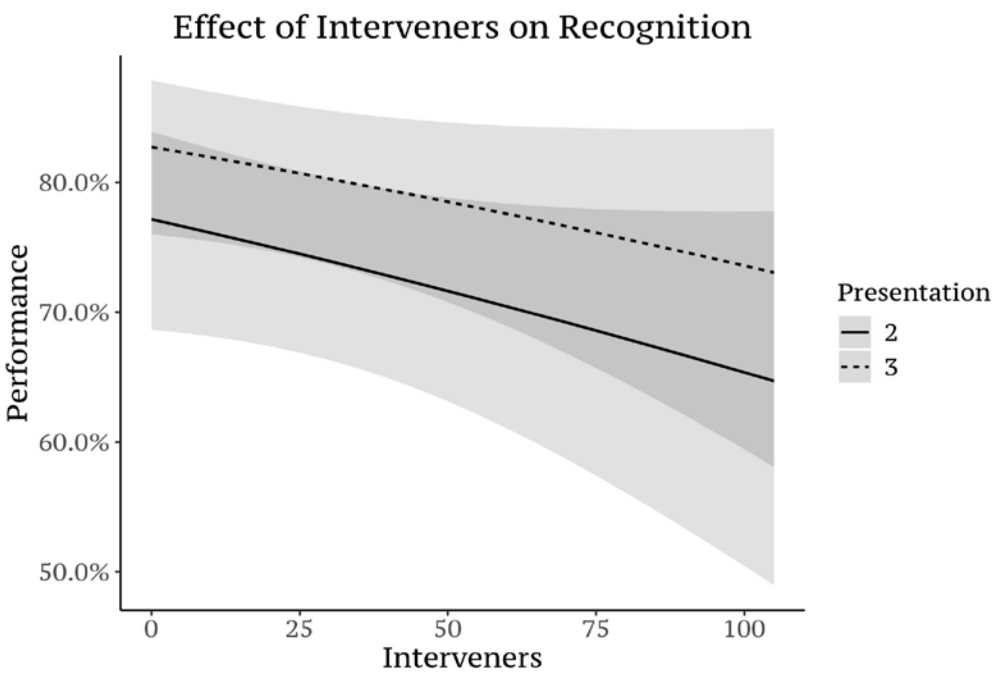

Figure 3. An interaction plot showing the effect of *Interveners* on the *Probability of Recognition Performance* for the second and third presentation of a melody for Experiment 1. First presentation is accounted for by the *False Alarm Rate* parameter of the model. Shaded areas denote 95% confidence intervals (CIs). Fewer observations for the higher number of interveners cause wider CIs at the right-hand side of the plot.

In Experiment 1 the aim was to investigate the effect of interveners on memory recognition in novel melodies that conform to one Western rule in pitch and one in rhythm. Experiment 1's melodies contained information in both the pitch and rhythm dimensions affording more features to be encoded into memory representations.

As predicted, interveners showed no significant cumulative disruptive effects on melodies with even small amounts of surface level Western pitch and rhythm information. This is contrary to results obtained when using melodies with Non-Western pitch and rhythm set—like those used in Herff, Olsen, Prince, et al. (2018)—, but consistent with the RMR conjecture. This means that melodies conforming only to the one Western compositional rule of pitch and rhythm, provides enough familiarity to aid the participant's perception, allowing it to be encoded as a complete melody. Which in turn allows for more successful recognition even with up to 106 intervening melodies.

Experiment 2 – Pitch Only

Experiment 1 showed no effect of interveners on recognition performance, when both pitch and rhythm information was available. Experiment 2 tests whether pitch information alone is also sufficient.

The literature on pitch perception indicates that pitch information should be sufficient for memory recognition in musical stimuli. Firstly, Western listeners learn through experience that pitch is an important aspect of Western music to allocate mental resources to as it has higher variability and therefore more discriminatory power (Dowling et al., 1987; Fraisse, 1982; Prince, 2009; Prince, 2011; Thompson, 2013). Secondly, pitch information provides a framework that is used to organise our perception as well as store and retrieve memories of melodies (Dowling, Kwak, & Andrews, 1995; Krumhansl, 2000; Thompson, 2013). Lastly, studies on patients with brain damage resulting in a loss of pitch perception could no longer recognize music that was once familiar to them without their ability to perceive pitch (Peretz et al., 1994). In summary, pitch is an instrumental part of memory for melodies. As a result, it is possible that using pitch information alone is sufficient to provide resilience against interference in memory for melody.

Method

Participants.

Participants were undergraduate students (*N* = 30) from Murdoch University in Perth, Western Australia. The sample size was chosen based on Herff, Olsen, Prince, et al. (2018) who found a significant effect of interveners with the same experimental paradigm and a similar sample size. The participants were aged 17-42 years (*M* = 23.43, *SD* = 6.53, *No. of females* = 26), had un-impaired hearing and minimal musical background (*M* = 2.75 years of training). All had grown up listening to Western music and were reimbursed with a 1-hour research portal credit or a coffee voucher ($4 Australian).

Stimulus.

In this experiment the rhythmic information was removed from the melodies by holding note duration constant at 440ms, thus only the dimension of pitch offered musical information. The average duration of the melodies was 3.34seconds.

Results and Discussion

An analysis on the participant-wise (*N* = 30) and melody-wise data (37 melodies), showed that participants were able to perform the task above chance ($t(29) = 9.36$, $p < .001$) as shown in Figure 4. A GLME model (see Figure 5) with the fixed factors of *Interveners*, *Presentation* and *False Alarm Rate* whilst controlling for random effects of *Participant* and *Melody* showed no significant effect of *Interveners* on the *Probability of Recognition Performance* (*coef* = -0.002, *p* = 0.714). This was supported by the model comparison showing that when the parameter of *Interveners* is removed from the model, the BIC value decreases (from 2736.4 to 2723.2). The ΔBIC supports the finding that *Interveners* do not have a significant impact on memory recognition as the model without *Interveners* is a better fit for the observed data in Experiment 2.

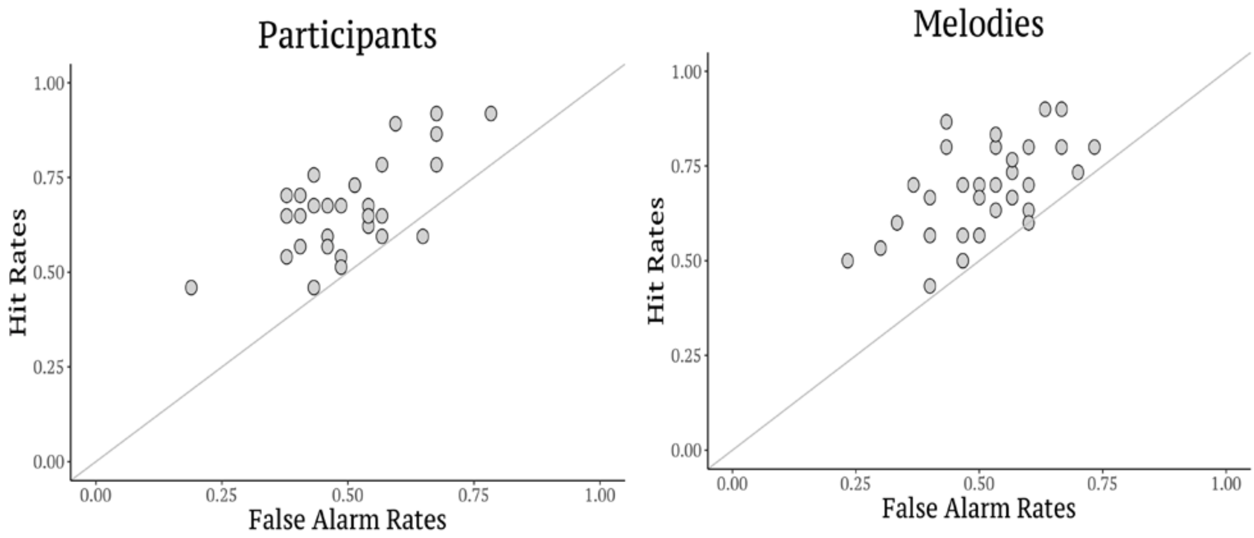

Figure 4. Scatterplots showing *Recognition Performance* for *Participant* and *Melody* based on the pair of *Hit* and *False Alarm Rates* for each participant and each melody. The diagonal line denotes chance level. The majority of data points above the chance line indicates that participants performed above chance, both when looking at the data participant and melody-wise.

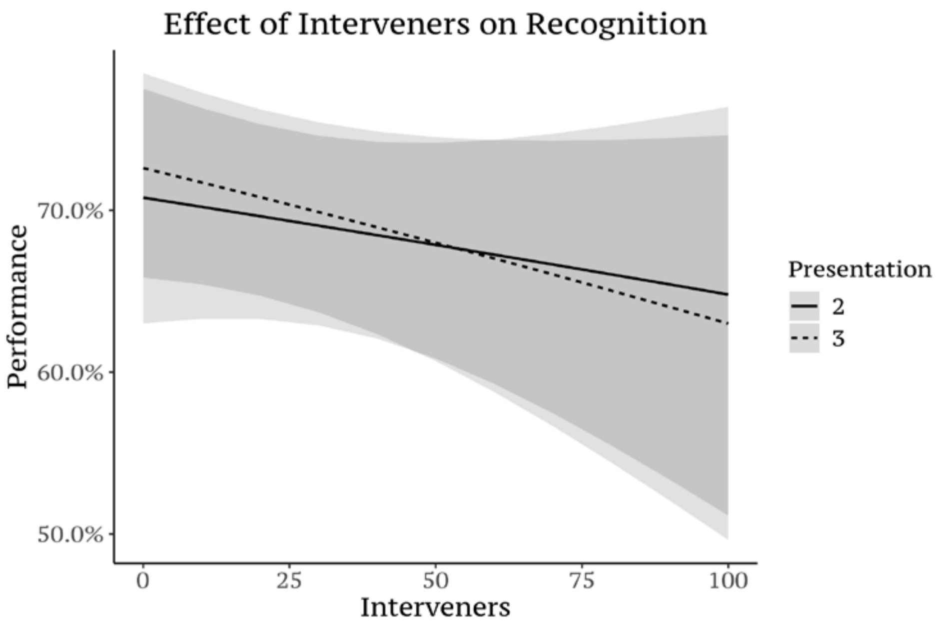

Figure 5. An interaction plot showing the effect of *Interveners* on the *Probability of Recognition Performance* for the second and third presentation of a melody for Experiment 2. First presentation is accounted for by the *False Alarm Rate* parameter of the model. The shaded areas denote 95% confidence intervals (CI's). Fewer observations for the higher number of interveners cause wider CIs at the right-hand side of the plot.

Experiment 2 aimed to investigate whether the resistance to memory interference from interveners was still observed when the rhythm information was removed from the melodies. Similar to Experiment 1, no significant effect of interveners on recognition performance was found, indicating that enough representations were created in spite of the elimination of the rhythm information. This means that having one compositional rule followed in terms of pitch, provides enough familiarity for the participant to perceive a whole melody and encode it with multiple overlapping representations providing resistance to memory interference.

Experiment 3 – Rhythm Only

Experiment 1 showed no effect of interveners on memory recognition when both pitch and rhythm information was available. Likewise Experiment 2 showed no effect of interveners when only pitch information was available. This indicates that pitch and rhythm information combined as well as pitch on its own provides sufficient familiarity to afford resilience to interference. Experiment 3 tests whether one aspect of Western rhythm is also sufficient.

The literature suggests that rhythm information on its own is not a sufficient cue for memory retrieval. For example, Hebert and Peretz (1997) found that rhythm information is only sufficient on its own when top-down processes are invoked by cueing retrieval with the title of the to be remembered melody. They theorised that due to the predictability of rhythm, especially in Western melodies (Schaal, Banissy, et al., 2015), it lacks the attentional demands that pitch creates (Hebert & Peretz, 1997; Prince, 2011). Due to our learned experience of its predictability, the perception of rhythm involves the allocation of very little mental resources (Fraisse, 1982). Taken together, as rhythm is more predictable it therefore elicits less attentional demands resulting in impaired memory retrieval. It is possible however, that rhythm information provides enough of a trigger for the stimuli to be recognised as following Western musical rules which then afford it the processes describe by the RMR conjecture resulting in resistance to interference.

Method

Participants.

Participants were undergraduate students (*N* = 30) from Murdoch University in Perth, Western Australia. The sample size was chosen based on Herff, Olsen, Prince, et al. (2018) who found a significant effect of *Interveners* with the same experimental paradigm and a similar sample size. The participants were aged 18-51 years (*M* = 26.03, *SD* = 10.15, *No. of female* = 26), had un-impaired hearing and minimal musical background (*M* = 2.67 years of training). All had grown up listening to Western music and were reimbursed with a 1-hour research portal credit or a coffee voucher ($4 Australian).

Stimulus.

In this experiment the pitch information in the melodies was neutralised by holding the pitch of every note constant at 330hz. The average melody duration was 2.94s.

Results and Discussion

An analysis on the participant-wise (*N* = 30) and melody-wise data (37 melodies), showed that participants were able to perform the task above chance ($t(29) = 7.44$, $p < .001$) as shown in Figure 6. Using a GLME model (see Figure 7) with the fixed factors of *Interveners*, *Presentation* and *False Alarm Rate* whilst controlling for random effects of *Participant* and *Melody*, no significant effect of *Interveners* on *Probability of Recognition Performance* (*coef* = -0.007, *p* = 0.123) was found. This was supported by the model comparison showing that when the parameter of *Interveners* is removed from the model the BIC value decreases (from 2533.3 to 2525.9). The ΔBIC supports the finding that *Interveners* do not have a significant impact on memory recognition as the model without *Interveners* is a better fit for the observed data in Experiment 3. Interestingly a significant effect of

Presentation was found in Experiment 3 (*coef* = 0.439, *p* = 0.020). This means that the more times a rhythmic sequence was presented the better the participants were able to recognise it.

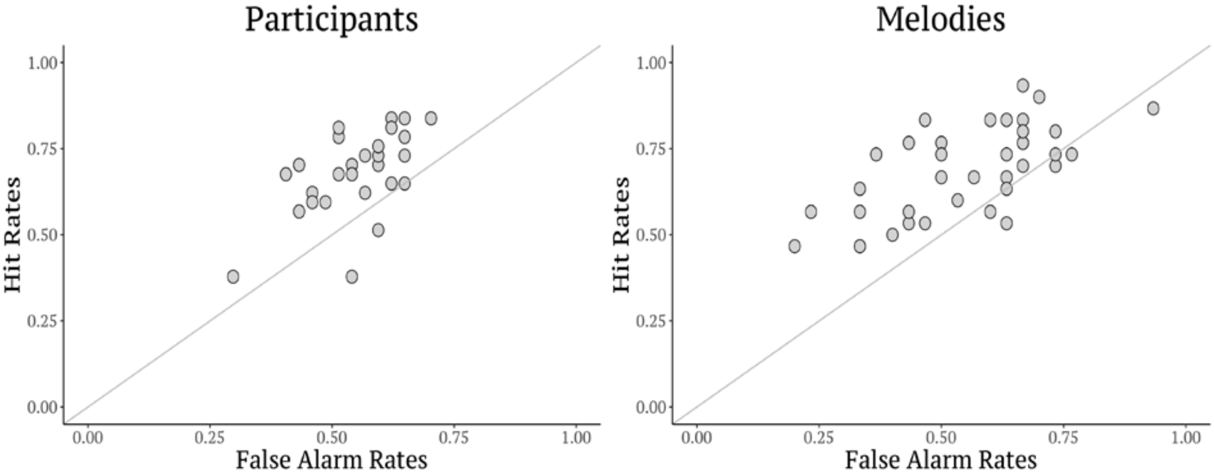

Figure 6. Scatterplots showing *Recognition Performance* for *Participants* and *Melodies* based on the pair of *Hit* and *False Alarm Rates* for each participant and each melody. Diagonal line denotes chance level. The majority of data points above the chance line indicates that participants performed above chance, both when looking at the data participant and melody-wise.

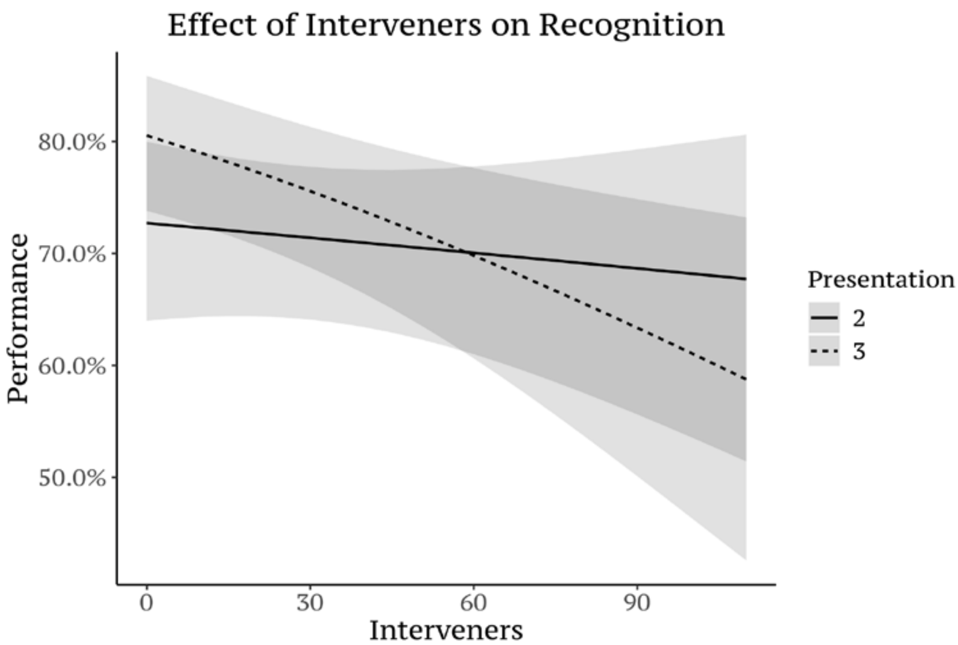

Figure 7. An interaction plot showing the effect of *Interveners* on the *Probability of Recognition Performance* for the second and third presentation of a melody for Experiment 3. The shaded areas denote 95% confidence intervals (CIs). Fewer observations for the higher number of interveners cause wider CIs at the right-hand side of the plot.

Combined Analysis

In order to get a more thorough picture of the results, all three experiments were analysed together by looking at performance in the pitch only (Experiment 2) and rhythm only (Experiment 3) sequences compared to the melodies in Experiment 1 (baseline) that contained information from both dimensions. Overall, participants (N = 90) still performed above chance ($t(89) = 14.59$, $p < .001$) and still no effect of *Interveners* on the *Probability of Recognition Performance* was found (see Figure 8): Pitch compared to baseline (*coef* = -0.003, p = 0.639); Rhythm compared to baseline (*coef* = -0.006, p = 0.328). This was supported by a model comparison which showed that when the parameter of *Interveners* was removed from the combined model, the BIC value decreased (from 7705.9 to 7669.8).

When doing the combined analysis, a significant effect of *False Alarm Rate* (*coef* = 0.738, p = 0.037) emerges. This evidence of a dynamic response bias was expected and demonstrates how important it is to account for the dynamic nature of response bias (Berch, 1976), which is why *False Alarm Rate* is added as a parameter in our model.

Visually, the interaction plots in each experiment and the combined analysis show a distinctive downwards trend. However, when inspecting these plots, it is important to pay attention to the shaded confidence intervals, as the interaction lines—although trending downwards—still remain within the overlapping CIs which is indicative of the lack of effect. Additionally, we analyse the data of up to 106 *Interveners* and do not find a significant effect of cumulative disruptive interference: Traditionally this kind of interference is already observed at 13 *Interveners* (Herff, Olsen, & Dean, 2018). One explanation as to why there still appears to be a latent, weak downward trend, is that the stimuli used here are similar but not perfectly aligned with the rules of Western music.

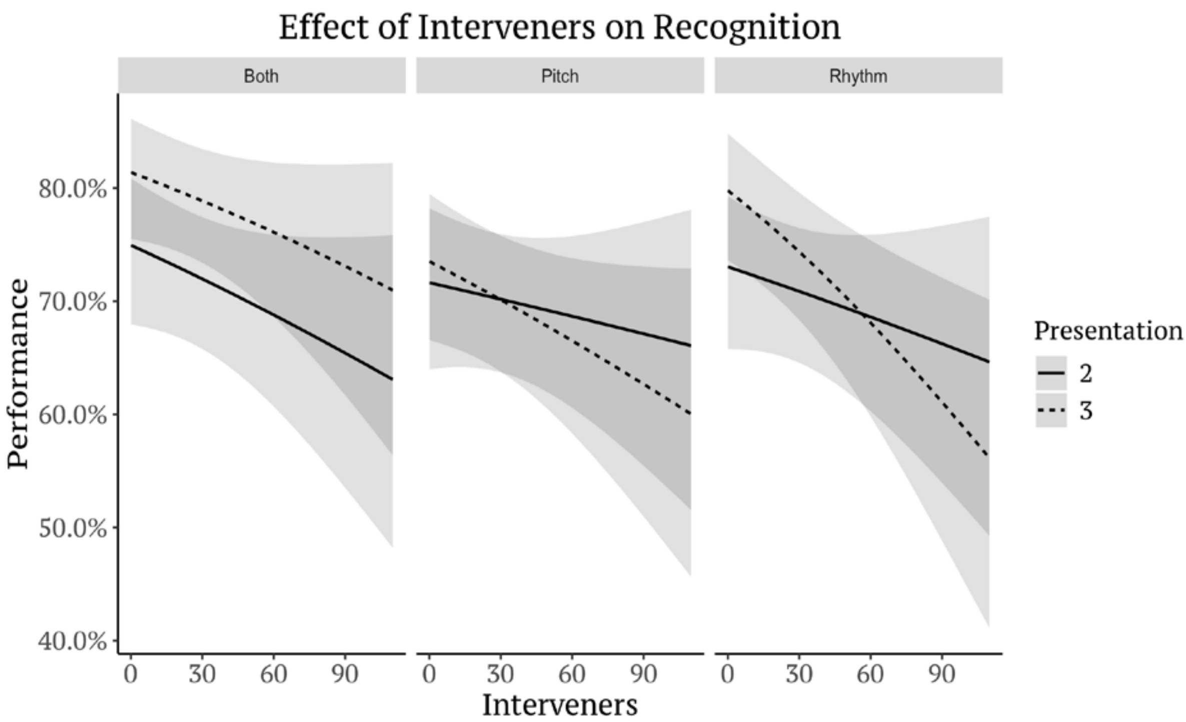

Figure 8. An interaction plot showing no effect of *Interveners* on the *Probability of Recognition Performance* for the second and third presentation of a melody when looking at the pitch only (Experiment 2) and rhythm only (Experiment 3) melodies compared to the melodies from Experiment 1. First presentation is accounted for by the *False Alarm Rate* parameter of the model. The shaded areas denote 95% confidence intervals (CIs). Fewer observations for the higher number of interveners cause wider CIs at the right-hand side of each of the three sections of the plot.

Discussion

Experiment 3 investigated the effect of interveners on memory recognition in rhythmic sequences that followed the compositional rule of a regular timing pattern. It was hypothesised that rhythm information alone would provide enough of a familiarity trigger for the listener to perceive a complete melody, encode multiple representations of it and recognise it when it was presented again. This is indeed what was found: Participants memories for melodies in Experiment 3 did not show an effect of interveners. However, unlike Experiments 1 and 2 where the performance was equally good across presentations, in Experiment 3 an effect of presentation becomes apparent. This indicates that although rhythmic sequences are resilient to the effects of interveners, additional presentations are needed to solidify recognition performance.

General Discussion

The present study aims to explain how our experience influences the resistance that musical stimuli show to cumulative disruptive interference. A continuous recognition paradigm using melodies that conform to only one Western rule in pitch and one in rhythm was implemented across three experiments. The results show that for participants whose experience is based in Western culture, melodies with rhythm and pitch information based on only one Western compositional rule show resistance to interveners. This effect of enculturation holds even when the melodies contain only surface-level pitch or only rhythm information.

Recognition Performance in Musical Pitch and Rhythm

Recognition performance in the present study was equally good across presentations of a melody when the melodies contained surface level pitch information (Experiments 1 and 2), however, when retrieval of a melody depended on only rhythm information (Experiment 3), presenting the melody for a third time was beneficial. These results are in accordance with the literature (Prince, Schmuckler, & Thompson, 2009) on the importance of pitch over rhythm in memory for Western melodies. Pitch information in Western music contains more variety and discriminability which Western listeners learn to automatically attend to when hearing music (Prince et al., 2009). Rhythm, on the other hand is more predictable (Prince et al., 2009), therefore, Western listeners experience has not required them to develop the processes required to use rhythm information as a discriminatory feature. Nevertheless, the rhythm information in the melodies in Experiment 3, was sufficient to trigger a perception of musicality engaging the encoding and memory formation processes described by the RMR conjecture.

Although the rhythm only melodies did appear to reach the threshold for perception of musicality, it is still possible that as melodies become less similar to Western music they are perceived more as a non-musical auditory stimulus. This would explain the benefit of multiple presentations found in the rhythm only melodies. This is because without the rise and fall in pitch, the melody becomes less musical, sounding more like Morse code rather than a tune. Although the rhythm only melodies in the present study are musically familiar enough to resist interference, the ability for participants to recognise them is weakened which is why presenting the melodies three times led to a significant improvement in recognition performance.

Contrary to the RMR conjecture, however, was the finding that recognition performance in Experiment 1—that had information from both pitch and rhythm dimensions—was not significantly better than when the melodies only offered information from one dimension. Previous studies (Hebert & Peretz, 1997; Schaal, Banissy, et al., 2015) suggest that although pitch information is a necessary cue for retrieval, optimal recognition performance occurs when the pitch and rhythm information is combined. A melody with both pitch and rhythm information provides more data for the participant to encode which would result in even more memory representations of the melody to aid in retrieval. Nevertheless, the combined analysis conducted for the present study found no significant differences in recognition performance between experiments. This suggests that beyond the multiple overlapping representations already created by a melody with information from only the pitch or rhythm dimension, the representations added by the combination of the two do not offer a significant benefit in the short, simple, pure tone melodies used in the present study.

Bottom-up versus Top-down processing

Furthermore, the current findings are evidence towards the idea that bottom-up processes—although considered to be automatic, innate processes that filter and group incoming stimuli—may actually be refined by experience (Narmour, 1989, 1991). Although, top-down (knowledge based) and bottom-up (unconscious automatic filtering) processes both play a role in memory for music, previous studies have shown distinctions between which features of music engage which levels of processing (Narmour, 1989, 1991). For example, the pitch and rhythm features in the melodies for the present study consist only of components that engage bottom-up processing (i.e. the musical key of the pitch and the regular timing framework of the rhythm) (Narmour, 1991). Given the results of the present study this indicates that bottom-up processing is sufficient to trigger the processes involved in providing resistance to interference but also that the templates used in this automatic bottom-up processing are tuned to identifying music as having specific characteristics. If the incoming stimuli consists of these characteristics it gets filtered through the 'music template' and grouped together as a complete melody.

In the same way that the Gestalt principles are used to understand how objects appear grouped together according to different features (Wagemans et al., 2012), Narmour (1991) suggests that music perception works in the same way. Certain features of music are grouped together because our experience tells us that is how music is constructed. However there is disagreements in the literature as to whether or not experience does change bottom-up processes, and which aspects of music perception can be attributed to which level of processing ((Schellenberg, 1996; Schellenberg, Stalinski, & Marks, 2014), for a review see Narmour (1991). The findings from the present study contribute to this debate by suggesting that perceiving and processing surface level features of music is a bottom-up process that can be refined by our experience with a particular style of music.

Musicality

Interestingly, the results from the present study indicate that stimuli that conform to only one Western compositional rule in pitch (all pitches in a musical key) or rhythm (regular timing pattern) are perceived as musical enough to receive the benefits associated with the processing of music as described by the RMR conjecture. This is extraordinary as the melodies used here contained very little familiar musical information for the participants to latch onto. The melodies were very brief, used only pure tones and a short combination of 5 or 6 notes. However, due to the strength of enculturation on the musical processing systems of participants, the stimuli were still perceived as musical. When stimuli become less perceivable, as what the participant recognises as music, recognition memory becomes vulnerable to the effects of interference.

Limitations

The aim of the current study was to replicate a previous study (Herff, Olsen, Prince, et al., 2018) so that the results are maximally comparable and useful. However, it is still important to discuss limitations for full transparency when the present results are being interpreted. The stimulus used in the present paper could be considered a limitation as they consist of a very short (2 - 3 seconds) combination of pure tones. The musicality of these melodies is not immediately apparent to a listener, however, musical rules were followed and the results indicate that these rules were perceived by the participants. Furthermore, the simplicity of the melodies was integral to the research question of isolating the influence of pitch and rhythm information.

Additionally, there are inherent weaknesses that come with using a between subject's design. Firstly, there is the potential for bias to influence the allocation of participants to experimental conditions, however, this was anticipated and accounted for by the blinding discussed in the General Method section. Secondly, multiple conditions can result in difficulties recruiting enough participants to detect an effect, however, 30 participants were recruited for each experiment which is sufficient for an effect to emerge when using GLME models for analysis.

Future research

To investigate the breadth of the RMR conjecture's applicability, future research needs to include diversity in research participants in terms of age, culture and expertise. Using participants across different ages and levels of development allows for the deeper investigation of experience: For example, determining when and why people become accustomed to specific rules in music is an interesting question to pursue as Trehub, Schellenberg, and Kamenetsky (1999) found significant differences in ease-of-processing of Western versus Non-Western melodies in infants compared to adults. Infants processed Non-Western music easier than Western music and adults showed the opposite, suggesting using our experience in the perception of music must have significant benefits if it over-rides what is naturally easier (Trehub et al., 1999). Furthermore, using participants who have only experienced Non-Western music would allow for the confirmation of the RMR predictions about the influence of experience. However, this may prove to be a particularly difficult task with increasing levels of globalisation resulting in people from most cultures being exposed to Western music at some point in their lives. Another future avenue for investigating the RMR conjecture lies in comparing recognition performance between participants with varying levels of expertise with a stimulus. Investigations into RMR so far demonstrate the importance of experience for recognition memory's resistance to interference but does an increased level of experience result in increased levels of recognition performance?

Future research should also include, not only alternative musical stimuli, but also other stimuli that may generate memory formations based on experience and perception in the same way music does (e.g. line drawings and poetry). A multitude of studies have explored memory for other stimuli, but not many have done so using the same experimental paradigm which makes it difficult to directly compare results. To address an aspect of this (Herff, Olsen, Anic, & Schaal, 2019) used a continuous recognition paradigm with multimodal stimuli - words (typed and handwritten), pictures and melodies – in order to compare results across stimuli while keeping the paradigm constant. They found that although recognition performance for words (for both the typed and handwritten stimuli) was better than pictures and melodies, only melodies showed no effect of interveners. This study offers strong support for the RMR conjecture, however replicability and expansion into different participants and stimuli is still needed.

Conclusion

The RMR conjecture is a novel theory that aims to explain the uniqueness of memory for stimuli that show resistance to cumulative disruptive interference. The current study has added further support to the accuracy of its claims. In memory for melodies that follow only a single Western rule in pitch and rhythm, cumulative disruptive interference does not occur for participants that are accustomed to music with Western compositional rules. These findings highlight the strength of musical enculturation which influences perception in both the top-down and bottom-up processes. Exploring memory for melodies provides one more step towards understanding the complexity of memory in general which is a crucial component of the human experience.

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