Vocal Timbre Influences Memory for Melodies

by

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Abstract

Several studies have demonstrated that melody recognition is reduced when the timbre (instrument) changes between exposure and test, but no study has evaluated the possibility that different timbres have differential effects on melody recognition. The current study evaluated adults’ recognition and liking of unfamiliar Irish melodies presented in four timbres: two familiar (voice, piano) and two less familiar (banjo, marimba). After exposure to a set of melodies, participants judged whether each melody from a larger set (original and novel) was old or new. Melodies presented vocally were remembered significantly better than those presented instrumentally even though they were liked less. The findings confirm that surface features of music and abstract, relational features are processed jointly as well as separately.
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1 Introduction

A melody is a rhythmically organized sequence of tones that is perceived as an entity or whole. Its identity does not depend on specific pitches, durations, or musical timbres (i.e., sound qualities that distinguish one instrument or singing voice from another), but on relational features involving pitch (i.e., successive intervals) and duration (i.e., rhythm). For example, Happy Birthday retains its identity in a high or low pitch register, at a fast or slow tempo, and whether it is sung without words by an unfamiliar person or played on a trumpet or a piano. For ordinary listeners, melody is the most salient part of a musical composition and the part they normally remember and sing. In the present investigation, we sought to determine whether timbre affects memory for melodies, and specifically, whether melodies are remembered better when presented in some timbres compared to others.

Timbre is an elusive concept because it encompasses multiple dimensions of sound. Essentially, it refers to the difference in sound quality or tone colour between instruments or voices producing the same pitch at the same amplitude and duration (Krumhansl & Iverson, 1992). Timbre encompasses both static and dynamic dimensions, including the sound envelope (i.e., attack, decay, and sustained portion) and differences in spectral energy (i.e., brightness) resulting from resonances of the instrument or vocal tract. In short, timbre is said to provide colour or texture to a melody without altering its identity.

Because melodies are defined by their pitch and temporal relations, long-term mental representations are thought to consist exclusively of relational information about pitch and time (Krumhansl, 2000). It is clear, however, that listeners remember much more than the pitch and temporal relations of music. For example, adults remember the pitch level of familiar and meaningful musical recordings (Levitin, 1994; Schellenberg & Trehub, 2003), as do children (Schellenberg & Trehub, 2008; Trehub, Schellenberg, & Nakata, 2008) and even infants.
(Volkova, Trehub, & Schellenberg, 2006). Musically untrained listeners also remember the tempo of a familiar recording (Levitin & Cook, 1996) and its specific timbre or combination of timbres. For example, timbre or sound quality can be highly memorable for iconic performances such as Marilyn Monroe’s rendition of *Happy Birthday* for President Kennedy or Jimi Hendrix’s live version of *The Star Spangled Banner*. In fact, listeners use information about timbre to identify pop recordings from 100- and 200-ms segments that are too short to provide relational cues to the music (Schellenberg, Iverson, & McKinnon, 1999).

Memory for previously heard melodies is reduced when the timbre is changed between exposure and test, which again confirms that surface features like musical timbre are encoded along with abstract relational features (Halpern & Müllensiefen, 2008; Peretz, Gaudreau, & Bonnel, 1998; Radvansky, Fleming, & Simmons, 1995; Wolpert, 1990). There are parallels in memory for speech. For example, a change of talkers between exposure and test reduces recognition of previously heard utterances (Bradlow, Nygaard, & Pisoni, 1999; Nygaard, Sommers, & Pisoni, 1994; Ryalls & Pisoni, 1997). Both lines of evidence are interpretable in terms of the encoding specificity hypothesis (Tulving & Thomson, 1973), which holds that the encoding context facilitates retrieval. For music and language, memory for abstract features is enhanced when the surface features remain unchanged from exposure to subsequent test.

In principle, some surface features (e.g., a particular timbre) may facilitate melodic encoding more than others (e.g., different timbres). Timbre is particularly important because it is multi-dimensional, unlike pitch and tempo, which vary along a single dimension (high to low or fast to slow). Multi-dimensional scaling solutions reveal that specific classes of timbres (e.g., horns, strings, woodwinds) cluster together in perceptual space (Grey, 1976; Lakatos, 2000; McAdams, Winsberg, Donnadieu, De Soete, & Krimphoff, 1995), forming relatively distinct perceptual categories. Although it is possible that the timbral characteristics that promote
categorization would affect memory, this question has not been examined to date. It is of particular interest to compare memory for melodies played in highly contrastive timbres (e.g., the piano, banjo, and marimba).

Vocal timbres may transcend traditional scaling solutions for instrumental timbres. The human voice represents a specially favoured category of timbres not only because of its familiarity but also because it activates cortical regions beyond those activated by non-vocal sounds, even in the absence of linguistic content (Belin, Zatorre & Ahad, 2002; Belin, Zatorre, Lafaille, Ahad, & Pike, 2000). Exceptional familiarity with the human voice may account for its selective activation in auditory cortex, which could result in enhanced memory for vocal melodies. Selective activation for familiar singing voices could provide a further advantage for melodies presented vocally rather than instrumentally. For example, exposure to a specific talker facilitates subsequent identification of novel words spoken by that talker in a noisy background (Nygaard & Pisoni, 1998). At times, however, the human voice interferes with memory for musical features, as in less accurate naming of vocal tones than instrumental tones by absolute pitch possessors (Vanzella & Schellenberg, 2010).

What mechanisms could underlie differential memory for melodies with contrasting timbres? Familiarity or exposure to specific timbres may increase processing fluency (Jacoby, Kelley, & Dywan, 1989; Winkielman, Schwarz, Fazendeiro, & Reber, 2003), leading to enhanced retention of music played by any frequently heard instrument. For example, human cortical responses are larger for the instrument of training than for other instruments and for musical tones compared to pure tones (Pantev, Oostenveld, Engelien, Ross, Roberts, & Hoke, 1998; Pantev, Roberts, Schulz, Engelien, & Ross, 2001). Larger EEG responses to trained instruments are evident even in childhood (Shahin, Roberts, Chau, Trainor, & Miller, 2008; Shahin, Roberts, & Trainor, 2004). Training may result in more elaborate or detailed encoding
of music played on the trained instrument (Tervaniemi, Rytkönen, Schröger, Ilmoniemi, & Näätänen, 2001). In short, if a timbre is heard often, memory for the music in question may benefit from streamlined processing.

Activation of motor as well as auditory representations while listening may also enhance memory for melodies presented in a highly familiar or trained timbre. Instrumental practice generates growth in the auditory cortex and in regions of the somatosensory cortex that correspond to instrument-specific motor movements (Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995; Pantev et al., 2001). These representations develop quickly when auditory and motor events occur together (Bangert & Altenmüller, 2003), leading to tightly coupled auditory and motor systems, especially for musicians (Zatorre, Chen, & Penhune, 2007). These effects need not be limited to instrumental practice because motor movements for the voice get “practice” in everyday conversation. In short, if the timbre of a melody engages multimodal (auditory and motor) representations during listening, one result may be enhanced memory for the melody.

Beyond basic auditory processing, familiarity also affects preference or liking, which could influence memory as well. For example, limited exposure to ecologically valid music results in increased liking and recognition (Schellenberg, Peretz, & Vieillard, 2008; Szpunar, Schellenberg, & Pliner, 2004). Listeners prefer previously heard melodies to novel melodies even when the instrumental timbre changes from exposure to test and even when listeners have no explicit memory for the melodies (Halpern & Müllensiefen, 2008; Peretz et al., 1998).

In the current study, we explored the possibility of differential recognition memory for melodies presented in four different timbres. Two of the timbres, the voice and piano, were highly familiar, and two, the banjo and marimba, were much less familiar. We predicted better memory for melodies presented in vocal timbre than in the other timbres on the basis of more
elaborate neural processing of the voice relative to the other timbres (Belin et al. 2000, 2002), multimodal mental representations (Zatorre et al., 2007), or greater processing fluency resulting from familiarity (Nygaard & Pisoni, 1998). If overall familiarity with a timbre enhances melodic processing and memory, then one would expect better performance for melodies in vocal and piano timbres than for those in banjo and marimba timbres. Listeners with musical training may also show selective facilitation for melodies presented with their instrument of training, perhaps by virtue of enhanced motor representations (Bangert et al., 2006; Haueisen & Knösche, 2001; Highben & Palmer, 2004). Finally, to evaluate the influence of liking on recognition, participants rated how much they liked each melody.

2 Methods

2.1 Participants

The participants were 64 undergraduates (49 women, 15 men), with a mean age of 20.5 years \((SD = 2.1)\), who were recruited without regard to music training and received course credit or token remuneration. On average, they had 4.1 years of training \((SD = 4.1; \text{range} = 0-14; \text{median} = 3)\) but the distribution was skewed positively, which is typical of samples from the same population (Hunter, Schellenberg, & Schimmack, 2010). For participants with a history of training, 25 had studied the piano, 5 had received vocal training, and 7 had received vocal and piano training. None had played the banjo or marimba. Participants had no family or personal history of hearing impairment and they were free of colds on the day of testing. Seven additional participants were tested but excluded from the sample because of failing to follow instructions \((n = 1)\), technical problems \((n = 1)\), or recognition scores that were higher for “new” than for “old” melodies (indicating a failure to attend to the task; \(n = 5)\).

2.2 Apparatus and Stimuli
Testing was conducted in a double-walled sound-attenuating booth (Industrial Acoustics Co.). Presentation of stimuli and recording of responses were controlled by PsyScript software (V2.1.1) installed on a Macintosh eMac computer. Participants listened to stimuli over high-quality noise-canceling headphones (Sony MDR-NC6).

Stimuli were drawn from a pool of 32 Irish folk melodies that were 13-19 s in duration. The melodies were selected because they conformed to the tonality of Western music yet they were unfamiliar to North American listeners. A list of melodies, along with their duration and tempo, is provided in Appendix 1. In the “Real Instrument” (hereafter “Real”) condition, each melody was recorded in two common timbres, voice and piano, and two less common timbres, banjo and marimba. For the vocal renditions, a musically trained but amateur female (alto) singer with a pleasant voice sang all 32 melodies in an everyday (non-operatic) manner to a MIDI backing track. The melodies were sung without lyrics (i.e., “la” for each note). Her performances were recorded digitally using Logic Pro 8 and a Neumann tlm-103 microphone. Melodyne Studio (V3.2.2.2) software was used to pitch-correct and quantize (time-correct) individual notes. The software divided the audio file into individual notes and centered the average pitch of each note to true tuning, while retaining natural qualities of vocal performances like vibrato and amplitude variations but eliminating inconsistencies in timing and relative pitch. For the instrumental versions, amateur musicians generated live performances of each melody on the piano, banjo, or marimba. They played along with the same MIDI file used for the vocal performances to ensure that tempo and overall duration of each melody were the same across the four timbres. The banjo and marimba performances were recorded with the same microphone and program as the vocals, whereas the piano performances were recorded with an AKG Perception microphone using Pro Tools 9.
Because the melodies in the Real condition were recorded live, one timbre might be more recognizable than another simply because of performance differences. To address this potential problem, there was a second condition in which the instruments closely matched the vocal renditions. Specifically, in the “MIDI” condition, MIDI data were generated from the vocal performances with Melodyne and used to create digital instrument versions of each melody. These MIDI signals were then used to trigger digital instrumental timbres (piano, banjo, marimba; from Big Fish Audio) using the program Logic Pro 8. Thus, these instrumental versions had notes that were matched in pitch, duration, and amplitude to the vocal versions. All sound files were normalized to the same average amplitude, -30 dB RMS, with Sample Manager (V3.3.3) and saved as CD-quality (44.1 kHz, 24-bit) monaural sound files.

Melodies (numbered 1-32) in the four different timbres were assigned to eight conditions using a modified Latin-square design. The design ensured that any intrinsic differences in the memorability of individual melodies were counterbalanced across timbres. In condition one, melodies 1-16 were presented during the exposure phase (1-4 voice, 5-8 piano, 9-12 banjo, 13-16 marimba), and melodies 17-32 served as foils during the test phase (17-20 voice, 21-24 piano, 25-28 banjo, 29-32 marimba). In the second, third, and fourth conditions, melodies 1-16 were again played during exposure and melodies 17-32 were foils, but the timbres were rotated. For example, in condition two, melodies 1-4 were in marimba timbre, 5-8 in voice, 9-12 in piano, and 13-16 in banjo. Conditions five to eight matched conditions one to four, respectively, with the exposure and foil melodies reversed. In other words, melodies 1-4 and 17-20 always had the same timbre, although the condition determined which timbre and which set of four was assigned to the exposure phase.

2.3 Procedure
Participants were tested individually while sitting in front of a computer. In both recording conditions (Real and MIDI), there were 32 participants who were assigned at random to melody and timbre conditions. Participants were told that each time they heard a melody, they should answer the question appearing on the monitor by using the mouse or keyboard. Although detailed instructions were provided on the monitor, participants were encouraged to ask questions whenever necessary. During the first of four phases of the test session, the participant heard 16 melodies, 4 played in each timbre. After hearing each melody, they judged whether it sounded happy, sad, or neutral, with such judgments aimed solely at ensuring that participants listened to each melody. The set of 16 melodies was blocked and presented three times during the exposure phase, with a different random order of the melodies in each of the three blocks.

During a 5-10 min break between the first and second phase of the test session, participants completed a background questionnaire (provided in Appendix 2). During the second phase, they heard the 16 melodies from the exposure phase (old melodies) and 16 timbre-matched foils (new melodies). They rated their confidence that the melodies were old or new on a 7-point Likert scale ranging from “1-definitely new” to “7-definitely old.” In the third phase of the test session, participants heard all 32 melodies and rated how much they liked each melody on a 5-point Likert scale ranging from “1-extremely dislike” to “5-extremely like”. The liking phase was included to ascertain whether recognition differences among the four timbres were related to differences in liking for the different timbres. In the final phase, participants heard one melody from each timbre, then named the instrument (by typing their answer) and rated their familiarity with that instrument in everyday life on a 5-point scale from “1-very unfamiliar” to “5-very familiar”. Participants were informed that the voice counted as an instrument. The final phase was included simply to confirm that the less common timbres were indeed less familiar to participants.
3 Results

Preliminary analyses confirmed that the four timbres differed in familiarity. The ability to identify an instrument was scored on a scale from 0-2, with a null score representing an incorrect response, a score of 1 representing a response in the same family of instruments (e.g., “guitar” rather than “banjo”, or “xylophone” rather than “marimba”), and a score of 2 representing a correct identification of the instrument. A mixed-design Analysis of Variance (ANOVA) with timbre (4 levels: voice, piano, banjo, or marimba) as a repeated measure and recording condition (2 levels: Real or MIDI) as a between-subjects variable revealed that participants did not differ in their ability to name timbres between the Real and MIDI conditions, $F(1, 59) = 2.81, p > .5$. There was a significant main effect for timbre, $F(3, 177) = 104.38, p < .001$, partial $\eta^2 = .63$, but no interaction between recording condition and timbre, $F(3, 177) = 1.79, p > .1$. The main effect for timbre resulted from the familiar timbres being named nearly perfectly, with the voice ($M = 2.00, SD = 0.00$) correctly identified in all responses, and the piano identified at near-ceiling rates ($M = 1.93, SD = 0.30$). Pairwise comparisons ($p$-values were Bonferroni-corrected for multiple tests in this and all subsequent sets of pairwise comparisons) confirmed that listeners’ ability to name the voice and piano did not differ, $p > .6$. Compared to the familiar timbres, participants had significantly more difficulty naming the banjo ($M = 1.34, SD = 0.72$) or marimba ($M = 0.88, SD = 0.41$), $ps < .001$. Unlike the two familiar timbres, the two unfamiliar timbres were not identified equally well; the marimba received significantly lower scores than the banjo, $p < .001$. Missing values in the ANOVA (3 voice, 3 marimba) resulted from a failure to respond to the naming question within a 60-s time limit. Assigning missing values a score of zero did not change the pattern of results.

An identical ANOVA on ratings of familiarity confirmed again that scores between recording conditions did not differ, $F(1, 62) = 1.15, p > .2$, and that there was no interaction
A main effect for timbre was again evident, $F(3, 186) = 76.17, p < .001$, partial $\eta^2 = .55$, which was a consequence of higher ratings for the voice ($M = 4.65, SD = 0.85$) and piano ($M = 4.29, SD = 1.06$) than for the banjo ($M = 2.50, SD = 1.35$) and marimba ($M = 2.54, SD = 1.37$). Scores for the two familiar timbres (voice and piano) did not differ significantly, $p > .1$, nor did those for the two unfamiliar timbres (banjo and marimba), $p > .9$, but both familiar timbres had higher familiarity ratings than both unfamiliar timbres, $ps < .001$. This analysis confirms again that the voice and piano were more familiar to our participants than the banjo or marimba.

The principal analysis examined recognition ratings with a three-way mixed-design ANOVA, with timbre (4 levels) and exposure (2 levels: old vs new) as repeated measures and recording condition (2 levels: Real vs MIDI) as a between-subjects variable. There was no main effect of recording condition and no interactions involving recording condition, $ps > .1$.

Descriptive statistics collapsed across recording conditions are illustrated in Figure 1. There was a robust main effect of exposure, $F(1, 62) = 567.02, p < .001$, partial $\eta^2 = .90$, confirming that participants did in general remember the melodies. There was a smaller main effect of timbre, $F(3, 186) = 5.84, p = .001$, partial $\eta^2 = .08$, which was qualified by an interaction between timbre and exposure, $F(3, 186) = 13.66, p < .001$, partial $\eta^2 = .18$. 
Figure 1. Recognition ratings for melodies. Old melodies (dark bars) were heard during the exposure phase and new melodies (light bars) were not heard previously. Error bars represent standard errors.

The two-way interaction between timbre and exposure was followed up with separate analyses of new and old melodies. A one-way repeated-measures ANOVA with timbre as the independent variable revealed no main effect of timbre on recognition ratings for new melodies, $F(3, 189) = 1.24, p > .2$. By contrast, there was a main effect of timbre on recognition of old melodies, $F(3, 189) = 13.61, p < .001$, partial $\eta^2 = .17$. In other words, timbre did not affect memory for foils but it influenced memory for previously exposed melodies regardless of whether the instrumental versions were real or MIDI generated. Pairwise comparisons revealed higher recognition ratings for the voice compared to the piano, the banjo, and the marimba, all $ps < .001$, but no differences among the instrumental timbres, $ps > .2$.

Because half of the sample (i.e., 32 of 64 participants) played the piano for at least one year, we recalculated the ANOVA on recognition scores with piano training (2 levels) as an additional (fourth) independent variable. As might be expected, the group with piano training
performed better on the recognition task across timbres, as revealed by a main effect for piano training, $F(1, 60) = 5.22, p < .05$, partial $\eta^2 = .08$, and an interaction between piano training and exposure, $F(1, 60) = 7.76, p < .01$, partial $\eta^2 = .11$. This finding is consistent with others indicating that trained individuals are good listeners on a variety of tasks, musical or otherwise (Kraus & Chandrasekaran, 2010). Importantly, there was no interaction between exposure, timbre, and piano training, $F < 1$, indicating that piano training did not influence memory for any timbre (i.e., the piano) more than others. Moreover, because our analysis uncovered better performance for those with piano training across timbres, it suggests that the null findings involving an interaction of piano training and timbre were not due to lack of power. Even so, the years of piano playing for the piano-trained group ($M = 4.95, SD = 4.00$, range = 1-14) was not comparable to professional musicians and typically took place during adolescence. Few claimed to play the instrument currently.

Another mixed-design ANOVA examined whether liking ratings varied as a function of timbre, exposure, and recording condition. As with recognition ratings, there was no main effect of recording condition, $p > .7$, and no interactions involving recording condition, $ps > .05$. Descriptive statistics, collapsed across recording conditions, are illustrated in Figure 2. There was a main effect of exposure on liking, $F(1, 62) = 22.90, p < .001$, partial $\eta^2 = .27$, with previously heard melodies rated higher than new melodies. A main effect of timbre was also observed, $F(3, 186) = 7.95, p < .001$, partial $\eta^2 = .11$. Liking was lower for the voice compared to each of the three instrumental timbres, $ps < .05$, which did not differ from each other, $ps > .5$. Because the voice was liked least but remembered best, it is possible that disliking the voice could have resulted in better memory. Nevertheless, correlations between liking scores and recognition scores were not significant in each of eight (exposure x timbre) instances, $ps > .05$. 
These results are consistent with others showing that disliked music is recognized with similar accuracy as music that is neither liked nor disliked (Stalinski, 2012).

Figure 2. Liking ratings for melodies. Old melodies (dark bars) were heard during the exposure phase and new melodies (light bars) were not heard previously. Error bars represent standard errors.

4 Discussion

After exposure to a series of melodies played in two familiar timbres (voice and piano) and two unfamiliar timbres (banjo and marimba), adults were tested on their recognition and liking of the melodies. Melodies presented in vocal timbre were remembered significantly better than those presented in the three instrumental timbres, whether natural or digitally generated. The advantage of the voice was not attributable to likeability. In fact, listeners liked vocal renditions significantly less than non-vocal renditions.
Overall, musical familiarity did not affect memory for timbres because the piano did not elicit higher recognition than the banjo or marimba. However, a lifetime of listening to and producing speech would make the voice much more familiar than any musical instrument. The extreme familiarity of the voice may confer processing advantages over instruments even if typical exposure to the voice is through speech rather than singing. Indeed, there seem to be dedicated neural resources for voice processing. The right anterior superior temporal sulcus (STS) responds selectively to human paralinguistic cues (Belin et al., 2002; Belin et al., 2000), with activation evident when listeners attend to the voice but not the verbal content of utterances (von Kriegstein, Eger, Kleinschmidt, & Giraud, 2003). In the present study, the use of a single vocal performer may have increased the salience of person-specific features. As listeners become familiar with a speaker, they show decreased activity in the right anterior STS (Belin & Zatorre, 2003), which is consistent with behavioural evidence of talker familiarity enhancing speech processing (e.g., Nygaard & Pisoni, 1998). Likewise, familiarity with the singer’s voice may have increased the processing fluency of melodies. In any event, increases in familiarity for all four timbres occurred over the course of the experiment.

There is other evidence of voice-specific processing. Vocal tones produce larger responses than instrumental tones in the area around Heschl’s gyrus (Gunji, Koyama, Ishii, Levy, Okamoto, Kakigi, & Pantev, 2003). Similarly, event-related potentials (ERPs) are evident at around 320 ms after the onset of vocal tones but not after matched instrumental tones, especially if listeners are attending to the timbre (Levy, Granot, & Bentin, 2001). When attention is directed elsewhere, ERPs to the voice are similar to ERPs to voice-like instruments such as the violin (Levy, Granot, & Bentin, 2003). In other words, the extent to which the voice triggers special processing depends on attentional focus and timbral similarity. Because the
current study featured instruments with little resemblance to the voice, one might expect distinctive responses to the voice.

It is also possible that the voice was remembered best because it recruits motor representations that may not be recruited by the instrumental timbres. Similarly, individuals with extensive instrumental training might not only hear a melody; they might also generate motor imagery that corresponds to playing the melody. When pianists listen to piano melodies, their primary motor cortex is activated (Haueisen & Knösche, 2001). In fact, pianists show overlapping activation in the pre-motor cortex for listening-only and motor-only conditions (Bangert et al., 2006). Moreover, their performance is improved by mental motor practice while listening to music (Highben & Palmer, 2004), which suggests that the mere activation of motor representations enhances memory. In contrast to the aforementioned studies, which involved expert pianists, the present sample had no professional or highly accomplished amateur musicians, and participants with piano training showed no facilitation for the piano timbre. It is impossible to know whether facilitation for the vocal timbre arose from participants covertly “singing along” with or generating motor imagery for the vocal versions. Future research could explore whether an articulatory suppression task (e.g., vocalizing while listening) would reduce memory for vocal melodies to the levels observed for instrumental melodies.

Participants rated the voice less favorably than the instrumental timbres, perhaps because of the monotony of the repeated syllable “la” relative to conventional lyrics. Nevertheless, liking ratings were higher for previously heard melodies than for novel melodies, which is consistent with previous research on the effects of exposure on the evaluation of music (Halpern & Müllensiefen, 2008; Peretz & Gagnon, 1998; Schellenberg et al., 2008; Szpunar et al., 2004). If liking ratings reflect implicit memory (e.g., Peretz et al., 1998), then the current results indicate that implicit memory for melodies (i.e., difference in liking ratings for old and new melodies)
did not differ by timbre. The present finding of a difference in recognition but not liking across timbres is consistent with previous evidence of impaired explicit memory but unchanged implicit memory after a timbre switch (Halpern & Müllensiefen, 2008; Peretz et al., 1998). The uncorrelated liking ratings and recognition ratings are concordant with that interpretation.

In sum, the present study provides the first direct test of the influence of timbre on memory for melodies. Moreover, it provides unequivocal evidence that vocal melodies are remembered better than instrumental melodies. Although the underlying mechanisms are unclear, it is evident that all timbres are not equal. Finally, the findings support the notion that surface features of music and abstract, relational features are processed jointly as well as separately, as they are for speech (Remez, Fellowes, & Rubin, 1997)
References


Appendix 1: List of melodies

<table>
<thead>
<tr>
<th>Number</th>
<th>Time Sig</th>
<th>BPM</th>
<th>Length (s)</th>
<th>Name</th>
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<tbody>
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<td>1</td>
<td>4/4</td>
<td>130</td>
<td>14</td>
<td>A May Day Carol</td>
</tr>
<tr>
<td>2</td>
<td>3/4</td>
<td>100</td>
<td>14</td>
<td>Allen Water</td>
</tr>
<tr>
<td>3</td>
<td>3/4</td>
<td>100</td>
<td>14</td>
<td>Baloo Baleerie</td>
</tr>
<tr>
<td>4</td>
<td>3/4</td>
<td>110</td>
<td>13</td>
<td>Can Ye Sew Cushions</td>
</tr>
<tr>
<td>5</td>
<td>3/4</td>
<td>105</td>
<td>13</td>
<td>Tarry Trousers</td>
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<td>4/4</td>
<td>100</td>
<td>19</td>
<td>Cruiskeen Lawn</td>
</tr>
<tr>
<td>7</td>
<td>4/4</td>
<td>110</td>
<td>17</td>
<td>Cuckoo Dear</td>
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<td>14</td>
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<td>100</td>
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<td>Down By The Sally Gardens</td>
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<td>Kevin Barry</td>
</tr>
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<td>14</td>
<td>3/4</td>
<td>100</td>
<td>14</td>
<td>Lark In The Clear Air</td>
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<tr>
<td>15</td>
<td>4/4</td>
<td>110</td>
<td>18</td>
<td>Let Erin Remember</td>
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<td>16</td>
<td>4/4</td>
<td>110</td>
<td>17</td>
<td>Little Red Fox</td>
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<td>Eriskay Love Lilt</td>
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<td>Andy McEnroe</td>
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<td>19</td>
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<td>14</td>
<td>Are Ye Right There Michael</td>
</tr>
<tr>
<td>20</td>
<td>6/8</td>
<td>100</td>
<td>14</td>
<td>Blow The Candle Out</td>
</tr>
<tr>
<td>21</td>
<td>4/4</td>
<td>110</td>
<td>18</td>
<td>The Three Ravens</td>
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<td>22</td>
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<td>115</td>
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<td>The Girl I Left Behind</td>
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<td>23</td>
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<td>110</td>
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<td>Megans Fair Daughter</td>
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<td>25</td>
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<td>18</td>
<td>O No John</td>
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<td>26</td>
<td>4/4</td>
<td>110</td>
<td>18</td>
<td>Oak And The Ash</td>
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<td>27</td>
<td>4/4</td>
<td>110</td>
<td>17</td>
<td>Odonnell Aboo</td>
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<td>28</td>
<td>3/4</td>
<td>110</td>
<td>13</td>
<td>Over The Mountains</td>
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<td>29</td>
<td>3/4</td>
<td>110</td>
<td>18</td>
<td>Parting Glass</td>
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<td>30</td>
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<td>13</td>
<td>Robin Adair</td>
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<td>32</td>
<td>6/8</td>
<td>110</td>
<td>13</td>
<td>Slatterys Mounted Fut</td>
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Appendix 2: Music questionnaire

MUSIC QUESTIONNAIRE

Name: _______________________
Age: _____
Gender: Male / Female
Phone: _______________________
Email: _______________________
Academic Major (e.g., Faculty of Arts & Science) _______________________________

Are you Right or Left Handed?  Right  /  Left
Is English your first language?  Yes  /  No
If no, at what age did you begin speaking English on a regular basis
And what other languages do you speak fluently?
Do you currently have any hearing issues or a hearing related illness? Yes / No
If Yes, please explain (e.g., ear infection, hearing impaired in right ear, etc.):

I. Formal music training:

1. Have you ever taken music lessons (ANY type of lessons count, e.g., high school band class)? Yes / No
   * If YES, please continue to #2; If NO, please proceed to #4

2. Please indicate your instrument/voice training, using a different line for each different instrument or voice:

<table>
<thead>
<tr>
<th>Instrument/Voice</th>
<th>Individual (years)</th>
<th>Group (years)</th>
<th>RC Grade*</th>
<th>Age at time of lessons</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

*If not Royal Conservatory training, what method of training?

3. Please indicate your music theory training (if any):

<table>
<thead>
<tr>
<th>Type (e.g., composition)</th>
<th>Individual (years)</th>
<th>Group (years)</th>
<th>RC Grade*</th>
<th>Age at time of lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
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</tbody>
</table>

*If not Royal Conservatory training, what method of training?

II. Informal music training/current music involvement:

4. Have you ever taught yourself to play an instrument (i.e., without formal lessons on that instrument)?

<table>
<thead>
<tr>
<th>Instrument</th>
<th>How long played?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
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<td>2)</td>
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</table>

5. Are you currently active musically? Yes / No
   *If ‘Yes’:  Recreational (indicate activity):
   Formal lessons (indicate activity):
   If ‘No’ how long has it been since you have been involved in music activities?

6. Do you listen to music (circle one)? Yes / No
   If ‘Yes’, how often (e.g., everyday for about 3 hours)?
   If ‘Yes’, what type (e.g., classical, rock)?

7. What is your favorite type of music?

8. Is music important to you? Yes / No
   If ‘Yes’, how?

9. Do you consider yourself musical? Yes / No / Somewhat
10. Do you have perfect (absolute) pitch? Yes / No